OFFSITE DOSE CALCULATION MANUAL

FOR

SOUTH CAROLINA ELECTRIC AND GAS COMPANY

VIRGIL C. SUMMER NUCLEAR STATION

REVISION 7

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J. H. Connelly 10/10/84

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The Steam Generator Blowdown Effluent may be released to the Circulating Water either directly in the Condenser outflow or via the ponds and sumps of the Industrial and Sanitary Waste System; the latter path is preferred for chemical reasons in the first hours following startup. The Turbine Building Sump and Condensate Demineralizer Backwash Effluents enter the Circulating Water through the Industrial and Sanitary System.

For the sake of clarity, two mutually exclusive setpoint calculation processes are outlined below. Section 1.1.3.1 is to be used whenever Steam Generator Blowdown in being released directly to the Circulating Water in the Condenser outflow, which is the normal mode. Section 1.1.3.2 is to be used whenever Steam Generator Blowdown is being released to the Industrial and Sanitary Waste System, or diverted to the Nuclear Blowdown Processing System, both of which are alternate modes. Each section covers all four monitors (RM-L3, RM-L8, RM-L10 and RM-L11).

NOTE: When Circulating Water is unavailable for effluent dilution, releases containing activity above LLD should be discouraged via pathways which lead to it. Steam Generator Blowdown should be diverted to the Nuclear Blowdown Processing System. Condensate Demineralizer Backwash may be diverted to the Turbine Building Sump or not released. Turbine Building Sump effluent should be diverted to the Excess Liquid Waste Processing System. (These steps are to keep the calculated dose to individuals as low as reasonably achievable.) Furthermore, sampling and analysis of the Industrial and Sanitary Waste System is to be initiated and the measured concentrations used in the dose calculations of Section 1.2.

1.2 Dose Calculation For Liquid Effluents

The method of this section is to be used in all cases for calculating doses to individuals from routine liquid effluents. Four notes at the end of the section confirm the values which certain parameters are to be assigned in some special cases.

The dose contribution from all radionuclides identified in liquid effluents released to unrestricted areas is calculated using the following expression:

$$D_\tau = \sum_i \left[A_{i\tau} \sum_{l=1}^{m} \Delta t_l \; C_{il} \; F_l \right] \tag{31}$$

where:

D_τ = the cumulative dose commitment to the total body or any organ, τ, from the liquid effluents for the total time period $\sum_{l=1}^{m} \Delta t_l$, in mrem (Reference 1).

Δt_l = the length of the lth time period over which C_{il} and F_l are averaged for all liquid releases, in hours.

C_{il} = the average concentration of radionuclide, i, in undiluted liquid effluent during time period Δt_l from any liquid release, in uCi/ml.

$A_{i\tau}$ = the site related ingestion dose commitment factor to the total body or any organ τ for each identified principal gama and beta emitter listed in Table 1.2-3 in mrem-ml per hr-uCi.

$$A_{i\tau} = K_o \left((U_w/D_w) + U_F BF_i \right) DF_i \tag{32}$$

F_l = the near field average dilution factor for C_{il} during any liquid effluent release. Defined as the ratio of the maximum undiluted liquid waste flow during release to the product of the average flow from the discharge structure to unrestricted receiving water times 2.

