PACIFIC GAS AND ELECTRIC COMPANY

DEPARTMENT OF NUCLEAR POWER GENERATION
DIABLO CANYON POWER PLANT

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1 AND 2

TITLE: CHEMICAL ANALYSIS PROCEDURE
OFF-SITE DOSE CALCULATIONS

APPROVED: R. C. Thornberry 2-27-87
PLANT MANAGER DATE EFFECTIVE DATE

SCOPE

This procedure describes the methodology for the following:

Effluent Type	T.S.	Technical Specification Surveillance Requirement	Implements
Liquids	4.3.3.9.1	Determination of alarm/trip set-points for RE-18, RE-23, RE-3 and RE-16	10 CFR20, App.B, Table II, Col. 2
Gases	4.3.3.10	Determination of alarm/trip setpoints for RE-22, RE-14A, 14B and RE-27	10CFR20, App.B, Table II, Col. 1
Liquids	4.11.1.1.1	Pre-release analyses of effluents	10CFR20, App. B, Table II, Col. 2
	4.11.1.1.2	Post-release analysis of effluents	
Liquids	4.11.1.2	Dose calculations	10CFR50, App. I
Liquids	4.11.1.3.1	Dose projections	10CFR50, App I.
Gases	4.11.2.1.1	Dose rate calculations, Noble Gases, Total Body and Skin	10CFR20, App. B, Table II, Col.1
Gases	4.11.2.1.2	Dose rate calculations, Iodines, Particulates and Radionuclides other than Noble Gases, per organ, per age group	10CFR20, App. B, Table II, Col. 2
Gases	4.11.2.2	Noble Gas Air Dose Calculations	10CFR50, App. I
Gases	4.11.2.3	Iodines, Particulates, and Radio-nuclides other than Noble Gases Organ Dose Calculations per age group	10CFR50, App. I
Gases	4.11.2.4.1	Noble Gases Iodines, Particulates, and Radionuclides other than Noble Gases, Dose Projection	10CFR50, App. I
Liquids and Gases	4.11.4.1 and 6.9.1.6	Cumulative Dose from: Liquids, Noble Gases Iodines; Particulates; and Radionuclides other than Noble Gases per age group, per organ	40CFR190
Direct Radiation	4.11.4.2	Direct Radiation Dose Rate and Dose Calculations to unrestricted areas due to plant and high radwaste storage sky-shine.	40CFR190

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The calculational methodology for doses are based on models and data that make it unlikely to substantially underestimate the actual exposure of an individual through any of the appropriate pathways. Tables containing the values for the various parameters used in these expressions are also included. This procedure, and any changes thereto, requires PSRC review.

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DISCUSSION

This procedure is used in support of the portion of the Appendix A Technical Specifications that deals with routine radioactive liquid and gaseous releases to the unrestricted area. Limits are based on the dose commitment to a member of the general public related to the release of radionuclides through either direct or indirect exposure (e.g. submersion in a cloud of radioactive Noble Gases, radionuclides deposited on the ground, direct radiation from radionuclides stored on site, inhalation of radionuclides or ingestion of radionuclides via a food pathway such as milk, meat, vegetable or fish, etc.).

PROCEDURE

1. Liquid Effluents

a. Dose calculation (T.S. 3.11.1.2).

The dose contributions to the total body and each individual organ (bone, liver, thyroid, kidney, lung and GI-LLI) of the maximum exposed individual (adult) for, say, m radioactive liquid releases shall be calculated for all radionuclides

identified in those m liquid effluents released to unrestricted areas using the following expression:

$$^{m}D_{\tau} = \frac{1}{300} \sum_{j=1}^{m} \frac{V_j}{F(j)} \sum_{i=1}^{n(j)} A_{i\tau} C_{ij} \qquad (1)$$

where ${}^{m}D_{\tau}$ = The cumulative dose to the total body or an organ τ from the liquid effluents for the total time covering those m releases.

$A_{i\tau}$ = Composite dose parameter for the total body or an organ τ of an adult for nuclide i, for salt water site, in mrem/hr per µCi/ml (refer to Table 1).

V_j = The volume of the jth release in gal. In the case of a batch release it is simply the volume in the batch tank released. For other releases this is the flowrate used times the actual release time.

C_{ij} = The average concentration of radionuclide i in the liquid effluent passing thru RE-18, RE-3, RE-16 or RE-23 (or from any liquid stream entering the circulating water discharge) as sampled and analyzed for in the "jth" release source, in µCi/ml.

$\frac{1}{300}$ = Product of the near field average dilution and mixing factor with 1/60 (hr/min). The applicable factor for this mixing and near field dilution during any liquid release at DCPP's site specific discharge structure to any marine organism or dose point was selected as 1/5.[1]

$F(j)$ = The total dilution water flowrate during the time of "jth" release, in gpm.

$n(j)$ = # nuclides i in "jth" release

b. Maximum Permissible Concentration (MPC) calculation (T.S. 3.11.1.1.)

1)- The MPC for the identified mixture of radionuclides in the "jth" batch of liquids is calculated as follows:

$$MPC_j = \frac{\sum_{i=1}^{n} C_{ij}}{\sum_{i=1}^{n} \frac{C_{ij}}{MPC_{ij}}}$$

[1]Refer to the FSAR, Section 11.2.8, "Dilution Factors".

where:

MPC_j = The unrestricted area total undiluted MPC for the "j^{th}" particular mixture of identified radionuclides, in µCi/ml.

MPC_{ij} = The MPC in unrestricted area water for radionuclide i, in general, in µCi/ml (from 10CFR20, Appendix B, Table II, Column 2.).

2) The overall MPC for a combination of discharges (e.g., simultaneous discharge of a batch of liquid radwaste, discharge of steam generator blowdown, discharge of oily water separator via the turbine building sump, and discharge of condensate demineralizer regenerate waste also via the turbine building sump) is calculated by reapplication of the above equation using the total concentration for the pathway and its associated MPC:

$$MPC_{overall} = \frac{\sum_{j=1}^{n} \Phi_j C_j}{\sum_{j=1}^{n} \frac{\Phi_j C_j}{MPC_j}}$$

where:

$MPC_{overall}$ = The unrestricted area MPC for the current radionuclide mixture for concurrent j discharges, in µCi/ml.

C_j = The total activity concentration for the "jth" individual stream in µCi/ml.

MPC_j = The total MPC for the "jth" individual individual mixture or stream determined as seen previously, in µCi/ml.

Φ_j = The ratio of an individual discharge "j^{th}" pathway flow rate to the sum total of all individual undiluted pathway flow rates.

c. High Alarm Set Point (HASP) Determinations (for Rad Monitors).

High Alarm Set Points are determined from the expressions in this section. These expressions enable determination of the appropriate maximum alarm setpoint for each liquid effluent pathway (i.e., liquid radwaste system, steam generator blowdown and turbine building sump effluents) conservatively taking into account not only existing and concurrent discharges, but also the improbable discharge of an imaginary batch resembling the RCS. The High Alarm Set Points are designed such that the combined total C/MPC at the point of entry into the environment (ocean in this case) will never exceed unity.

Each of the independent liquid effluent pathways to the common entry point to the environment (namely at "outfall"), are treated basically the same. There are four separate entities considered in the HASP determinations all of which introduce realistic conservatism. First, there is the effect of concurrent releases from the other possible independent liquid effluent sources. This is manifested by the so-called "dilution flowrate reduction term", ΔF, and is addressed for each separate monitor/release pathway in Appendix 1. Second using this along with the actual release per pre-release analysis, (already in progress or scheduled) there is yielded the term, $\frac{C_j}{MPC_j} \frac{F_j}{F-\Delta F_j}$ which is assembled so as to reduce the "1" (unity) of the max. allowed $\frac{C}{MPC}$ at the outfall (ocean). Third, this remainder, namely,

$1 - \frac{C_j}{MPC_j} \frac{F_j}{F-\Delta F_j}$, is then allotted to an imaginary release

from the most conservative of possible sources, namely one that is scaled in the same isotopic mix proportions as a recent RCS sampling which has been decayed 24 hours (with exception that H3 is not scaled). Also, since all liquid effluent radiation monitors are only gross gamma sensitive, then all non-gamma concentrations must be scaled according to their gamma counterparts in the same mix. Lastly, and very important, is the fact that an uncertainty factor (called "I&C uncertainty factor") from the monitor's manufacturer specifications is conservatively applied to the final calculated HASP value.

Below are the final expressions resulting from the deviations. First, some useful symbols and definitions that were used and are needed are as follows:

F_c = Main or Auxiliary seawater flow rate (in gpm).

$F = F_c + \sum_j F_j$, the total dilution water flow rate (in gpm).

In reality, F_c is always >> F_j and any concurrent sum of F_j's, so for all practical engineering purposes (i.e., HASPS, pre-release calculations, dose projections, etc.) one can approximate $F \simeq F_c$ henceforth.

F_j = Liquid effluent flowrate of "j^{th}" source prior to dilution with F_c (in gpm).

C_j = Total radionuclide concentration in the liquid effluent of "jth" source proposed for release or actually in progress. Here $C_j = \sum_i {}^jC_i$ where subscript "i' identifies the "ith" isotope per pre-release analysis (all C_j's, ${}^jC_i$'s are in µCi/ml)

MPC_j = Unrestricted area total MPC for water in the "j"th effluent source (in µCi/ml).

$$\text{Here, } MPC_j = \frac{\sum_i {}^jC_i}{\sum_i \frac{{}^jC_i}{MPC_i}}$$

OR

$$MPC_j = \left(\sum_i \frac{{}^jf_i}{MPC_i}\right)^{-1} \quad \text{with } {}^jf_i = \frac{{}^jC_i}{C_j}$$

ΔF_j = The effective "dilution flowrate reduction term" due to other liquid discharges potentially occurring at the same time (see Appendix 1).

Subscript "j" refers to the "jth" release source and takes on values b, 1, 2, 3, 4, 5 whence.

b, denotes any one of the following batch tanks EDR(2), FDR(2), CDT(2), WECT(2), SRRT(2), LHST(2).

