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OFFSITE DOSE CALCULATION MANUAL

FOR

SOUTH CAROLINA ELECTRIC AND GAS COMPANY

VIRGIL C. SUMMER NUCLEAR STATION

PSRC Approval Gary J Taylor / 12-14-90
Date

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Term		Definition	Section of Initial Use
$\overline{Q}_i'$	=	the release rate of non-noble gas radionuclide i as determined from the concentrations measured in the analysis of the appropriate sample required by Table 1.2-3 (μCi/sec).	(3.2.2.2)
$\tilde{Q}_i$	=	cumulative release of noble gas radionuclide i over the period of interest (μCi).	(3.2.3.1)
$\tilde{Q}_i'$	=	cumulative release of non-noble gas radionuclide i (required by ODCM Specification 1.2.4.1) over the period of interest (μCi).	(3.2.3.2)
R_{ij}	=	dose factor for radionuclide i and pathway j, (mrem/yr per uCi/m^3) or (m^2-mrem/yr per μCi/sec) from Tables 3.2-2 through 3.2-6.	(3.2.3.2)
W_{ij}'	=	relative dispersion parameter for the maximum exposed individual, as appropriate for his exposure pathway j and radionuclide i.	(3.2.3.2)
	=	$\overline{X/Q}'$ for inhalation and all tritium pathways	
	=	$\overline{D/Q}'$ for other pathways and non-tritium radionuclides	
$\overline{X/Q}$	=	the highest annual average relative concentration in any sector, at the site boundary in sec/m^3.	(3.2.2.1)
3.17×10^{-8}	=	the fraction of one year per one second	(3.2.3.1)
$\overline{X/Q}'$	=	Annual average relative concentration for the location of the maximum exposed individual for the site (sec/m^3).	(3.2.3.2)
$\overline{D/Q}'$	=	Annual average relative deposition for the location of the maximum exposed individual for the site (m^{-2}).	(3.2.3.2)

D_β = air dose due to beta emissions from noble gas radionuclide i (mrad)

$$= 3.17 \times 10^{-8} \sum_i N_i \overline{X/Q} \tilde{Q}_i \quad (50)$$

where, N_i = air dose factor due to beta emission from noble gas radionuclide i (mrad/yr per uCi/m3) from Table 3.1-1.

3.2.3.2 Dose to an individual from radioiodines and radioactive materials in particulate form and radionuclides (other than noble gases), with half-lives greater than eight (8) days (Calendar quarter: ≦ 7.5 mrem any organ, Calendar year: ≦ 15 mrem any organ) will be calculated for the purpose of implementation of section 1.2.4.1 as follows:

D_p = dose to an individual from radioiodines and radionuclides in particulate form, with half-lives greater than eight days (mrem)

$$= 3.17 \times 10^{-8} \sum_{ij} R_{ij} W_{ij}' \tilde{Q}_i' \quad (51)$$

where:

W_{ij}' = relative concentration or relative deposition for the maximum exposed individual, as appropriate for exposure pathway j and radionuclide i.

$$= \begin{cases} \overline{X/Q}' \text{ for inhalation and all tritium pathways} \\ \quad = 2.2 \times 10^{-6} \text{ sec/m}^3 \\ \\ \overline{D/Q}' \text{ for other pathways and non-tritium radionuclides} \\ \quad = 1.2 \times 10^{-8} \text{ m}^{-2} \end{cases}$$

(See the notes to Table 3.2-7 and 3.2-8 for the origin of these factors.)

Table 3.2-7

CONTROLLING RECEPTORS, LOCATIONS, AND PATHWAYS*

SECTOR	DISTANCE (METERS)	PATHWAY	AGE GROUP	ORIGIN (FOR INFORMATION ONLY)
N**	6,100	Vegetation	Child	-Vegetable Garden
NNE**	5,300	Vegetation	Child	-Vegetable Garden
NE	4,500	Vegetation	Child	-Vegetable Garden
	4,500	Grass/Cow/Meat	Child	Grazing Beef Cattle
ENE	2,600	Vegetation	Child	-Vegetable Garden
	2,600	Grass/Cow/Meat	Child	Grazing Beef Cattle
E	1,800	Vegetation	Child	-Vegetable Garden
ESE	1,800	Vegetation	Child	-Vegetable Garden
SE	2,400	Vegetation	Child	-Vegetable Garden
SSE	4,300	Vegetation	Child	-Vegetable Garden
S**	6,300	Vegetation	Child	-Vegetable Garden
SSW**	5,500	Vegetation	Child	-Vegetable Garden
SW**	5,300	Vegetation	Child	-Vegetable Garden
WSW	3,100	Grass/Cow/Meat	Child	-Grazing Beef Cattle
W	4,300	Vegetation	Child	-Vegetable Garden
	3,500	Grass/Cow/Meat	Child	Grazing Beef Cattle
WNW**	7,700	Vegetation	Child	-Vegetable Garden
NW**	6,600	Vegetation	Child	-Vegetable Garden
NNW	4,800	Vegetation	Child	-Vegetable Garden
	4,800	Grass/Cow/Meat	Child	Grazing Beef Cattle

