TECHNICAL DIVISION
SAVANNAH RIVER LABORATORY

DPST--83-625

DE91 006415

CC: J. L. Crandall
J. W. Stewart
M. R. Buckner
C. B. Jones
H. P. Olson

D. A. Sharp
C. E. Apperson
R. Banerjee
EAPD File
SRL Records (4)

June 27, 1983

TO: T. V. CRAWFORD

FROM: W. L. PILLINGER *WLP*

JAN 23 1984

300-AREA ACCIDENT ANALYSIS FOR EMERGENCY PLANNING ZONES

INTRODUCTION AND SUMMARY

The Department of Energy has requested SRL assistance in developing offsite Emergency Planning Zones (EPZs) for the Savannah River Plant, based on projected dose consequences of atmospheric releases of radioactivity from potential credible accidents in the SRP operating areas.¹ The potential 300-Area accidents and the postulated releases have been described in DPST-83-427.² This memorandum presents the assessment of the offsite doses via the plume exposure pathway from the 300-Area potential accidents.

Table 1 shows the calculated maximum doses to an offsite adult based on "worst-case" meteorology (worst-case, worst-sector probability analysis at the 0.5% level, except for tornados). As indicated by underlining in the table, the highest whole-body dose is 0.12 rem from the extrusion fire, and the highest critical-organ dose is 8.6 rem to the lung from the aircraft crash. None of these calculated doses exceed the prescribed threshold (5 rem whole body and 25 rem critical organ) for establishment of plume exposure pathway EPZ.¹ All of the 300-Area potential accidents have been considered except for the hurricane, for which the meteorology was not available.

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DISCUSSION

As indicated by Reference 1, we assume that the accidental atmospheric release occurs within a two-hour period and that offsite man subsequently receives a two-hour exposure to the plume. The plume exposure pathway consists of internal exposure by inhalation (active-man breathing rate, $12000\text{m}^3/\text{yr}$), external exposure to gamma radiation from the plume, and external exposure to radiation from ground-deposited nuclides (latter not analyzed for the tornado).

Accident Releases

The postulated releases of radioactivity from each accident have been presented in DPST-83-427,² which assumes the radionuclides are released to atmosphere at ground level from the 321-M Building. Table 2 shows the minimum distances from this release point to the SRP site boundary by cardinal compass sector.

As opposed to the other accidents, the release from the criticality accident - Table 2 of Reference 2 - includes short-lived nuclides which decay to important daughter radionuclides not shown in that table. The inventory of released radionuclides and their daughters as a function of time out to ten hours has been given in a separate memorandum.³ Utilizing that inventory, the criticality-accident releases were conservatively taken to be the maximum amounts (Ci) in the ten-hour period (plus uranium from Table 2 of Reference 2). This is necessary because the computer code utilized for the dose assessment does not provide for ingrowth of daughter nuclides during plume transit to the receptor.

Meteorology

Except for the tornado (or the hurricane for which the meteorology was not available), the probable meteorological conditions are represented by the joint frequency distribution (JFD) shown in Table 3. These stability-windrose statistics (the JFD) have been derived by two-hour averaging of wind data collected at the 62-meter elevation of the A-Area meteorological tower during the five-year period, 1975-79.⁴ As appropriate for a ground-level release, the JFD windspeeds are (power-law) adjusted to the 10-meter level by the computer code utilized to calculate the relative air concentrations (X/Q 's) and deposition rates (D/Q), and the resulting doses.⁵

The meteorology for the tornado is assumed to be as described in DPST-82-982.⁶ The resulting relative air concentration (X/Q) as a function of distance from the release point is taken to be the upper curve in Figure 1 of Reference 6, which attains a maximum value at a distance of about one kilometer (0.62 miles) and then decreases with increasing distance.

Based on the meteorological models (References 5 and 6), the relative air concentration (X/Q) and deposition rate (D/Q) in a given compass sector would decrease in value with increasing distance beyond the SRP site boundary (Table 2). Hence, maximum offsite-individual exposure to a 300-Area accidental ground-level release occurs on the SRP boundary.