1, denotes Unit 1's steam generator blowdown tank
2, denotes Unit 2's steam generator blowdown tank
3, denotes the Oily Water Separator Reservoir portion of the turbine building sump
4, denotes Unit 1's Cond. Demin. Regen. Sys. Waste Transfer Discharge
5, denotes Unit 2's Cond. Demin. Regen. Sys. Waste Transfer Discharge

1) Liquid Radwaste (LRW) system batch releases and the radiation monitor RE-18 (subscript "b" applies here).

$$HASP_{18}(calc) = BKGD_{18} + \frac{{}_{\gamma}k_{18}\left[\left(\frac{F-\Delta F_b}{F_b}\right) - \frac{C_b}{MPC_b} - \frac{{}^{RCS}C_{H3}}{MPC_{H3}}\right]}{\frac{1}{{}^{RCS}C'_{\gamma}} \sum_{\beta \neq H3} \frac{{}^{RCS}C_{\beta}}{MPC_{\beta}} + \frac{1}{{}^{RCS}MPC'_{\gamma}}} \quad (2)$$

$$\text{where} = {}^{RCS}MPC'_{\gamma} = \left(\sum_i \frac{{}^{RCS}_{\gamma}f'_i}{MPC_i}\right)^{-1}$$

$${}^{RCS}_{\gamma}f'_i = \frac{{}^{RCS}C_i e^{-\lambda_i(1\ day)}}{{}^{RCS}C'_{\gamma}} \quad , \quad (i = \text{gammas only})$$

$${}^{RCS}C'_{\gamma} = \sum_{\substack{i \neq H3 \\ i \neq \beta}} {}^{RCS}C_i\, e^{-\lambda_i(1\ day)} \quad \text{(see footnote * below)}$$

* The RCS sample used for the set ${}^{RCS}C_i$ in this analysis is the one (from either Unit 1 or 2 that is selected and tagged for this purpose by C&RP Engineer. The choice is based on it being most representative of the current trend on RCS samples (isotopically) and being replete with the most isotopes seen well above L.L.D. The values generated from this sample will prevail in all HASP calculations every 3 months unless otherwise dictated by the C&RP Engineer.

β(subscript) indicates the isotopes, Sr 90/Y90, Sr 89 and any other non-gamma emitter (except H3).

$$_{\gamma}k_{18} = \sum_i {}^{18}k_i \; {}^{RCS}_{\gamma}f_i{}' \qquad (k_i\text{'s are supplied from CAP D-19})$$

Lastly, from $HASP_{18}$ (calc) a usable high alarm set point is needed for the actual setting or comparing with what is already physically on the instrument (rad monitor) itself. This is called projected $HASP_{18}$ and takes into account (as said earlier) the I&C uncertainty factor correction. It is given as:

$$\text{proj. } HASP_{18} \le 10^{(\log_{10} HASP_{18}(calc) - 0.3)}$$

and must be entered on the release permit as called for in CAP A-5.

All of the above is performed automatically by the computer software per each pre-release analysis. The software also calculates a projected reading of the radiation monitor vis-a-vis the ${}^{b}C_i$ and ${}^{18}k_i$.

Generally if the proj. $HASP_{18}$ is greater than the existing setting (from previous releases) then no action is taken. That is, Operations and I&C do not have to change the $HASP_{18}$ on the monitor unless the projected reading calculation shows that, although less than proj. $HASP_{18}$, it is yet larger than the existing $HASP_{18}$. In this case the $HASP_{18}$ should be changed upward to the proj. $HASP_{18}$ so the release can be legally discharged. On the other hand should the proj. $HASP_{18}$ be less than the existing $HASP_{18}$, then the release cannot be discharged until the $HASP_{18}$ is changed to the proj. $HASP_{18}$.

2) Steam generator blowdown tank liquid discharges and the radiation monitor RE-23 for both units (subscripts "1" and "2" apply here).

$${}^{1}HASP_{23}(calc) = {}^{1}BKGD_{23} + \frac{{}^{1}_{\gamma}k_{23}\left[\left(\frac{F-\Delta F_1}{F_1}\right) - \frac{C_1}{MPC_1} - \frac{{}^{RCS}C_{H3}}{MPC_{H3}}\right]}{\frac{1}{{}^{RCS}C_{\gamma}{}'}\sum_{\beta \neq H3}\frac{{}^{RCS}C_{\beta}}{MPC_{\beta}} + \frac{1}{{}^{RCS}MPC_{\gamma}{}'}} \tag{3}$$

AND (for Unit 2)

$$^{2}HASP_{23}(calc) = {}^{2}BKGD_{23} + \frac{{}^{2}_{\gamma}k_{23}\left[\left(\frac{F-\Delta F_{2}}{F_{2}}\right) - \frac{C_{2}}{MPC_{2}} - \frac{RCS_{C_{H3}}}{MPC_{H3}}\right]}{\frac{1}{RCS_{C_{\gamma}}{}'}\sum_{\beta \neq H3}\frac{RCS_{C_{\beta}}}{MPC_{\beta}} + \frac{1}{RCS_{MPC_{\gamma}}{}'}} \qquad (4)$$

As in 1) a usable high alarm setpoint must be prepared from this final calculated value. Again this consists of applying the I&C instrument uncertainty factor. This instrument correction factor for RE-23, as supplied by the manufacturer, is simply the following product:

proj. $^{1(2)}HASP_{23} = 0.7\,^{1(2)}HASP_{23}(calc)$

This, of course, is entered on the release permit as called for in CAP A-5. Also as in 1), these calculations are performed by the computer software per each pre-release analysis along with a projected rad monitor reading (from the $^{1(2)}C_{i}$'s and $^{23}k_{i}$'s). And here as well, the same discipline as in 1) is followed, namely reset the HASP if the projected is lower than the existing, otherwise do nothing unless the existing is below what the actual release may cause the rad monitor to read, in which case reset it to the projected.

3) Oily water separator discharge and the radiation monitor RE-3 (subscript "3" applies here).

$$HASP_{3}(calc) = BKGD_{3} + \frac{{}_{\gamma}k_{3}\left[\left(\frac{F-\Delta F_{3}}{F_{3}}\right) - \frac{C_{3}}{MPC_{3}} - \frac{RCS_{C_{H3}}}{MPC_{H3}}\right]}{\frac{1}{RCS_{C_{\gamma}}{}'}\sum_{\beta \neq H3}\frac{RCS_{C_{\beta}}}{MPC_{\beta}} + \frac{1}{RCS_{MPC_{\gamma}}{}'}} \qquad (5)$$

Here, as in 1), a projected $HASP_3$ is formed as:

$$\text{Proj. } HASP_3 = 10^{(\log_{10} HASP_3 - 0.3)}$$

This is the I&C uncertainty factor correction. This projected $HASP_3$ is then entered as called for in CAP A-5 on release permits. Also, the same discipline for resetting, as seen in 1) and 2) above, applies here for RE-3.

4) Condensate demineralizer regenerant system waste transfer discharges for Unit 1 and 2 and radiation monitors RE-16 for both units (subscripts "4" and "5" apply here).

$$^{1}HASP_{16}(\text{calc}) = {}^{1}BKGD_{16} + \frac{{}^{1}_{\gamma}k_{16}\left[\left(\frac{F-\Delta F_4}{F_4}\right) - \frac{C_4}{MPC_4} - \frac{RCS_{C_{H3}}}{MPC_{H3}}\right]}{\frac{1}{RCS_{C_\gamma}'} \sum_{\beta \neq H3} \frac{RCS_{C_\beta}}{MPC_\beta} + \frac{1}{RCS_{MPC_\gamma}'}} \qquad (6)$$

AND

$$^{2}HASP_{16}(\text{calc}) = {}^{2}BKGD_{16} + \frac{{}^{2}_{\gamma}k_{16}\left[\left(\frac{F-\Delta F_5}{F_5}\right) - \frac{C_5}{MPC_5} - \frac{RCS_{C_{H3}}}{MPC_{H3}}\right]}{\frac{1}{RCS_{C_\gamma}'} \sum_{\beta \neq H3} \frac{RCS_{C_\beta}}{MPC_\beta} + \frac{1}{RCS_{MPC_\gamma}'}} \qquad (7)$$

Here, as above, one performs the I&C uncertainty factor correction to yield a projected HASP and then enters this on the release form per CAP A-5 along with the same discipline on resetting as for RE-18, 3, and 23.

d. Dose Projection (T.S. 4.11.1.3.1 and T.S. 4.11.1.3.3)

Dose projections for the categories of calculated total body exposure and organ exposure are recorded at least once per 31 days. The period over which projections are made is 31 days. The calculations are also made prior to each release to satisfy T.S. 4.11.1.3.3

The purpose of this is to determine if appropriate treatment of liquid radioactive materials in relation to maintaining releases "as low as reasonably achievable", is necessary.

Projections will in any case be recorded on the last working day of each month with attention to the Technical Specification frequency requirement contained in Section 4.11.1.3.1.

The projected dose is calculated by application of equation (8) below. The following guidance of default flowrates is provided, where appropriate when using equation (8).

1) Maximum Rated Flowrates (for default use)

   a) Chemical Drain Tanks (26 gpm).

   b) Laundry Waste Tanks (13 gpm).

   c) Floor Drain Receiver Tanks (35 gpm).

   d) Waste Concentrator Condensate Tanks (60 gpm).

   e) Equipment Drain Receiver Tanks (36 gpm).

   f) Steam Generator Blowdown, both-units, (150 gpm).

   g) Spent Regenerant Receiver Tanks (70 gpm).

   h) Oily Water Separator (Turbine Building Sump) (100 gpm).

   i) Condensate Demin. Regen. Sys. Waste Transfer Discharge Line, Unit 1, (Max 240 gpm).

   j) Condensate Demin. Regen. Sys. Waste Transfer Discharge Line, Unit 2, (Max 240 gpm).

Using the form of equation (1), define

${}_{(0,1,2)}^{j'}d_{\tau} \equiv$ Dose to organ "τ" by proposed "j^{th}" release from either both units in common "(0)", unit "(1)" or unit "(2)" using pre-release sample analysis for C_{ij}; along with rated flowrate for pump in stream of "j^{th}" release (namely F_j'), and maximum time, Δt_j (max) envisioned for release period (with $V_j' = F_j' \Delta t_j$ (max)) or V_j = maximum capacity of tank for "j^{th}" release. That is,

$$ {}_{(0,1,2)}^{j'}d_{\tau} = \frac{1}{300} \frac{V_j'}{F(j)} \sum_{i=1}^{n(j)} A_{i\tau} C_{ij} $$

Here the F(j) depends on the circ. water flowrate to be used $F_C(j)$ at the time of the "j^{th}" discharge

With ${}_{(0,1,2)}^{pm}D_{\tau}$ defined as the total dose to organ τ covering all the "m" (post) releases occuring in the previous month of "T" days and ${}_{(0,1,2)}d_{\tau}$ defined as the total dose delivered to organ τ by all releases occurring for the "t" days of the present month, one has the definition of the 31 day dose projection as:

$$ {}_{(0,1,2)}^{31\ day}D_{\tau} = 31 \frac{{}_{(0,1,2)}^{pm}D_{\tau} + {}_{(0,1,2)}d_{\tau} + {}_{(0,1,2)}^{j'}d_{\tau}}{T + t} \quad (8) $$

2. Gaseous Effluents

In view of the more instantaneous impact of gaseous releases, a variety of calculational disciplines is necessitated. Each calculational method (herein described in detail) is dedicated wholly to a specific Technical Specification or purpose and consequently must be totally comprehensive toward that goal even though some of the equations and their constituents appear repeated or very similar.

a. Noble gases (exists as a unique pathway dose and applies equally to all age groups when tissue doses are calculated).