* See note on the following page for the method used to identify these controlling receptors.

** If a cow were located at 5.0 miles (8,000 meters) in this sector, an infant consuming only its milk would receive a greater total radiation dose than would the real receptor listed. However, such an infant would not be the Maximum Exposed Individual for the site.

NOTE: The controlling receptor in each sector was identified in the following way. Receptor locations and associated pathways were obtained from the August 1990 field survey. A child was assumed at each location, except that where a milk cow was listed, an infant was assumed. $\overline{X/Q}$' for each candidate receptor was obtained by interpolation of values in Table 6.1-10 of Reference 5; $\overline{D/Q}$' for each candidate receptor was obtained by interpolation of values in Table 6.1-13 of Reference 5. Expected annual releases of each nuclide were taken from Table 5.2-2 of Reference 5. The pathway dose factors given above in Tables 3.2-3 and 3.2-4 were then used with the referenced values in the methodology of Section 5.3 of Reference 1 to compute total annual doses at each candidate receptor site for [illegible] hways existing at that site. The controlling receptor for each [illegible] was then chosen as the candidate receptor with the highest total annual dose of any candidate receptor in the given sector. All listed pathways are in addition to inhalation and ground plane exposure.

Table 3.2-8

ATMOSPHERIC DISPERSION PARAMETERS
FOR CONTROLLING RECEPTOR LOCATIONS*

SECTOR	$\overline{X/Q'}$	$\overline{D/Q'}$	DISTANCE (MILES/METERS)
N	1.5 E-07	7.0 E-10	3.8 / 6,100
NNE	2.5 E-07	1.1 E-09	3.3 / 5,300
NE	3.7 E-07	1.8 E-09	2.8 / 4,500
ENE	1.1 E-06	5.8 E-09	1.6 / 2,600
E	2.2 E-06	1.2 E-08	1.1 / 1,800
ESE	2.2 E-06	8.4 E-09	1.1 / 1,800
SE	1.6 E-06	5.8 E-09	1.5 / 2,400
SSE	3.0 E-07	1.0 E-09	2.7 / 4,300
S	1.7 E-07	3.7 E-10	3.9 / 6,300
SSW	2.0 E-07	6.4 E-10	3.4 / 5,500
SW	2.6 E-07	1.0 E-09	3.3 / 5,300
WSW	6.4 E-07	3.2 E-09	1.9 / 3,100
W	2.2 E-07	9.2 E-10	2.7 / 4,300
W	3.2 E-07	1.5 E-09	2.2 / 3,500
WNW	5.9 E-08	2.2 E-10	4.8 / 7,700
NW	9.6 E-08	4.1 E-10	4.1 / 6,600
NNW	1.8 E-07	9.8 E-10	3.0 / 4,800

* Annual average relative dispersion and deposition values for the receptor locations in Table 3.2-7. Values were obtained by interpolation in Tables 6.1-10 and 6.1-13 of Reference 5. Those tables are based on one year (1975) of meteorological readings and the FSAR dispersion model (ground-level release, sector-averaged model, with open terrain recirculation factors, dry depletion by Figure 3.3-1, and using decay with a half-life of 8.0 days). As a result of the analysis described in the note to Table 3.2-7, the location of the maximum exposed individual for the site was identified as being the vegetable garden at 1.1 miles in the E sector. Therefore, the site $\overline{X/Q'}$ and $\overline{D/Q'}$ (Section 3.2.3.2 and following) are those from this table for that location.

NOTES

1. Site-specific annual average absolute humidity. For each month, an average absolute humidity was calculated from the 7 years of monthly average temperatures in Table 2.3-49 of Reference 4 and the 5 years of monthly average dew points in Table 2.3-64 of Reference 4. The 12 monthly values were averaged to obtain the annual average of 8.84 gm/m^3. (Section 5.2.1.3 of Reference 1 gives a default value of 8 gm/m^3.)