Dose Models

The dose models are two-hour exposure analogs (i.e., 2-hour time integrals) of the pertinent dose-rate equations in NRC Regulatory Guide 1.109; namely, regulatory-guide Equations 10 (with $S_F=1$), 12 (with $S_F=1$) and 13($R_a=12000\text{ m}^3/\text{yr}$, $a=\text{adult}$), as further interpreted in the appendices to the regulatory guide.⁷ The inhalation doses are organ specific based on adult-inhalation 50-year dose commitment factors, which actually apply to chronic intake but are reasonably accurate for acute intake ($\sim 5\%$ error - the factors for other age-groups are not applicable for acute intake).⁸ For external exposure (regulatory-guide dose factors not age-specific), only the total-body dose is calculated; the other body organs listed in Table 1 are assume to receive the same dose as the total body.

Tornado Doses

As indicated in Reference 6, the probable tornado direction is towards the northeast, and the distance from the release point to the SRP boundary in that sector is 4.5 kilometers (Table 2). Utilizing the upper curve in Figure 1 of Reference 6, the relative air concentration at the location of maximum offsite exposure (4.5 km NE) is estimated to be $X/Q = 1.1 \times 10^{-6}\text{ sec}/\text{m}^3$. Based on this X/Q , the tornado releases and the dose models, the doses have been calculated and reported in Table 1.

Doses From Other Accidents

The doses from the other accidental releases, which are shown in Table 1, have been calculated using the NRC145-2 computer code, which has been described in DP-1646.⁵ In this code, doses are determined for all the probable meteorological conditions in Table 3, which also gives the probable frequency of occurrence of each meteorological condition. Based on worst-case probability analysis,⁵ the reported dose is that dose which would be exceeded 0.5% of the time for the compass sector having the highest doses. Typically, these reported doses occur on the site boundary, in the northwest quadrant about one mile from the release point.

REFERENCES

1. R. P. Denise to J. R. Hilley, "Development of Emergency Planning Zones for the Savannah River Plant," February 23, 1983 (Letter).
2. R. Banerjee to M. R. Buckner, "300-Area Accident Analysis for Emergency Planning Zones," DPST-83-427, April 11, 1983.
3. C. E. Apperson to R. Banerjee, "Daughter Products for 300 Area Accident Analysis," April 19, 1983 (Memorandum).
4. A. J. Garrett and D. D. Hoel to T. V. Crawford, "Preparation of Meteorological Data for Dose Calculations in 1982 SRP Reactor Safety Analysis Report (SAR)," DPST-82-512, June 4, 1982.
5. M. M. Pendergast, NRC145-2, A Computer Code to Assess Dose from Accidental Pollutant Releases. Du Pont Report DP-1646 (May 1983).
6. H. R. Haynes and D. H. Taylor to H. D. Harmon and R. L. Folger, "Estimating Doses from Tornado Winds," DPST-82-982, February 14, 1983.
7. "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 20, Appendix I." USNRC Regulatory Guide 1.109, Revision 1, U.S. Nuclear Regulatory Commission, Washington, D.C. (1977).
8. G. R. Hoennes and J. K. Soldat, Age-Specific Radiation Dose Commitment Factors for a One-Year Chronic Intake. USNRC Report NUREG-0172, Battelle Pacific Northwest Laboratories, Richland, WA (1977).

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Table 1

Maximum Offsite Adult Doses via the plume Exposure Pathway
from 300-Area Potential Accidents*

Accident	Organ Doses, rem					
	T. Body	Bone	Thyroid	Liver	Kidney	Lung
Tornado ^a	4.7E-3	7.6E-2	- ^b	3.1E-7	1.8E-2	3.8E-1
Aircraft Crash	1.1E-1	1.7E+0	2.7E-7	6.4E-5	4.1E-1	8.6E+0
Extrusion Fire	1.2E-1	4.9E+0	2.8E-8	4.5E-1	5.3E-1	2.0E-1
Billet Meltdown	1.0E-1	4.2E+0	2.4E-8	3.8E-1	4.5E-1	1.7E-1
Earthquake	4.8E-4	8.0E-4	1.2E-9	3.2E-5	1.9E-3	3.8E-2
HEPA Filter Failure	6.0E-6	9.6E-5	1.5E-11	4.5E-11	2.3E-5	4.8E-4
Exhaust Failure	1.3E-4	2.1E-3	1.1E-7	3.0E-7	4.9E-4	1.0E-1
Criticality	5.8E-2	5.8E-2	3.2E-2	5.9E-2	5.9E-2	2.4E-2

* Maximum doses based on "worst-case" meteorology (see text).