1) Release rate limit of Noble Gases (Tech. Spec. 3.11.2.1.). This discipline is primarily used in determining gaseous effluent rad monitor high alarm setpoints and pre-batch release decision criteria. The release rate limit for the noble gases is determined in accordance with the following expressions:

$$\sum_{i=1}^{n} (K_i)\ (\overline{X/Q}_i)\ (\dot{Q}_i) \leq 500 \text{ mrem/yr} \quad (9)$$

$$\sum_{i=1}^{n} (L_i + 1.1M_i)\ (\overline{X/Q})\ (\dot{Q}_i) \leq 3000 \text{ mrem/yr} \quad (10)$$

where:

K_i = The total body dose factor due to gamma emissions for each identified noble gas radionuclide, in mrem/yr per $\mu Ci/m^3$ (from Table 2).

L_i = The skin dose factor due to beta emissions for each identified noble gas radionuclide, in mrem/yr per $\mu Ci/m^3$ (from Table 2).

M_i = The air dose factor due to gamma emissions for each identified noble gas radionuclide, in mrad/yr per $\mu Ci/m^3$ (from Table 2). Unit conversions constant of 1.1 mrem/mrad converts air dose to skin dose.

$(\overline{X/Q})$ = The "controlling"[1] historical five year running average meteorological diffusion dispersing factor, in sec/m^3. This is almost always the highest amongst the past five year running averages of hourly X/Q's for the candidate dose recipient locations in any land sector area at or beyond the unrestricted area boundary (See Table 6). It is based on the five years of data just previous to the current year but always updated each calendar year (by dropping the fifth year back and adding the current year's data - See Table 5A). X/Q's used here are from the Gaussian plume model (Reg. Guide 1.111), in $\frac{sec}{m^3}$

1 See the explanation on controlling in section 2.c.

$\dot{Q}_i$ = The release rate of radionuclide i, in gaseous effluents from all release points at the site, in µCi/sec. This is generated from radiochemical analyses and effluent rad monitor scaling data plus flow rates (plant vent, etc.). See discussion following $\tilde{Q}_i$ below.

2) Air dose in unrestricted areas due to noble gases (T.S. 3.11.2.2 and T.S. 3.11.2.4).

The air dose in unrestricted areas due to noble gases released in gaseous effluents shall be calculated in accordance with the following expressions:

$$D_{a\gamma} = 3.17E\text{-}8 \sum_{i=1}^{n} M_i \, [(X/Q)\tilde{Q}_i] \qquad (11)$$

$$D_{a\beta} = 3.17E\text{-}8 \sum_{i=1}^{n} N_i \, [(X/Q)\tilde{Q}_i] \qquad (12)$$

where:

$D_{a\gamma}$ = The set of air doses due to gamma emissions for all identified noble gas radionuclides, in mrad, calculated for each of the site boundary center-of-sector locations (land sector) or any other candidate hypothetical individual dose recipient in the unrestricted area during time Δt.

$D_{a\beta}$ = The set of air doses due to beta emissions for all identified noble gas radionuclides, in mrad, calculated for each of the site boundary center-of-sector locations (land sector), or any other candidate hypothetical individual dose recipient in the unrestricted area during time Δt.

3.17E-8 = The reciprocal of the number of seconds in a year.

(X/Q) = The "set" of real time hourly average X/Q's for each of the site boundary center-of-sector (land) locations or any other candidate hypothetical individual dose recipient location in the unrestricted area (See Table 6). The first contingency level values to use in the event of Met Tower Data collection failure are the set of $\overline{X/Q}$'s generated for 2.a.1) above preferably from Table 5A. X/Q's used here are from the Gaussian plume model (Reg. Guide 1.111), in $\frac{sec}{m^3}$

N_i = The air dose factor due to beta emission for each identified noble gas radionuclide, in mrad/yr per µCi/m³ (from Table 2).

At this junction its well to point out, that aside from satisfying the Tech. Spec. 3.11.2.2, the gamma air dose of 2.a.2) will always provide for all noble gases a suitably conservative (approximately + 5%) surrogate to the whole body external tissue dose to individuals. Furthermore, with the exception of the extremely short half-lived noble gases of Kr-88 and Xe-135M, (which in all probability will never dominate the isotopic constituency of any release), indirectly, the beta air dose of 2a.2), with its Tech. Spec. 4.11.2.2 never exceeded, will also (vis-a-vis Tech. Spec. 4.11.2.1.1), ensure a safe surrogate for the skin dose to individuals. At all candidate dose recipient locations which are not recognized by the annual land use census as being locations for real individuals (residences, farms, etc.) but where individuals could hypothetically exist (e.g., site boundary), then the gamma and beta air dose calculations can serve as surrogates to the external whole body and skin tissue doses.

3) External tissue dose to real individuals in unrestricted areas due to noble gases (Tech. Spec. 4.11.4.1 and 6.9.1.6). The whole body and skin doses to real individuals in unrestricted areas due to noble gases released in gaseous effluents shall be calculated in accordance with the following expressions:

$$D_{wb} = 3.17E-8 \sum_{i=1}^{n} K_i \; [(X/Q)\bar{Q}_i] \quad (11a)$$

$$D_{sk} = 3.17E-8 \sum_{i=1}^{n} (L_i + 1.1M_i) \; [(X/Q)\bar{Q}_i] \quad (12a)$$

where:

D_{wb} = The set of external whole body tissue doses from all identified noble gas radionuclides in mrem, calculated for each of the candidate real individual dose recipients in the unrestricted areas during period Δt.

D_{sk} = The set of external skin doses from all identified noble gas radionuclides, in mrem, calculated for each of the candidate real individual dose recipients in the unrestricted area during period Δt.

(X/Q) = The set of real time hourly average X/Q's for each of the candidate real individual dose recipient locations in the unrestricted area (e.g., residences, farms, etc., based on the annual land use census). (See Table 6.) The first contingency level values to use in the event of Met Tower Data collection failure are the set of $\overline{X/Q}$'s generated for 2.a.1) above, preferably from Table 5A. X/Q's used here are from the Gaussian plume model (Reg. Guide 1.111). It is noteworthy here to also mention that the X/Q's calculated here are for real individuals as opposed to those hypothetical individuals of 2.a.2) and include all off-center-line (from plume or wind direction) contributions using $y \leq 2\sigma_y$ as the consideration cut-off criteria, in $\frac{sec}{m^3}$

$\bar{Q}_i$ = The average release of noble gas radionuclides in μCi over time period Δt. This entity is a product of a release rate $\dot{Q}_i$ and a release time, Δt. Normally Δt = 1 hour (or less) so as to be compatible with the computer's hour-by-hour "real time" dose calculation which depends on a matching hourly average X/Q from the Met Data. $\dot{Q}_i$ comes from the product of a release vent's concentration, C_i, and flowrate F (plant vent and/or steam generator blowdown tank vent) information during Δt. C_i results from a detailed grab sample isotopic analysis as scaled by ratios of the attendant effluent rad monitor's gross readings for the periods Δt that occur out of sequence or in between the grab sampling times.

Should the plant vent grab samples indicate less than LLD or the rad monitors fail to register detection when a known batch release is in progress (e.g., containment purge or G.D.T. release), however short Δt, then if a more measurable and reliable C_i^* (directly sampled from the batch source) can be made and scaled by batch-to-vent flowrate ratios to give the appropriate C_i, then it should be pursued. Should the release's Δt be less than 1 hour and within the hourly clock time that X/Q represents, then the X/Q for that hour will prevail for Δt's period. Any Δt greater than 1 hour or with any other span (< 1 hr.) that overlaps the regular hourly clock time that X/Q represents (wherein X/Q changes but C_i is constant), then separate fractioning of the Δt should occur to yield the correspondingly different $\bar{Q}_i$ that coincides with the X/Q changes.

b. Radioiodines, radioactive materials in particulate form and radionuclides other than noble gases.

In contrast to the calculational methodology just seen in 2.a. for the external doses (and dose rates) from noble gases, the methods utilized here are quite different and more complex with the exception of the "ground plane" deposition pathway dose, which is also an external dose and similar to the noble gases (but considers only the whole body and not the skin). Doses (and dose rates) other than "ground plane", delivered here are strictly internal and are segregated according to intake pathway as well as age group. Furthermore, while noble gases (and "ground plane" iodines, particulates, and tritium - I.P.T.) essentially dose only the two organs, namely whole body and skin, here seven major radiation sensitive organs of the body are considered, namely: bone, liver, total body, thyroid, kidney, lung and GI-LLI tract. The internal intake pathways are four (aside from the external ground plane mentioned) in number, with one being inhalation, which is X/Q (diffusion dispersing factor) dependent and the other three being food ingestion pathways, which are D/Q (deposition dispersing factor) dependent (as is ground plane). The three food ingestion pathways in this case are, namely:

foliage-to-cow-to-milk-to-human;
foliage-to-animal-to-meat-to-human;
and vegetable-to-human.

Finally, the four age groups considered here are respectively: infant, child, teen and adult (see Reg. Guide 1.109 and NUREG 0133). The infant is subjected to only the inhalation, cow-milk and ground plane pathways by the assumption of not being old enough to consume meats and vegetables.

For each of the radionuclides, intake pathways, age groups, and organs affected, their dose (and dose rate) factors are given in Tables 3A through 3P, and are to be used in the equations which follow below.

To add to the complexity and in deference to the hour-by-hour "real time" pace set by the noble gas chronology of dose archiving, the real time matching X/Q's and D/Q's used here must be recalled, in "flash-back" fashion, from temporary storage by the computer. This is necessary since at the present time, and until an upgrading on the gaseous effluent iodine and particulate rad monitoring system occurs, the existing effluent rad monitors, are not being used to scale with their ratio of readings the in between hour-by-hour periods for knowledge on isotopic concentrations in the release quantities (as is provided from the noble gas grab sampling and analysis). Tritium analysis plus gamma isotopic analyses on iodine and particulates are normally conducted on a week-to-week basis and daily (at best) from spot grab sampling or composite sampling. Consequently, the C_i's which generate the $\dot{Q}_i$'s and $\tilde{Q}_i$'s used in the expressions below, must be fractionated or pro-rated according to the Δt's when F (vent flowrate), or X/Q, (or D/Q) change. Certainly the Strontium's (Sr-90 and Sr-89) mandate this with their quarterly composite sampling and analysis period. Additionally, this facilitates dose projection requirements and their calculations. Since a "previous" period's pre-release analysis for some specific $\dot{Q}_i$'s can be substituted with the current X/Q's (or D/Q's) and later purged with the aid of the stored knowledge on these X/Q's (or D/Q's) until the post-release analysis data becomes available.

1) Release rate limit (T.S. 3.11.2.1).