TABLE 1.2-3

SITE RELATED INGESTION DOSE COMMITMENT FACTOR, A_{it}*

(mrem/hr per uCi/ml)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H-3	0.00E+00	0.96E+00	0.96E+00	0.96E+00	0.96E+00	0.96E+00	0.96E+00
C-14	3.15E+04	6.30E+03	6.30E+03	6.30E+03	6.30E+03	6.30E+03	6.30E+03
Na-24	5.40E+02	5.40E+02	5.40E+02	5.40E+02	5.40E+02	5.40E+02	5.40E+02
P-32	4.62E+07	2.87E+06	1.79E+06	0.00E+00	0.00E+00	0.00E+00	5.20E+06
Cr-51	0.00E+00	0.00E+00	1.49E+00	6.94E-01	3.29E-01	1.98E+00	3.76E+02
Mn-54	0.00E+00	4.76E+03	9.08E+02	0.00E+00	1.42E+03	0.00E+00	1.46E+04
Mn-56	0.00E+00	1.20E+02	2.12E+01	0.00E+00	1.52E+02	0.00E+00	3.82E+03
Fe-55	8.87E+02	6.13E+02	1.43E+02	0.00E+00	0.00E+00	3.42E+02	3.52E+02
Fe-59	1.40E+03	3.29E+03	1.26E+03	0.00E+00	0.00E+00	9.19E+02	1.10E+04
Co-58	0.00E+00	1.51E+02	3.39E+02	0.00E+00	0.00E+00	0.00E+00	3.06E+03
Co-60	0.00E+00	4.34E+02	9.58E+02	0.00E+00	0.00E+00	0.00E+00	8.16E+03
Ni-63	4.19E+04	2.91E+03	1.41E+03	0.00E+00	0.00E+00	0.00E+00	6.07E+02
Ni-65	1.70E+02	2.21E+01	1.01E+01	0.00E+00	0.00E+00	0.00E+00	5.61E+02
Cu-64	0.00E+00	1.69E+01	7.93E+02	0.00E+00	4.26E+01	0.00E+00	1.44E+03
Zn-65	2.36E+04	7.50E+04	3.39E+04	0.00E+00	5.02E+04	0.00E+00	4.73E+04
Zn-69	5.82E+01	9.60E+01	6.67E+00	0.00E+00	6.24E+01	0.00E+00	1.44E+01
Br-83	0.00E+00	0.00E+00	4.38E+01	0.00E+00	0.00E+00	0.00E+00	6.38E+01
Br-84	0.00E+00	0.00E+00	5.67E+01	0.00E+00	0.00E+00	0.00E+00	4.45E-04
Br-85	0.00E+00	0.00E+00	2.33E+00	0.00E+00	0.00E+00	0.00E+00	1.09E-15
Rb-86	0.00E+00	1.03E+05	4.79E+04	0.00E+00	0.00E+00	0.00E+00	2.83E+04
Rb-88	0.00E+00	2.95E+02	1.56E+02	0.00E+00	0.00E+00	0.00E+00	4.87E-09
Rb-89	0.00E+00	1.95E+02	1.37E+02	0.00E+00	0.00E+00	0.00E+00	1.13E-11
Sr-89	4.78E+04	0.00E+00	1.37E+03	0.00E+00	0.00E+00	0.00E+00	7.66E+03
Sr-90	1.18E+06	0.00E+00	2.89E+05	0.00E+00	0.00E+00	0.00E+00	3.40E+04
Sr-91	8.79E+02	0.00E+00	3.55E+01	0.00E+00	0.00E+00	0.00E+00	4.19E+03
Sr-92	3.33E+02	0.00E+00	1.44E+01	0.00E+00	0.00E+00	0.00E+00	6.60E+03
Y-90	1.36E+00	0.00E+00	3.69E-02	0.00E+00	0.00E+00	0.00E+00	1.46E+04
Y-91m	1.30E-02	0.00E+00	5.04E-04	0.00E+00	0.00E+00	0.00E+00	3.82E-02
Y-91	2.02E+01	0.00E+00	5.39E-01	0.00E+00	0.00E+00	0.00E+00	1.11E+04
Y-92	1.21E-01	0.00E+00	3.53E-03	0.00E+00	0.00E+00	0.00E+00	2.12E+03
Y-93	3.63E-01	0.00E+00	1.06E-02	0.00E+00	0.00E+00	0.00E+00	1.22E+04
Zr-95	2.77E+00	9.88E-01	6.01E-01	0.00E+00	1.39E+00	0.00E+00	2.82E+03
Zr-97	1.53E-01	3.09E-02	1.41E-02	0.00E+00	4.67E-02	0.00E+00	9.57E+03
Nb-95	4.47E+02	2.49E+02	1.34E+02	0.00E+00	2.46E+02	0.00E+00	1.51E+06
Mo-99	0.00E+00	4.62E+02	8.79E+01	0.00E+00	1.05E+03	0.00E+00	1.07E+03
Tc-99m	2.94E-02	8.32E-02	1.06E+00	0.00E+00	1.26E+00	4.07E-02	4.92E+01
Tc-101	3.03E-02	4.36E-02	4.28E-01	0.00E+00	7.85E-01	2.23E-02	1.31E-13
Ru-103	1.98E+01	0.00E+00	6.54E+00	0.00E+00	7.57E+01	0.00E+00	2.31E+03
Ru-105	1.65E+00	0.00E+00	6.52E-01	0.00E+00	2.13E+01	0.00E+00	1.01E+03
Ru-106	2.95E+02	0.00E+00	3.73E+01	0.00E+00	5.69E+02	0.00E+00	1.91E+04
Ag-110m	1.42E+01	1.31E+01	7.80E+00	0.00E+00	2.58E+01	0.00E+00	5.36E+03
Te-125m	2.79E+03	1.01E+03	3.74E+02	8.39E+02	1.13E+04	0.00E+00	1.11E+04
Te-127m	7.05E+03	2.52E+03	8.59E+02	1.80E+03	2.86E+04	0.00E+00	2.36E+04