^a Tornado doses exclusive of external exposure to radiation from ground-deposited nuclides.

^b Dash signifies absence of dose conversion factors for released nuclides.

Table 2

Minimum Distances to SRP Boundary from 300-Area Accident Release Point by Cardinal Compass Sector*

<u>Sector No.</u>	<u>Cardinal Compass Sector</u>	<u>Distance (mi)</u>	<u>Distance (km)</u>
1	S	8.68	14.0
2	SSW	4.31	6.94
3	SW	3.06	4.92
4	WSW	1.55	2.49
5	W	0.94	1.51
6	WNW	1.11	1.79
7	NW	1.04	1.67
8	NNW	1.07	1.72
9	N	1.06	1.71
10	NNE	1.49	2.40
11	NE	2.82	4.54
12	ENE	8.11	13.1
13	E	13.9	22.4
14	ESE	14.9	24.0
15	SE	16.7	26.9
16	SSE	15.8	25.3

* The SRP Grid coordinates for the assumed Bldg. 321-M release point are E49800 ft. and N104200 ft.

Joint Frequency Distribution, percent of the time

		SECTOR NO.															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PG STABILITY CLASS A																	
WIND SPEED(M/SEC)																	
1	(1.30)	0.249	0.175	0.263	0.190	0.322	0.285	0.395	0.278	0.329	0.256	0.446	0.453	0.504	0.373	0.256	0.292
2	(2.80)	0.599	0.680	0.702	0.614	0.753	0.870	0.775	0.702	0.914	1.009	1.287	1.535	1.257	1.521	0.811	0.607
3	(4.60)	0.146	0.183	0.256	0.395	0.285	0.234	0.256	0.292	0.292	0.570	0.541	0.431	0.395	0.482	0.322	0.249
4	(6.60)	0.015	0.022	0.022	0.037	0.022	0.007	0.029	0.037	0.161	0.051	0.051	0.044	0.073	0.080	0.066	0.051
5	(9.30)	0.022	0.0	0.0	0.015	0.007	0.0	0.0	0.0	0.044	0.015	0.022	0.022	0.007	0.015	0.0	0.015
6	(15.30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.007	0.0
PG STABILITY CLASS B																	
WIND SPEED(M/SEC)																	
1	(1.30)	0.044	0.037	0.022	0.044	0.073	0.073	0.044	0.058	0.029	0.058	0.066	0.066	0.051	0.066	0.037	0.022
2	(3.00)	0.139	0.183	0.278	0.278	0.336	0.424	0.366	0.161	0.300	0.424	0.614	0.497	0.526	0.534	0.336	0.219
3	(4.80)	0.146	0.190	0.234	0.314	0.563	0.322	0.161	0.256	0.358	0.475	0.519	0.387	0.409	0.431	0.278	0.156
4	(6.60)	0.044	0.022	0.051	0.088	0.088	0.037	0.015	0.073	0.073	0.124	0.154	0.132	0.095	0.132	0.058	0.037
5	(8.90)	0.022	0.007	0.007	0.0	0.0	0.0	0.0	0.007	0.037	0.007	0.0	0.015	0.022	0.044	0.007	0.0
6	(13.80)	0.0	0.0	0.007	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PG STABILITY CLASS C																	
WIND SPEED(M/SEC)																	
1	(1.30)	0.022	0.015	0.080	0.044	0.051	0.058	0.073	0.095	0.066	0.037	0.015	0.051	0.066	0.080	0.037	0.037
2	(3.10)	0.161	0.197	0.256	0.461	0.439	0.482	0.431	0.453	0.263	0.373	0.548	0.621	0.453	0.431	0.417	0.146
3	(4.80)	0.154	0.227	0.402	0.673	0.709	0.468	0.409	0.526	0.453	0.658	0.636	0.658	0.629	0.694	0.482	0.263
4	(6.80)	0.029	0.044	0.146	0.234	0.300	0.051	0.066	0.154	0.102	0.154	0.183	0.190	0.292	0.453	0.212	0.080