This discipline is primarily used in determining rad monitor high alarm setpoints and batch pre-release decision criteria. The release rate limit for all radioiodines and radioactive materials in particulate form and radionuclides other than noble gases is determined in accordance with the following expression:

$$\sum_{i=1}^{n} (a)P_i^{(\rho)(o)} [\overline{W}\, \dot{Q}_i] \leq 1500 \text{ mrem/yr} \qquad (13)$$

where:

${}^{(\rho)}_{(a)}P_i^{(o)}$ = The dose factor for gaseous radionuclides (trailing subscript "i") other than noble gases. The dose factors are based on organ (trailing superscript "(o)", age group (leading subscript "(a)") and pathway (leading superscript "(ρ)"). For the inhalation pathway, ${}^{inh}_{(a)}P_i^{(o)}$; the units are in [mrem/yr per μCi/m³]. For the ground plane pathway, ${}^{gp}P_i$; the cow-milk pathway, ${}^{cm}_{(a)}P_i^{(o)}$; the meat-animal pathway , ${}^{ma}_{(a)}P_i^{(o)}$; and vegetable pathway ${}^{v}_{(a)}P_i^{(o)}$; the units are in [m²-mrem/yr per μCi/m³]. Refer to Tables 3A through 3N and Table 3P.

$\overline{W}$ = The "controlling"[1] historical five year running average meteorological dispersion factor for the candidate dose recipient locations in any land sector at or beyond the unrestricted area boundary.

$\overline{W} = \overline{X/Q}$ $[\frac{sec}{m^3}]$ for the inhalation pathway. (refer to Table 5A.)

[1] See the explanation on controlling in 2.c. which follows.

$\overline{W} = \overline{D/Q}$ [m^{-2}] for any food and ground plane pathway (refer to Table 5B.) (See also definition in 2.b.2) below)

The same logic for obtaining this average (both $\overline{X/Q}$ and $\overline{D/Q}$) is that is explained in 2.a.1)'s definition on the $\overline{X/Q}$ for noble gases there. Remember the $\overline{X/Q}$ values used here, in 2a.1), and seen in Table 5A come from the five year running average of hour-by-hour X/Q's archived for each of the candidate dose recipient locations (See Table 6). For all X/Q's generating the average $\overline{X/Q}$ at real individual dose recipient location (e.g., residence, farm, etc.), included are the off-center-line contributions mentioned in 2.a.3).

$\dot{Q}_i$ = See definition under 2.a.1).

2) Doses in the unrestricted are due to radioiodines, radioactive materials in particulate form and radioactive materials other than noble gases (T.S. 3.11.2.3, T.S. 3.11.2.4, T.S. 4.11.4.1, and T.S. 6.9.1.6).

The dose to an individual from radioiodines, radioactive materials in particulate form and radioactive materials other than noble gases shall be calculated in accordance with the following expression:

$$ {}^{(p)\,(o)}_{(a)}D = 3.17E\text{-}8 \sum_{i=1}^{n} {}^{(p)\,(o)}_{(a)}R_i \; \overline{W} \; \dot{Q}_i \qquad (14) $$

where:

$(\rho)(o)(a)R_i$ = The dose factor for each identified gaseous radionuclides (trailing subscript "i") other than noble gases. The dose factors here are identical to the "P_i" dose factors given in the definition 2.b.1). That is, $(\rho)(o)(a)P_i \equiv (\rho)(o)(a)R_i$

except for the "ground plane" pathway, where

$^{gp}P_i \neq {}^{gp}R_i$. Refer to Tables 3A through 3N and Table 3O. The units here are

[mrem/yr per µCi/m³] or
[m² mrem/yr per µCi/sec]

W = The "set" of "real time" hourly average dispersion factors for all of the candidate dose recipient locations in the unrestricted area.

W = X/Q [sec/m³] diffusion dispersion factor for the inhalation pathway (Refer to definition in 2.a.2) and 2.a.3), also see 2.b.1) above).

W = D/Q [m⁻²] deposition dispersion factor for any food and ground plane pathway.

The D/Q values are extracted from Fig. 6, Reg. Guide 1.111 for each candidate dose recipient location's downwind distance from the plant. The only other variables for dependency in this are wind direction and location's arc length normal to the plant's direction. For site boundary and other hypothetical or virtual individual locations this latter is simply the sector's (22½°) arc length at its particular distance. For real individual locations (e.g., residences and farms) the arc length is, arbitrarily chosen as, 1½ times the max property width normal to the plant's direction. This arc also determines the cut off for the frequency distribution of wind directions to that particular real-individual dose recipient location.

$\tilde{Q}_i$ = The average release of radionuclides, radioactive airborne particulates, and gaseous radionuclides other than noble gases in the gaseous effluents [in μCi] over time period Δt. This entity is structured similarly to the definition in 2.a.2) and 2.a.3). The principle exception being, as explained above in 2.b., is that, unlike for the noble gases, these radionuclide releases do not use the attendant rad monitor ratio of readings (i.e. real time to sample time) to scale the C_i values for periods of Δt in between sampling and analysis. As explained above at 2.b., this makes for a preferred lengthy prorating or fractionation on the C_i's, which are assumed constant over the much shorter hour-by-hour Δt's or the Δt's when F (vent flowrate) or W (dispersion factor) is subject to a change. The week-to-week, or month-to-month, or quarter-to-quarter (in case of the strontiums) composite analyses mandate this.

$_{(a)}^{(p)\,(o)}D$ = The set of internal doses (plus the lone external dose from the "ground plane" pathway) per pathway, per age group, per principal organ (of that age group) from all identified non-noble gas airborne radionuclides, in mrem, calculated for each of the candidate individual (real, hypothetical, or virtual - See 2.c. below) dose recipients in the unrestricted area during period Δt.

c. Gaseous effluents' candidate dose recipients (and locations).

Much reference in 2.a. and 2.b. above, was made to the so called "candidate dose recipient" locations. These are particular site specific geographical locations in land areas of the unrestricted area between (or at) the site boundary and a 5 mile circular perimeter around the plant site. Particular to these locations are positions where a maximum exposed individual might in all probability exist without benefit of licensee control. These are labeled candidate dose recipients simply because of the higher probability and the fact that the random wind with its meteorological dispersion makes the final decision on who, when, and how much gets dosed. For obvious reasons, the site boundary provides part of this set of locations. However, the Annual Land Use Census dictates the ultimate locations. Here an extensive survey, locates the residences, farms and other institutions where real individuals may exist along with information on their occupation factors, property dimensions, and potential pathways for doses.

Conveniently the areas for these locations are divided into the 22½° land sectors between site boundary and the 5 mile outer limit. Finally, reasonableness or common sense probability with implicit guiding by NUREG 0543 tempers the final selection of "candidates". For example, the individual that wanders to the site boundary daily from a nearby town only to inhale and be externally exposed is unlikely to also drink the milk from the imaginary cows at 5 miles. Similarly the child living at 4½ miles in the N sector while inhaling and simultaneously ingesting cattle meat on his property probably does not eat vegetables grown on the farm in the ESE sector, and so on.

From the land use census, only the closest-to-the-plant residence per sector was selected. Since information as to the ages of the residents (or their visiting relatives) was not garnered, then conservatively all age groups must be assumed to live year-round at the residences.

Furthermore, specific to the site the following is assumed to exist:

1) Meat cattle for marketing are assumed to be able to graze right up to site boundary in all land sectors. This generates the newly defined "degraded" hierarchy of dose recipients called the "virtual" individual. Degraded in the sense that the only, but most probable, dose received is via the meat ingestion pathway (for all age groups except infants).

2) The vegetable farm in the ESE sector while possessing virtual individuals of the type defined in 2.c.1), above, (but for vegetables in place of meat), do indeed have real individuals. These are migrant farm workers who in all probability spend 12 hours per work day there with their entire family and more than likely take home vegetables grown there and cattle meat from there. For this reason, this is treated conservatively as a real individual residence for all age groups possessing meat animals and a vegetable garden.

3) While each residence is assumed to have its meat animals or vegetable gardens confined within their property boundary the one exception is the residence in the NNW sector at 1½ miles where its meat animals can graze right up to the site boundary in both the N and NNW sectors.

4) At the site boundary another form of "degraded" hierarchy of dose recipients is now defined, namely the "hypothetical" individual. Degraded here in the sense that the land use census does not recognize this individual as a bonafide real individual residing there with property to enclose meat animals, vegetable gardens, and such. Reasonableness assumes however that this type of individual could wander daily to the site boundary and receive the external doses from the nobles along with ground plane external doses from the non-nobles and only the inhalation internal dose from the non-nobles (applies to all age groups). Here the gamma air and beta air doses serve as a surrogate to the noble external doses.

5) Thus far the land use census indicates no milk cows within the 5 mile perimeter. However, the utility has conservatively assumed imaginary milk cows can exist at or beyond 5 miles in all land sectors for which the milk can be marketed for consumption. This then generates the third virtual individual as in 2.c.1) or 2.c.2), above, but constrained this time to only the cow-milk ingestion pathway for all age groups (generally the infant predominates).

6) Finally for all categories of individual dose recipients described above in 2.c.1) through 2.c.5), for their respective locations, an occupational factor of one "1" is assumed with exception of the real individuals (all age groups) at the vegetable farm in the ESE sector, namely in 2.c.2), and only in the case of the noble gas, ground plane and inhalation pathways (non-noble) there. In that exception, for the external noble gas (whole body and skin) dose along with the non-noble ground plane and internal non-noble inhalation pathway doses there, a one half (0.5) occupancy factor is assumed.

In usage of the equations of 2.a. and more notably 2.b., when computing an individual's dose (or dose rate), it only makes sense to ultimately sum up over the individual's (any age group) dose pathways, where permitted, at each of the candidate dose recipient locations. It is this summing for a max over these different pathways of doses (i.e., for each age group's organs, etc.) at each location, whether during only a Δt, daily, weekly, quarterly or annually, that eventually determines the so called controlling candidate (with max dose) and hence "controlling" location in that time period (e.g., site boundary nobles in NW sector; or nobles plus non-nobles for the real child at residence in E sector because of bone dose; or virtual-cow-milk-infant at 5 miles in NNW sector because of thyroid dose; etc.). For reason that the meteorological conditions may change over or in between any Δt, but most certainly between any week, month or quarter, then these summations of dose (or dose rate) entities dictate that any of the candidate dose recipient locations can at sometime, (certainly, some month or some quarter) be the "controlling" (max dosed) location. Table 8 indicates the existing land-use-census-based selection of candidate dose recipient locations and is subject to change anytime but is usually determined annually.

d. Gaseous effluents contingency levels for "real-time" calculation of doses (and dose rates).

Normally the dose (and dose rate) information for all candidate dose recipients shall be calculated hour-by-hour, twenty-four hours per day, 365 days per year using the equations of 2.a. and 2.b. on the data gathered from the radiochemical analyses, rad monitors and met tower's computer and all performed on the HP 1000. In the event of temporary unavailability of certain systems feeding this "train", certain "default" plans of calculation operation must be pursued. Most important of these concerns the met tower and HP-1000.

1) Met tower data ("real-time" hourly averages) - Unavailability.

Here the computer software is instructed to use the historical average met data from Tables 5.