2. Inhalation and ingestion dose factors were taken from the indicated source. For each age group, for each nuclide, the organ dose factor used was the highest dose factor for that nuclide and age group in the referenced table.

3. Typically beef cattle are raised all year on pasture. Annual land surveys have indicated that the small number of goats raised within 5 miles typically are used for grass control and not food or milk. Nevertheless, the goats were treated as full meat and milk sources where present, despite the fact that their numbers cannot sustain the meat consumption rates of Table E-5 of Reference 3.

4. According to the August 1990 land use census, dairy cattle possibly graze at 4.9 miles in the West sector. If dairy cattle graze at this location, the dose to an infant consuming milk from these animals would be less than the dose received by the critical receptor identified for the sector. No other milking activity within five miles of the plant was identified. These values are included for reference only.

5. Two columns of R_i's were calculated - one for cows kept exclusively on local pasture ($f_p = f_s = 1$), and one for cows kept exclusively on locally grown stored feed ($f_p = f_s = 0$). See the note on page 2.0-37.

= 2.1E-3 mRem/yr to skin.

$$D_o = \sum_i \overline{X/Q}\ P_i \overline{Q}_i$$

= (5.3E-6) (1.624E + 7) (6.73E-8) (481)

= 2.8E-3 mrem/yr (Organ Dose Rate)

b) Unrestricted Area Dose to Individual (Section 3.2.3)

$$D_\gamma = 3.17E-8 \sum_i M_i\ \overline{X/Q}\ \widetilde{Q}_i$$

$$= 3.17E-8 \sum_i [(1.2E3)(5.3E-6)(1.1E-6)(1.04E6) + (1.5E4)(5.3E-6)(3.5E-7)$$

$$(1.04E6) + (1.6E2)(5.3E-6)(3.9E-6)(1.04E6) + (353)(5.3E-6)(8.5E-4)(1.04E6)$$

$$+ (327)(5.3E-6)(1.2E-5)(1.04E6) + (1.9E3)(5.3E-6)(5.1E-5)(1.04E6)]$$

= 5.6E-8 mrad γ air dose.

$$D_\beta = 3.17E-8 \sum_i N_i\ \overline{X/Q}\ \widetilde{Q}_i$$

$$= 3.17E-8 \sum_i [(2.0E3)(5.3E-6)(1.1E-6)(1.04E6) + (2.9E3)(5.3E-6)(3.5E-7)$$

$$(1.04E6) + (1.1E3)(5.3E-6)(3.9E-6)(1.04E6) + (1.1E3)(5.3E-6)(8.5E-4)(1.04E6)$$

$$+ (1.5E3)(5.3E-6)(1.2E-5)(1.04E6) + (2.5E3)(5.3E-6)(5.1E-5)(1.04E6)]$$

= 1.82E-7 mrad β air dose.

$$D_p = 3.17E-8 \sum_i R_{ij}\ W_{ij}\ \widetilde{Q}'$$

$$= 3.17E-8 \sum_{ij} [(1.624E7)(2.2E-6)(6.73E-8)(1.04E6) + (2.089E7)(1.2E-8)$$

$(6.73E-8)(1.04E6) + (4.754E10)(1.2E-8)(6.73E-8)(1.04E6)]$

= 1.35E-6 mrem individual dose due to radioiodines and radionuclides in particulate form with $t_{\frac{1}{2}} > 8$ days.

D. RM-A10

Given: $\overline{X/Q}$ = 5.3E-6 sec/m^3

Kr-89 = 1E-5 uCi/ml

1) Monitor Setpoint Calculation

Permissible release conditions for the Waste Gas System are defined in terms of both radionuclide concentration and waste gas flow rate (using previous nuclide concentrations).

a) The maximum permissible flow rate is set on the same basis but include the engineering safety factor of 0.5. The RM-A10 setpoint level S_d is defined as:

$$S_d \leq 1.5c$$

b) The maximum permissible waste gas flow rate f_w (cc/sec) is calculated from the maximum permissible dose rates at the site boundary according to:

$$f_w \leq \text{the lesser of } f_t \text{ or } f_s$$

f_t = the maximum permissible discharge rate based on total body dose rate.

$$= \frac{0.25 \times 500\ mrem/yr}{(\overline{X/Q})(1.5)\sum_i (X_{id})(K_i)}$$

= (0.25)(500) / 5.3E-6)(1.5((1E-5)(1.66E4))

= 9.47E7 cc/sec