5	(9.10)	0.015	0.007	0.029	0.022	0.022	0.007	0.007	0.0	0.022	0.037	0.066	0.073	0.197	0.256	0.132	0.058
6	(12.40)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.007	0.015	0.0	0.007	0.0	0.0
PG STABILITY CLASS D																	
WIND SPEED(M/SEC)																	
1	(1.00)	0.0	0.015	0.015	0.044	0.029	0.022	0.051	0.044	0.007	0.029	0.044	0.037	0.073	0.080	0.015	0.015
2	(3.20)	0.183	0.154	0.387	0.409	0.468	0.461	0.490	0.497	0.351	0.366	0.409	0.585	0.548	0.307	0.344	0.227
3	(4.90)	0.234	0.175	0.709	0.936	1.367	0.928	0.877	0.790	0.921	0.921	0.958	0.943	0.943	0.950	0.702	0.395
4	(6.70)	0.029	0.095	0.395	0.665	0.475	0.285	0.205	0.322	0.270	0.270	0.175	0.161	0.446	0.892	0.307	0.073
5	(9.20)	0.015	0.0	0.007	0.029	0.015	0.0	0.022	0.037	0.058	0.051	0.029	0.022	0.205	0.497	0.219	0.015
6	(13.30)	0.0	0.007	0.037	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.044	0.007	0.0
PG STABILITY CLASS E																	
WIND SPEED(M/SEC)																	
1	(0.90)	0.007	0.007	0.007	0.0	0.007	0.007	0.029	0.015	0.022	0.015	0.015	0.015	0.0	0.0	0.0	0.0
2	(3.30)	0.044	0.080	0.088	0.044	0.197	0.227	0.358	0.300	0.132	0.066	0.132	0.183	0.175	0.102	0.132	0.117
3	(5.00)	0.197	0.095	0.380	0.358	0.731	0.680	1.038	1.075	0.541	0.329	0.556	0.599	0.731	0.665	0.490	0.241
4	(6.50)	0.029	0.044	0.249	0.307	0.314	0.154	0.168	0.205	0.073	0.110	0.183	0.190	0.249	0.227	0.161	0.080
5	(8.90)	0.0	0.0	0.0	0.007	0.0	0.0	0.015	0.0	0.0	0.0	0.007	0.015	0.0	0.0	0.0	0.0
6	(12.90)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.007	0.0	0.0	0.0
PG STABILITY CLASS F																	
WIND SPEED(M/SEC)																	
1	(1.80)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.007	0.0	0.0
2	(3.40)	0.007	0.0	0.022	0.0	0.015	0.007	0.066	0.0	0.007	0.0	0.0	0.015	0.007	0.007	0.007	0.007
3	(5.10)	0.015	0.015	0.102	0.037	0.051	0.058	0.161	0.102	0.037	0.0	0.015	0.073	0.124	0.080	0.044	0.044
4	(6.50)	0.007	0.007	0.015	0.044	0.095	0.066	0.044	0.037	0.007	0.0	0.007	0.015	0.051	0.029	0.022	0.007
5	(8.90)	0.0	0.0	0.007	0.0	0.0	0.0	0.029	0.0	0.0	0.0	0.0	0.0	0.022	0.0	0.0	0.0
6	(12.70)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.051	0.0	0.0	0.0
PG STABILITY CLASS G																	
WIND SPEED(M/SEC)																	
1	(0.60)	0.0	0.0	0.0	0.007	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.015	0.0	0.0	0.0
2	(3.20)	0.095	0.0	0.0	0.0	0.0	0.0	0.022	0.0	0.015	0.0	0.015	0.0	0.0	0.0	0.0	0.0
3	(5.10)	0.007	0.0	0.022	0.0	0.0	0.0	0.095	0.0	0.007	0.0	0.037	0.0	0.022	0.0	0.007	0.0
4	(7.50)	0.0	0.007	0.007	0.0	0.0	0.0	0.022	0.0	0.0	0.0	0.058	0.0	0.154	0.0	0.0	0.0
5	(8.60)	0.0	0.007	0.0	0.0	0.0	0.0	0.022	0.0	0.0	0.0	0.015	0.0	0.124	0.0	0.0	0.0
6	(12.10)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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