2) HP-1000 - Unavailability

Here the HP 9845 computer is instructed to take over with the use of the data from Tables 4A and 4B. Since the factors for use in the equations of 2.a. (Table 2) are never the complexity of those used in 2.b., Tables 4A and 4B represent the conservative degeneration of the dose factors of Tables 3A to 3P into the single columns of a "super" age group - "critical" organ factor per pathway per nuclide. These were selected out of Tables 3A to 3P as being the maximum factor out of the age groups and in turn amongst the organs for each pathway and nuclide.

3) Met Tower data and HP-1000 - Unavailability

Here contingency level 2.d.1) and 2.d.2) are jointly pursued.

4) HP 1000 and HP 9845 - unavailability

Calculations by hand where possible, will be conducted on the most significant nuclides reported from radiochemical analyses along with the use of met data from Tables 5A and 5B, and dose factors from Table2 and Tables 4A and 4B. Use of forms 69-10387 and 69-10388 from CAP A-6 will be used in such situations (See CAP A-6).

e. Gaseous effluents, alarm setpoint determinations

1) Plant vent noble gas monitor, RE-14A and RE-14B

The channel high alarm is to be set no higher than a count rate which corresponds to the maximum permissible dose rate at the "controlling" locations, usually the boundary of the restricted area (site boundary), which is 500 mrem/yr (250 mrem/yr-2 plant operator) for total body exposure and 3000 mrem/yr (1500 mrem/yr-2 plant operator) for skin exposure. Each unit constitutes a release source, and each is therefore allotted one-half[1] the limiting condition for annual dose.

To calculate the high alarm setpoint, it is necessary to establish the release rate limit, and then working "backwards", calculate the corresponding max concentration in the plant vent. Once this concentration is known, the corresponding count rate can be calculated using the channel sensitivity value or k_i values relating count rate to isotopic activity concentration.

First, the release rate limit is determined using equations (9) and (10), the more restrictive release rate (of the two) being used for establishing the alarm point. Then calculate the concentrations corresponding to the limiting release rate using the expression

$$^{Max}C_i = \frac{^{Max}\dot{Q}_i}{472F_{pv}} \qquad (15)$$

[1] The fraction one-half is selected for convenience. Each unit's release may be proportioned differently as long as the site dose max limitations are met.

where:

${}^{Max}C_i$ = the max allowable concentration of radionuclide i, in μCi/ml

F_{pv} = the flow rate in the plant vent in ft³/min.

472 = a conversion constant, ml/sec per ft³/min.

For normal operation, the value used for F_{pv} can be as high as 220,000 ft³/min (two auxiliary building exhaust fans and two fuel handling building exhaust fans in operation) or one half that value.

The unadjusted high alarm set point is then determined as follows:

$$\text{High Alarm Set Point (HASP in cpm)} \leq k_{RE14}\,{}^{Max}C_T + \text{Bkg cpm} \qquad (16)$$

where:

k_{RE14} = the pressure-drop-corrected* gross channel sensitivity to typical mixtures, in cpm per μCi/ml ($\sum_i k_i\, C_i/C_T$)

${}^{Max}C_T$ = the total max allowable concentration of noble gas activity, in μCi/ml ($\sum_i {}^{Max}C_i$) per equation (9) or (10).

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* Due to the friction pressure head loss in the long sampling tube plus the drop across the filter paper of the plant vent particulate monitor, (RE-28) in tandem with RE-14, there exists a density reduction in RE-14's measuring chamber. This reduced radioactivity concentration as sampled from the plant vent must necessarily impose a correction to RE-14's reading so as to yield an accurate measure (by RE-14) of what's being released by the plant vent. This pressure drop (between RE-14's chamber and the outside atmosphere is gauged at the chamber and is called ΔP. The corrected k value for RE-14 is then $k_{RE14} = \dfrac{P_{atm} - \Delta P}{P_{atm}}\, k_{RE14}$ (uncorrected).

This entity is expounded upon again in Appendix 2.

Now this final calculated value must have applied to it the so-called I&C uncertainty factor adjustment to compensate for the statistical bounce and drift of the actual radiation monitor. This is called the projected $HASP_{14}$ and is given as $10^{(\log_{10} HASP_{14} - 0.3)}$ as per mfg. specs. This then is what is actually set on the monitor.

2) Gas decay tank monitor, RE-22

The high alarm setpoint for RE-22 is determined in similar fashion as for RE-14A and RE-14B except for the pressure correction. The desired condition is to have RE-22 alarm (and thereby trip the release isolation valve (RCV-17) at a release rate which is no higher than that required to cause alarm of RE-14A and B given the added concentration of radioactivity from the gas decay tank to that already in the plant vent.

First, determine the release rate limit on the basis of the "f_i's", resulting from the projected release of gas decay tanks, being added to the normal plant vent noble gas activity concentration, using equations (9) and (10). This net result must now be converted to the corresponding concentration in the undiluted pathway by multiplying by the ratio of the plant vent flow rate to the gas decay tank release flow rate (normally, approximately 31 scfm). This represents the limiting concentration passing through RE-22, and the high alarm setpoint is determined as similarly prescribed above for RE-14. This entity is also expounded upon again in Appendix 2.

There is no pressure correction here (as with RE-14) since the sampling line is short and there is no filter in between, however the same I&C uncertainty factor correction is applied as with RE-14. This then is what's set on the monitor.

3) Steam generator blowdown tank vent monitor, RE-27

The site boundary dose contribution for releases from this independent pathway during normal operation are expected to be a very small fraction of the dose contribution resulting from releases via the plant vent. For purposes of establishing the high alarm setpoint on RE-27, use as a basis release rates such that the dose contribution from this pathway will not exceed one percent of the maximum limits on dose rates due to noble gases, that is, 5 mrem/year to the total body and 30 mrem/year to the skin. For two-unit operation, one-half of these values should be allotted to each unit.

First, determine the release rate limit for typical mixtures, using equations (9) and (10), but with the reduced doses described above. Next, calculate the corresponding activity concentration which flows through RE-27. Note that a concentrating effect of gaseous activity occurs in the blowdown tank vent because virtually all of the gaseous activity is carried out by only about one-third of the water mass which had entered the blowdown tank. Use the following expression to determine the activity concentration flowing through RE-27:

$$C_t = \frac{\dot{Q}_t}{(R)W_1} \qquad (17)$$

where:

C_t = the total activity concentration in RE-27, in μCi/gram

$\dot{Q}_t$ = the activity release rate, in μCi/sec

W_1 = the total steam generator blowdown flow rate from all steam generators, in grams/sec

R = the fraction of the blowdown which flashes to (R = 0.32, for most of the time, assuming that the inlet temperature is ~ 490°F).

The high alarm setpoint is established using a similar relationship as described above for RE-14 and RE-22. As with RE-22 there is no pressure correction, however, there is the I&C uncertainty and it is given a little differently as: proj. $HASP_{27} = 0.7\ HASP_{27}(calc)$. This then is what is set on the monitor. The value used for C_t should not exceed 0.015 μCi/gram, considered as dose equivalent I-131, because this is the implied concentration in the blowdown tank vent when the secondary coolant is at its technical specification limit of 0.10 μ/Ci/gram dose equivalent I-131.

f. Gaseous effluents dose projections (T.S. 3.11.2.4)

Dose projections for the categories of calculated air dose due to noble gases to the controlling location and calculated dose to the controlling individual due to radioiodines, radioactive materials in particulate form and radionuclides other than noble gases are made at least once per 31 days. Projections will normally be made on the last working day of each month, with attention to the technical specification frequency requirement contained in section 4.11.2.4.1.

The projected doses are calculated by application of equation (11), (11a), (12), (12a), or (14), as appropriate, using estimated releases from expected releases from Gas Decay Tanks, Containment Purges, and building ventilation exhaust.

The projected doses, whether from GDT, containment venting (or purging), and plant vent continuous releases, could contain interim portions of the calculations (performed by the computer's "real time" software package) based on pre-batch release data or a previous periods composite analyses' data. And, in almost every instance, a scaling is involved by the ratio of 31 days to the number of days in the current quarter added to the previous quarter all multiplied by the sum of last quarter's max dose to the max doses accrued and calculated to date thus far this quarter. At any rate, this always ends up stored in the instantaneous running archive of doses (by computer). These "interim" dose calculations after use for projection purposes must eventually be purged and replaced with "correct" dose portions based on actual days involved i.e. update or post-release analysis data on batches, and concurrent data from the composites.

3. Direct Radiation (T.S. 4.11.4.2)

Direct radiation from the plant site to the unrestricted area is composed of two principal components, namely line-of-site (or primary) radiation and sky-shine (or secondary scattered) radiation. For significant distances the latter component becomes quite dominant.

At Diablo Canyon Power Plant, being a P.W.R., turbine building shine (in contrast to B.W.R.'s) is all but non-existent. Likewise the containment structures being so thickly shielded, never become the major sources for direct radiation. The most likely candidates for any measurable source of direct radiation to the unrestricted area are the cask liners and drums holding the radioactively hot spent resins; filter beds; evaporator sludges; etc., which are slurried with concrete and compacted for high radwaste storage. The high radwaste storage bunkers themselves, although heavily shielded, for storing these casks, drums, etc., do represent the only continuous low level source of direct radiation. The most probable time for concern in calculating doses or dose rates due to direct radiation is during the preparation and transportation (to the bunkers from the Auxiliary building) of the casks, drums, beds, etc. of radwaste.

Two basic assumptions are made in the following expressions used for calculating dose rates and the doses. One, is that, since the nearest unrestricted area (i.e. closest site boundary) location is 800 meters (or greater) away, and the bunker rooms, cask liners, and drums are < 10' or 15' in dimension, then all sources will be assumed point sources. This allows at least two significant figure confidence on dose and dose rate calculations. Secondly the "sky-shine" or scattered radiation is assumed spherical rather than hemispherical about the source. That is the ground is conservatively assumed to be a perfect mirror to the radiation. In that which follows the so-called "build-up" factor, B, accounts for the sky-shine contribution whereas the

$e^{-\mu r}/r^2$ term accounts for the line-of-sight contribution.

a. Dose rate calculations (air dose rate only).

1) When isotopic concentrations of unshielded directly exposed sources are known.

$$\dot{D}\ (R/hr) = \frac{156}{r^2} \sum_i C_i \sum_j E_{ij} \left[\frac{\gamma_j}{d_i}\right] \mu'_{a_j} B_{ij} e^{-\mu'_{o_j} r} \qquad (18)$$

where:

r = distance from source (i.e. open cask, open drum or exposed source) on site to point of interest for calculating dose rates in unrestricted area, in meters

C_i = number of curies of isotope "i" in source.