Te-127	1.14E+02	4.11E+01	2.48E+01	8.48E+01	4.66E+02	2.80E+00	9.03E+03
Te-129m	1.28E+04	4.47E+03	1.89E+03	4.11E+03	5.00E+04	0.00E+00	6.03E+04
Te-129	3.27E+01	1.23E+01	7.96E+00	2.51E+01	1.37E+02	0.00E+00	2.47E+01
Te-131m	1.80E+03	8.81E+02	7.34E+02	1.39E+03	8.92E+03	0.00E+00	8.74E+04
Te-131	2.05E+01	8.57E+00	6.47E+00	1.69E+01	8.99E+01	0.00E+00	2.98E+00
Te-132	2.62E+03	1.70E+03	1.59E+03	1.87E+03	1.63E+04	0.00E+00	8.02E+04
I-130	9.01E+01	2.64E+02	1.05E+02	2.25E+04	4.15E+02	0.00E+00	2.29E+02
I-131	4.96E+02	7.09E+02	4.06E+02	2.32E+05	1.22E+03	0.00E+00	1.87E+02
I-132	2.42E+01	6.47E+01	2.26E+01	2.26E+03	1.03E+02	0.00E+00	1.22E+01
I-133	1.69E+02	2.94E+02	8.97E+01	4.32E+04	5.13E+02	0.00E+00	2.64E+02
I-134	1.26E+01	3.43E+01	1.23E+01	5.94E+02	5.46E+01	0.00E+00	2.99E+02
I-135	5.28E+01	1.38E+02	5.10E+01	9.11E+03	2.22E+02	0.00E+00	1.56E+02
Cs-134	3.03E+05	7.21E+05	5.83E+05	0.00E+00	2.33E+05	7.75E+04	1.26E+04
Cs-136	3.17E+04	1.25E+05	9.01E+04	0.00E+00	6.97E+04	9.55E+03	1.42E+04
Cs-137	3.85E+05	7.31E+05	3.48E+05	0.00E+00	1.00E+05	5.99E+04	1.03E+04
Cs-138	2.69E+02	5.31E+02	2.63E+02	0.00E+00	3.90E+02	3.85E+01	6.27E+02
Ba-139	9.00E+00	6.41E+03	2.64E+01	0.00E+00	5.99E+04	3.64E+03	1.62E+01
Ba-140	1.08E+03	2.37E+00	1.23E+02	0.00E+00	8.05E+01	1.35E+02	3.88E+02
Ba-141	4.37E+00	3.30E+03	1.48E+01	0.00E+00	3.07E+03	1.87E+03	2.26E+09
Ba-142	1.99E+00	2.03E+03	1.24E+01	0.00E+00	1.72E+03	1.15E+03	2.78E+18
La-140	3.58E+01	1.80E+01	4.76E+02	0.00E+00	0.00E+00	0.00E+00	1.32E+04
La-142	1.83E+02	8.33E+03	2.07E+03	0.00E+00	0.00E+00	0.00E+00	6.08E+01
Ce-141	8.01E+01	5.42E+01	6.15E+02	0.00E+00	2.52E+01	0.00E+00	2.07E+03
Ce-143	1.41E+01	1.04E+02	1.16E+02	0.00E+00	4.60E+02	0.00E+00	3.98E+03
Ce-144	4.18E+01	1.75E+01	2.24E+00	0.00E+00	1.04E+01	0.00E+00	1.41E+04
Pr-143	1.32E+00	5.28E+01	6.52E+02	0.00E+00	3.05E+01	0.00E+00	5.77E+03
Pr-144	4.31E+03	1.79E+03	2.19E+04	0.00E+00	1.01E+03	0.00E+00	6.19E+18
Nd-147	9.00E+01	1.04E+00	6.22E+02	0.00E+00	6.08E+01	0.00E+00	4.99E+03
W-187	3.04E+02	2.55E+02	6.90E+01	0.00E+00	0.00E+00	0.00E+00	8.34E+04
Np-239	1.28E+01	1.25E+02	6.91E+03	0.00E+00	3.91E+02	0.00E+00	2.57E+03

*Calculated using equation (32) and Tables 1.2-1 and 1.2-2.

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

$$= 3.17 \times 10^{-8} \sum_i N_i \overline{X/Q} Q_i, \quad (17)$$

where:

N_i = air dose factor due to beta emissions from noble gas radionuclide i (mrad/yr per uCi/m^3) from Table 2.1-1.

2.2.2.b 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 will be calculated for the purpose of implementation of section 3.11.2.3 of the Technical Specifications as follows:

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

$$= 3.17 \times 10^{-8} \sum_{ij} R_{ij} \; W_{ij}' \; \widetilde{Q}_i', \quad (18)$$

where:

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

$$= \begin{cases} \overline{X/Q}' \text{ for inhalation and all tritium pathways} \\ \quad = 3.5 \times 10^{-6} \text{ sec/m}^3 \\ \\ \overline{D/Q}' \text{ for other pathways and non-tritium radionuclides} \\ \quad = 1.0 \times 10^{-8} \text{ m}^{-2} \end{cases}$$

(See the notes to Table 2.2-7 and 2.2-8 for the origin of these factors.)