E_{ij} = gamma energy, in Mev, of j gamma decay scheme in the ith isotope

$\left[\frac{\gamma_j}{d_i}\right]$ = pure number of gamma decays in j^{th} decay scheme per disintegration of the i^{th} isotope

156 = units compatibility constant

μ'_{o_j} = existing total gamma attenuation coefficient for air, in meters $^{-1}$ - a function of E_{ij}

μ'_{a_j} = existing total gamma absorption coefficient for air, in meters $^{-1}$ (Note: $\mu_a = \sigma_a \rho_{air}$ with

$\sigma_a = \sigma_{photo\ elect} + \sigma_{compt.\ abs} + \sigma_{pair\ prod}$)

- a function of E_{ij}

$$B_{ij} = 1 + r\mu'_{s_j}\left(1 + \frac{\bar{\mu}'_{s_j}}{\mu'_{a_j}}\right) \quad \text{(Ref 7)} \qquad (19)$$

μ'_{s_j} = existing compton scatteringcoefficient for air in meters $^{-1}$ -a function of E_{ij}

$$\mu_0' = \mu'_a + \mu'_s \tag{20}$$

$$\mu' \text{ (any subscript)} = \mu \text{ (any subscript)} \frac{P}{P_0} \frac{T_0}{T} \tag{21}$$

P = existing press. (atm, mmHg, etc.)

T = existing temp. (°R, °K)

P_0, T_0 = S.T.P. (i.e. 760 mm, 273°K etc.)

From the curves in Ref. 7 and Ref. 8, the following expressions were empirically curve fitted (any subscript).

$$\mu_a(m^{-1}) = 0.001e^{[1.34-0.105(\ln(10E)-1.57)^2]} \tag{22}$$

$$\mu_s(m^{-1}) = 0.001e^{[3.10-0.089(\ln(10E)+1.89)^2]} \tag{23}$$

<u>NOTE:</u> (22) and (23) are accurate within ± 10% for 0.1Mev<E<2.5 Mev.

2) When isotopic concentrations are not known but, C_T, the total concentration, is known along with an effective $\bar{E}$ (gamma) (external to the source) per disintegration also known, equation (18) becomes:

$$\dot{D}(R/hr) = \frac{156}{r^2(m)} C_T \text{ (curies) } \bar{E}(\text{Mev}) \; \mu_a'(\bar{E}) \; B(\bar{E}) e^{-\mu_0'(\bar{E})r} \tag{24}$$

$$\text{where: } B = 1 + r\mu_s'(\bar{E}) \left[1 + \frac{\mu_s'(\bar{E})}{\mu_a'(\bar{E})} \right] \tag{25}$$

Here equations (20), (21), (22) and (23) are repeated for $\bar{E}$ here.

3) When no isotopic or total concentrations are known, but rather $\bar{E}$ (gamma external) is known plus a up-close survey meter reading (at some close distance r_o), i.e., $\dot{D}(r_o)$ in R/hr, is known. Such is the case for an

enclosed source (already in cask, drum, or storage

bunker) behind shielding with an effective $\bar{E}$ (known) in Mev. (Note: $r >> r_o$), then:

$$\dot{D}(R/hr) = \left(\frac{r_o}{r}\right)^2 \quad \dot{D}(r_o) \quad B(\bar{E})e^{-\mu'_o(\bar{E})r} \qquad (26)'$$

(NOTE: The buildup factor, $B(r_o)$ times the

attenuation, $e^{-\mu' r_o}$, for r_o(<10 meter) ~ 1)

where: equations (20), (21), (22), (23) and (25) are used here also.

4) Examples:

Example 1.

i = Cs-137

j = 1

E_{ij} = 0.662 Mev

$\left[\frac{Y_j}{d_i}\right]$ = 0.9

T = 289° K (16°C or 66°F)

P = 1 atm

r = 800 meters

$C_i = \bar{2}$ curies

B calculates to = 13.45

whereas:

$e^{-\mu'_j r}$ calculates to 0.000522 Then: $\dot{D}$ = 7.3E-9 R/hr

Example 2.

$\overline{E}$ = 0.662 (Mev)
P = 1 atm
r_o = 1 meter

T = 289°
r = 800 meters

$\dot{D}$ (r_o) = 2.0 R/hr

B calculates to = 13.45 and again

$e^{-\mu'_o(\overline{E})r}$ calculates to 0.000522 Thus: $\dot{D}$ = 2.19E-8 R/hr

b. Dose Calculation (air dose only). Here we simply calculate the dose rate by equations (18), (24), or (26) and multiply by the recorded time, Δt.

$$D(R) = \dot{D}\ (R/hr)\ \Delta t(hr) \quad (27)$$

1) Continuous

Δt = 1 yr = 365 days = 8760 hrs

2) When processing and moving radwaste for storage in the high radwaste storage area, the radwaste foreman's records for this processing and moving time is used for Δt. Equation (27) is applied and the dose archived and summed to previous such doses.

3) Example: 2 curies of Cs-137 are lying on ground directly exposed for continuously direct radiation to site boundary 800 meters away neglecting decay.

D = 6.4E-5 Rads = 0.064 mrads 0.064 mrems annually

4. Uranium Fuel Cycle Cumulative Dose (T.S. 3.11.4)

The cumulative dose off-site to any member of the public due to radioactive releases is determined by summing the calculated doses from the following as appropriate.

a. Liquids, using equation (1). Usually this is not added to b, c, or d below.

b. Noble gases, using equations (11) and (12) or (11a) and (12a).

c. Iodines and particulates, and radionuclides other than noble gases, using equation (14).

d. Direct radiation from 3. using equation (27).

5. On-site dose calculations to any member of the public due to (their) activity inside the site boundary (T.S. 6.9.1.6).

Although the main body of this procedure is dedicated primarily to off-site dose calculations, with the demarcation between off-site and on-site being the site boundary, in some instances the methodology used for off-site can be used for on-site calculations. However, there are limitations to the expressions used and these will be delineated in that which follows.

Particular to this site are situations where on occasions some member of the public are allowed within the site boundary but only in the owner controlled area up to the protected area boundary. Although this area is considered under license control, because of situations usually so transient, film badging, TLDs, dosimeters and such are not felt necessary. Nonetheless, dose calculations will be made according to this section to satisfy this licensee control. The most prevalent or frequent members of the public are: tour participants to the simulator (training building) or bio-lab, policemen to the shooting range (most frequent); ranch hands driving cattle through from adjacent properties; and American Indians visiting ancient onsite burial grounds (closest to plant). Doses due to liquid releases are too improbable, hence not calculated for here. However, doses due to gaseous releases and direct radiation are considered. Of course, of prime concern are the time and distances involved. There are limitations on these distances used, however. For gaseous releases the doses are calculated using equations (11a), (12a) and (14) with the R_i's in (14) confined to the inhalation and ground plane pathways, and furthermore excluding the infant age group. The major distance limitation here is where the X/Q and D/Q dispersion factors breakdown mathematically. These values are obtained by extrapolating linearly backwards the logarithms of the most proximate site boundary (S.B.) values (dispersion factor versus distance) and some other known location (loc.) to the appropriate distance onsite. That is:

$$\log [X/Q \text{ (or } D/Q]_{onsite} =$$

$$\frac{\log [X/Q \text{ (or } D/Q]_{S.B.} - \log [X/Q(\text{or} D/Q]_{loc.}}{\log (\text{dist.S.B.}) - \log (\text{dist.loc.})} [\log (\text{dist.onsite}) - \log (\text{dist.S.B.}] + \log [X/Q(\text{or}D/Q)]_{S.B.}$$

Considering Reg. Guide 1.111's figure bounds and DCPP's site specific "building wake" correction factors, the distance limitations for which the mathematical expressions can be expected to be reasonably reliable are for distances greater than (>) 200 meters.

Likewise for direct radiation, the doses are calculated using equations (18) through (27). Here the storage of solid radwastes is assumed a point source although finite source dimensions of approximately 15' to 20' do certainly exist. For field point dose calculations less than (<) 100 meters away, an error would start showing up in those equations.

Consequently 200 meters away from the plant's (both units) centroid and the storage bunkers is arbitrarily selected as the closest perimeter for which onsite doses will be calculated with reasonable reliability using the ODCP equations.

Fortunately, the types of the members-of-the-public onsite described above, at worst, barely approach that 200 meter limit. Below is a table describing the type of onsite member-of-the-public expected at DCPP, the sectors and closest distances in which they may visit and finally their average expected visitation times (based on Security Dept. information).

	ONSITE MEMBER OF THE PUBLIC	SECTOR OF VISITATION	CLOSEST POINT OF APPROACH TO PLANT	AVERAGE EXPECTED VISITATION TIME PER YEAR
(1)	Police at shooting range	SE	700m	208 hours
(2)	Tour Participants			
	(a) Simulator Bldg	S (SE)	310m	4 hours
	(b) Bio Lab	SSE (SE)	460m	6 hours
	(c) Overlook	E	210m	1 hours
(3)	American Indians at burial grounds	NW NNW	200m 200m	96 hours 96 hours
(4)	Ranch hands driving cattle around site	NW NNW N NNE NE	250m 350m 320m 450m 630m	1 hour 1 hour 1 hour 1 hour 1 hour

TABLE 1

COMPOSITE DOSE FACTOR, $A_{i\tau}$, FOR ADULTS, SALTWATER SITE

(mrem/hour per μCi/ml)

NUCLIDE	T. BODY	THYROID	KIDNEY	LUNG	GI-LLI	BONE	LIVER
H 3	2.82E-01	2.82E-01	2.82E-01	2.82E-01	2.82E-01	NO DATA	2.82E-01
Be 7	6.52E+01	NO DATA	NO DATA	NO DATA	2.61E+02	2.61E+01	NO DATA
C 14	2.90E 03	2.90E 03	2.90E 03	2.90E 03	2.90E 03	1.45E 04	2.90E 03
Na 24	4.57E-01	4.57E-01	4.57E-01	4.57E-01	4.57E-01	4.57E-01	4.57E-01
P 32	6.45E 05	NO DATA	NO DATA	NO DATA	1.88E 06	1.67E 07	1.04E 06
Cr 51	5.58E 00	3.34E 00	1.23E 00	7.40E 00	1.40E 03	NO DATA	NO DATA
Mn 54	1.35E 03	NO DATA	2.10E 03	NO DATA	2.16E 04	NO DATA	7.06E 03
Mn 56	3.15E 01	NO DATA	2.26E 02	NO DATA	5.67E 03	NO DATA	1.78E 02
Fe 55	8.23E 03	NO DATA	NO DATA	1.97E 04	2.03E 04	5.11E 04	3.53E 04
Fe 59	7.27E 04	NO DATA	NO DATA	5.30E 04	6.32E 05	8.06E 04	1.90E 05
Co 57	2.36E 02	NO DATA	NO DATA	NO DATA	3.59E 03	NO DATA	1.42E 02
Co 58	1.35E 03	NO DATA	NO DATA	NO DATA	1.22E 04	NO DATA	6.03E 02
Co 60	3.82E 03	NO DATA	NO DATA	NO DATA	3.25E 04	NO DATA	1.73E 03
Ni 63	1.67E 03	NO DATA	NO DATA	NO DATA	7.18E 02	4.96E 04	3.44E 03
Ni 65	1.20E 01	NO DATA	NO DATA	NO DATA	6.65E 02	2.02E 02	2.62E 01
Cu 64	1.01E 02	NO DATA	5.40E 02	NO DATA	1.83E 04	NO DATA	2.14E 02
Zn 65	2.32E 05	NO DATA	3.43E 05	NO DATA	3.23E 05	1.61E 05	5.13E 05
Zn 69	4.56E 01	NO DATA	4.26E 02	NO DATA	9.85E 01	3.43E 02	6.56E 02
As 76	3.94E 03	NO DATA	7.86E 03	NO DATA	7.86E 06	NO DATA	4.71E 03
Br 82	4.07E 00	NO DATA	NO DATA	NO DATA	4.66E 00	NO DATA	NO DATA
Br 83	7.25E-02	NO DATA	NO DATA	NO DATA	1.04E-01	NO DATA	NO DATA
Br 84	9.40E-02	NO DATA	NO DATA	NO DATA	7.38E-07	NO DATA	NO DATA
Br 85	3.86E-03	NO DATA	NO DATA	NO DATA	1.80E-18	NO DATA	NO DATA
Rb 86	2.91E 02	NO DATA	NO DATA	NO DATA	1.23E 02	NO DATA	6.24E 02
Rb 88	9.49E-01	NO DATA	NO DATA	NO DATA	2.47E-11	NO DATA	1.79E 00
Rb 89	8.34E-01	NO DATA	NO DATA	NO DATA	6.89E-14	NO DATA	1.19E 00
Sr 89	1.43E 02	NO DATA	NO DATA	NO DATA	8.00E 02	4.99E 03	NO DATA
Sr 90	3.01E 04	NO DATA	NO DATA	NO DATA	3.55E 03	1.23E 05	NO DATA
SR 91	3.71E 00	NO DATA	NO DATA	NO DATA	4.37E 02	9.18E 01	NO DATA
Sr 92	1.51E 00	NO DATA	NO DATA	NO DATA	6.90E 02	3.48E 01	NO DATA
Y 90	1.25E-01	NO DATA	NO DATA	NO DATA	6.42E 04	6.06E 00	NO DATA
Y 91M	2.22E-03	NO DATA	NO DATA	NO DATA	1.68E-01	5.73E-02	NO DATA
Y 91	2.37E 00	NO DATA	NO DATA	NO DATA	4.89E 04	8.88E 01	NO DATA
Y 92	1.56E-02	NO DATA	NO DATA	NO DATA	9.32E 03	5.32E-01	NO DATA
Y 93	4.66E-02	NO DATA	NO DATA	NO DATA	5.35E 04	1.69E 00	NO DATA
Zr 95	3.46E 00	NO DATA	8.02E 00	NO DATA	1.62E 04	1.59E 01	5.11E 00
Zr 97	8.13E-02	NO DATA	2.68E-01	NO DATA	5.51E 04	8.81E-01	1.78E-01
Nb 95	1.34E 02	NO DATA	2.46E 02	NO DATA	1.51E 06	4.47E 02	2.49E 02
Mo 99	2.43E 01	NO DATA	2.89E 02	NO DATA	2.96E 02	NO DATA	1.28E 02
Tc 99M	4.66E-01	NO DATA	5.56E-01	1.79E-02	2.17E 01	1.30E-02	3.66E-02

TABLE 1 - (Continued)

NUCLIDE	T. BODY	THYROID	KIDNEY	LUNG	GI-LLI	BONE	LIVER
Tc101	1.88E-01	NO DATA	3.46E-01	9.81E-03	5.77E-14	1.33E-02	1.92E-02
Ru103	4.60E 01	NO DATA	4.07E 02	NO DATA	1.25E 04	1.07E 02	NO DATA
Ru105	3.51E 00	NO DATA	1.15E 02	NO DATA	5.44E 03	8.89E 00	NO DATA
Ru106	2.01E 02	NO DATA	3.06E 03	NO DATA	1.03E 05	1.59E 03	NO DATA
Ag110M	8.45E 02	NO DATA	2.80E 03	NO DATA	5.80E 05	1.54E 03	1.42E 03
Sn113	4.28E 03	1.82E 03	NO DATA	NO DATA	3.10E 05	7.66E 04	2.83E 03
Cd115	6.12E 02	NO DATA	1.13E 04	NO DATA	9.39E 06	NO DATA	1.56E 04
Sn117M	2.02E 04	NO DATA	NO DATA	NO DATA	2.26E 05	NO DATA	NO DATA
Sb122	5.98E 00	2.70E-01	NO DATA	1.07E 01	6.72E 03	1.07E 01	5.37E-01
Sb124	1.09E 02	6.70E-01	NO DATA	2.15E 02	7.84E 03	2.76E 02	5.22E 00
Sb125	4.20E 01	1.79E-01	NO DATA	1.36E 02	1.94E 03	1.77E 02	1.97E 00
Te125M	2.91E 01	6.52E 01	8.82E 02	NO DATA	8.66E 02	2.17E 02	7.86E 01
Te127M	6.68E 01	1.40E 02	2.23E 03	NO DATA	1.84E 03	5.48E 02	1.96E 02
Te127	1.93E 00	6.60E 00	3.63E 01	NO DATA	7.03E 02	8.90E 00	3.20E 00
Te129M	1.47E 02	3.20E 02	3.89E 03	NO DATA	4.69E 03	9.31E 02	3.47E 02
Te129	6.19E-01	1.95E 00	1.07E 01	NO DATA	1.92E 00	2.54E 00	9.55E-01
Te131M	5.71E 01	1.08E 02	6.94E 02	NO DATA	6.80E 03	1.40E 02	6.85E 01
Te131	5.03E-01	1.31E 00	6.99E 00	NO DATA	2.26E-01	1.59E 00	6.66E-01
Te132	1.24E 02	1.46E 02	1.27E 03	NO DATA	6.24E 03	2.04E 02	1.32E 02
I 130	4.61E 01	9.91E 03	1.82E 02	NO DATA	1.01E 02	3.96E 01	1.17E 02
I 131	1.79E 02	1.02E 05	5.35E 02	NO DATA	8.23E 01	2.18E 02	3.12E 02
I 132	9.96E 00	9.96E 02	4.54E 01	NO DATA	5.35E 00	1.06E 01	2.85E 01
I 133	3.95E 01	1.90E 04	2.26E 02	NO DATA	1.16E 02	7.45E 01	1.30E 02
I 134	5.40E 00	2.62E 02	2.40E 01	NO DATA	1.32E-02	5.56E 00	1.51E 01
I 135	2.24E 01	4.01E 03	9.75E 01	NO DATA	6.87E 01	2.32E 01	6.08E 01
Cs134	1.33E 04	NO DATA	5.27E 03	1.75E 03	2.85E 02	6.84E 03	1.63E 04
Cs136	2.04E 03	NO DATA	1.57E 03	2.16E 02	3.21E 02	7.16E 02	2.83E 03
Cs137	7.85E 03	NO DATA	4.07E 03	1.35E 03	2.32E 02	8.77E 03	1.20E 04
Cs138	5.94E 00	NO DATA	8.81E 00	8.70E-01	5.12E-05	6.07E 00	1.20E 01
Ce139	3.81E 02	NO DATA	NO DATA	NO DATA	3.25E 03	NO DATA	NO DATA
Ba139	2.30E-01	NO DATA	5.23E-03	3.17E-03	1.39E 01	7.85E 00	5.59E-03
Ba140	1.08E 02	NO DATA	7.02E-01	1.18E 00	3.38E 03	1.64E 03	2.06E 00
Ba141	1.29E-01	NO DATA	2.68E-03	1.63E-03	1.80E-09	3.32E 00	2.88E-03
Ba142	1.08E-01	NO DATA	1.50E-03	1.00E-03	2.43E-18	1.72E 00	1.77E-03
La140	2.10E-01	NO DATA	NO DATA	NO DATA	5.83E 04	1.57E 00	7.94E-01
La142	9.13E-03	NO DATA	NO DATA	NO DATA	2.68E 02	8.06E-02	3.67E-02
Ce141	2.63E-01	NO DATA	1.08E 00	NO DATA	8.86E 03	3.43E 00	2.32E 00
Ce143	4.94E-02	NO DATA	1.97E-01	NO DATA	1.67E 04	6.04E-01	4.46E 02
Ce144	9.59E 00	NO DATA	4.43E 01	NO DATA	6.04E 04	1.79E 02	7.47E 01
Pr143	2.87E-01	NO DATA	1.34E 00	NO DATA	2.54E 04	5.79E 00	2.32E 00
Pr144	9.64E-04	NO DATA	4.44E-03	NO DATA	2.73E-09	1.90E-02	7.87E-03
Nd147	2.74E-01	NO DATA	2.68E 00	NO DATA	2.20E 04	3.96E 00	4.58E 00
W187	2.68E 00	NO DATA	NO DATA	NO DATA	2.51E 03	9.16E 00	7.66E 00
Np239	1.91E-03	NO DATA	1.08E-02	NO DATA	7.11E 02	3.53E-02	3.47E-03

TABLE 2

DOSE FACTORS FOR NOBLE GASES AND DAUGHTERS[1]

Radionuclide	Total Body Dose Factor K_i (mrem/yr per μCi/m³)	Skin Dose Factor L_i (mrem/yr per μCi/m³)	Gamma Air Dose Factor M_i (mrad/yr per μCi/m³)	Beta Air Dose Factor N_i (mrad/yr per μCi/m³)
Kr-83m	7.56E-02	----	1.93E+01	2.88E+02
Kr-85m	1.17E+03	1.46E+03	1.23E+03	1.97E+03
Kr-85	1.61E+01	1.34E+03	1.72E+01	1.95E+03
Kr-87	5.92E+03	9.73E+03	6.17E+03	1.03E+04
Kr-88	1.47E+04	2.37E+03	1.52E+04	2.93E+03
Kr-89	1.66E+04	1.01E+04	1.73E+04	1.06E+04
Kr-90	1.56E+04	7.29E+03	1.63E+04	7.83E+03
Xe-131m	9.15E+01	4.76E+02	1.56E+02	1.11E+03
Xe-133m	2.51E+02	9.94E+02	3.27E+02	1.48E+03
Xe-133	2.94E+02	3.06E+02	3.53E+02	1.05E+03
Xe-135m	3.12E+03	7.11E+02	3.36E+03	7.39E+02
Xe-135	1.81E+03	1.86E+03	1.92E+03	2.46E+03
Xe-137	1.42E+03	1.22E+04	1.51E+03	1.27E+04
Xe-138	8.83E+03	4.13E+03	9.21E+03	4.75E+03
AR-41	8.84E+03	2.69E+03	9.30E+03	3.28E+03

1. From Table B-1 of Regulatory Guide 1.109 (Rev. 1, Oct. 1977)

TABLE 3A
DOSE PARAMETERS[1], R_i OR P_i, FOR RADIOIODINES, RADIOACTIVE PARTICULATES, AND ANY RADIONUCLIDE OTHER THAN NOBLE GAS, GASEOUS EFFLUENTS, INFANT AGE GROUP, INHALATION PATHWAY
ORGAN (mrem/yr per μCi/m³)

RADIONUCLIDE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
1. H-3[2]	0.000E+00	6.468E+02	6.468E+02	6.468E+02	6.468E+02	6.468E+02	6.468E+02
2. C-14[2]	2.646E+04	5.306E+03	5.306E+03	5.306E+03	5.306E+03	5.306E+03	5.306E+03
3. CR-51	0.000E+00	0.000E+00	8.946E+01	5.754E+01	1.323E+01	1.284E+04	3.570E+02
4. MN-54	0.000E+00	2.534E+04	4.984E+03	0.000E+00	4.984E+03	9.996E+05	7.056E+03
5. FE-59	1.357E+04	2.352E+04	9.478E+03	0.000E+00	0.000E+00	1.015E+06	2.478E+04
6. CO-58	0.000E+00	1.219E+03	1.820E+03	0.000E+00	0.000E+00	7.770E+05	1.113E+04
7. CO-60	0.000E+00	8.022E+03	1.177E+04	0.000E+00	0.000E+00	4.508E+06	3.192E+04
8. ZN-65	1.932E+04	6.258E+04	3.108E+04	0.000E+00	3.248E+04	6.468E+05	5.138E+04
9. RB-86	0.000E+00	1.904E+05	8.820E+04	0.000E+00	0.000E+00	0.000E+00	3.038E+03
10. SR-89	3.976E+05	0.000E+00	1.141E+04	0.000E+00	0.000E+00	2.030E+06	6.398E+04
11. SR-90/Y90	4.088E+07	0.000E+00	2.590E+06	0.000E+00	0.000E+00	1.151E+07	2.351E+05
12. Y-91	5.880E+05	0.000E+00	1.568E+04	0.000E+00	0.000E+00	2.453E+06	7.263E+04
13. ZR-95	1.154E+05	2.786E+04	2.030E+04	0.000E+00	3.108E+04	1.750E+06	2.170E+04
14. NB-95	1.568E+04	6.426E+03	3.780E+03	0.000E+00	4.718E+03	4.788E+05	1.267E+04
15. RU-103	2.016E+03	0.000E+00	6.790E+02	0.000E+00	4.242E+03	5.516E+05	1.610E+04
16. RU-106	8.680E+04	0.000E+00	1.088E+04	0.000E+00	1.065E+05	1.156E+07	1.638E+05
17. AG-110M	9.982E+03	7.224E+03	4.998E+03	0.000E+00	1.092E+04	3.668E+06	3.304E+04
18. CD-115/115M	0.000E+00	2.433E+05	8.712E+03	0.000E+00	1.368E+05	2.199E+06	1.336E+03
19. SB-124	3.794E+04	5.558E+02	1.198E+04	1.005E+02	0.000E+00	2.646E+06	5.908E+04
20. SB-125	5.166E+04	4.774E+02	1.089E+04	6.230E+01	0.000E+00	1.638E+06	1.470E+04
21. TE-129M	1.414E+04	6.090E+03	2.226E+03	5.474E+03	3.178E+04	1.680E+06	6.902E+04
22. I-131	3.794E+04	4.438E+04	1.960E+04	1.484E+07	5.180E+04	0.000E+00	1.058E+03
23. I-133	1.324E+04	1.918E+04	5.600E+03	3.556E+06	2.240E+04	0.000E+00	2.156E+03
24. CS-134	3.962E+05	7.028E+05	7.448E+04	0.000E+00	1.904E+05	7.966E+04	1.334E+03
25. CS-136	4.830E+04	1.345E+05	5.292E+04	0.000E+00	5.642E+04	1.176E+04	1.428E+03
26. CS-137	5.488E+05	6.118E+05	4.550E+04	0.000E+00	1.722E+05	7.126E+04	1.334E+03
27. BA-140	5.600E+04	5.600E+01	2.898E+03	0.000E+00	1.343E+01	1.596E+06	3.836E+04
28. CE-141	2.772E+04	1.666E+04	1.988E+03	0.000E+00	5.250E+03	5.166E+05	2.156E+04
29. CE-144	3.192E+06	1.211E+06	1.764E+05	0.000E+00	5.376E+05	9.842E+06	1.484E+05
30. ND-147	7.938E+03	8.134E+03	4.998E+02	0.000E+00	3.150E+03	3.220E+05	3.122E+04

[1] Values for the dose parameters for all pathways are calculated by the PGandE "Tech. Spec." Code and based on Reg. Guide 1.109 or NUREG 0133.

[2] For Tritium and Carbon 14, the units of the dose parameters are mrem/yr per μCi/m³ for all pathways, and they must be multiplied by X/Q.

TABLE 3B
DOSE PARAMETERS[1], R_i OR P_i, FOR RADIOIODINES, RADIOACTIVE PARTICULATES, AND ANY RADIONUCLIDE OTHER THAN NOBLE GAS, GASEOUS EFFLUENTS, INFANT AGE GROUP, COW MILK PATHWAY
ORGAN (m^2 mrem/yr per μCi/sec)

RADIONUCLIDE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
1. H-3[2]	0.000E+00	2.382E+03	2.382E+03	2.382E+03	2.382E+03	2.382E+03	2.382E+03
2. C-14[2]	3.226E+06	6.888E+05	6.888E+05	6.888E+05	6.888E+05	6.888E+05	6.888E+05
3. CR-51	0.000E+00	0.000E+00	1.441E+05	9.328E+04	2.054E+04	1.829E+05	4.201E+06
4. MN-54	0.000E+00	3.111E+07	7.051E+06	0.000E+00	6.895E+06	0.000E+00	1.143E+07
5. FE-59	1.929E+08	3.369E+08	1.328E+08	0.000E+00	0.000E+00	9.957E+07	1.609E+08
6. CO-58	0.000E+00	2.018E+07	5.034E+07	0.000E+00	0.000E+00	0.000E+00	5.029E+07
7. CO-60	0.000E+00	6.984E+07	1.649E+08	0.000E+00	0.000E+00	0.000E+00	1.662E+08
8. ZN-65	4.998E+09	1.714E+10	7.905E+09	0.000E+00	8.313E+09	0.000E+00	1.448E+10
9. RB-86	0.000E+00	2.072E+10	1.024E+10	0.000E+00	0.000E+00	0.000E+00	5.302E+08
10. SR-89	1.077E+10	0.000E+00	3.089E+08	0.000E+00	0.000E+00	0.000E+00	2.214E+08
11. SR-90/Y90	1.009E+11	0.000E+00	2.570E+10	0.000E+00	0.000E+00	0.000E+00	1.915E+09
12. Y-91	6.172E+04	0.000E+00	1.644E+03	0.000E+00	0.000E+00	0.000E+00	4.424E+06
13. ZR-95	5.706E+03	1.390E+03	9.860E+02	0.000E+00	1.498E+03	0.000E+00	6.924E+05
14. NB-95	5.193E+05	2.139E+05	1.237E+05	0.000E+00	1.534E+05	0.000E+00	1.806E+08
15. RU-103	7.544E+03	0.000E+00	2.523E+03	0.000E+00	1.570E+04	0.000E+00	9.175E+04
16. RU-106	1.533E+05	0.000E+00	1.915E+04	0.000E+00	1.813E+05	0.000E+00	1.164E+06
17. AG-110M	3.217E+08	2.348E+08	1.554E+08	0.000E+00	3.359E+08	0.000E+00	1.218E+10
18. CD-115/115M	0.000E+00	9.053E+06	3.148E+05	0.000E+00	4.720E+06	0.000E+00	5.654E+07
19. SB-124	1.759E+08	2.589E+06	5.448E+07	4.668E+05	0.000E+00	1.101E+08	5.424E+08
20. SB-125	1.180E+08	1.142E+06	2.427E+07	1.477E+05	0.000E+00	7.406E+07	1.573E+08
21. TE-129M	5.271E+08	1.808E+08	8.117E+07	2.024E+08	1.318E+09	0.000E+00	3.147E+08
22. I-131	1.337E+09	1.576E+09	6.929E+08	5.178E+11	1.840E+09	0.000E+00	5.625E+07
23. I-133	1.817E+07	2.646E+07	7.749E+06	4.812E+09	3.111E+07	0.000E+00	4.478E+06
24. CS-134	2.873E+10	5.357E+10	5.410E+09	0.000E+00	1.379E+10	5.654E+09	1.455E+08
25. CS-136	1.872E+09	5.529E+09	2.064E+09	0.000E+00	2.204E+09	4.505E+08	8.346E+07
26. CS-137	4.155E+10	4.864E+10	3.447E+09	0.000E+00	1.306E+10	5.286E+09	1.520E+08
27. BA-140	2.304E+08	2.304E+05	1.187E+07	0.000E+00	5.470E+04	1.415E+05	5.659E+07
28. CE-141	3.818E+04	2.329E+04	2.741E+03	0.000E+00	7.181E+03	0.000E+00	1.203E+07
29. CE-144	1.838E+06	7.524E+05	1.030E+05	0.000E+00	3.040E+05	0.000E+00	1.055E+08
30. ND-147	8.569E+02	8.801E+02	5.392E+01	0.000E+00	3.393E+02	0.000E+00	5.578E+05

[1] Values for the dose parameters for all pathways are calculated by the PGandE "Tech. Spec." Code and based on Reg. Guide 1.109 or NUREG 0133.

[2] For Tritium and Carbon 14, the units of the dose parameters are mrem/yr per μCi/m^3 for all pathways, and they must be multiplied by X/Q.

TABLE 3C

DOSE PARAMETERS[1], R_i OR P_i, FOR RADIOIODINES, RADIOACTIVE PARTICULATES, AND ANY RADIONUCLIDE OTHER THAN NOBLE GAS, GASEOUS EFFLUENTS, CHILD AGE GROUP, INHALATION PATHWAY

ORGAN (mrem/yr per μCi/m³)

RADIONUCLIDE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
1. H-3[2]	0.000E+00	1.125E+03	1.125E+03	1.125E+03	1.125E+03	1.125E+03	1.125E+03
2. C-14[2]	3.589E+04	6.734E+03	6.734E+03	6.734E+03	6.734E+03	6.734E+03	6.734E+03
3. CR-51	0.000E+00	0.000E+00	1.543E+02	8.547E+01	2.431E+01	1.698E+04	1.084E+03
4. MN-54	0.000E+00	4.292E+04	9.509E+03	0.000E+00	1.003E+04	1.576E+06	2.290E+04
5. FE-59	2.068E+04	3.345E+04	1.669E+04	0.000E+00	0.000E+00	1.269E+06	7.067E+04
6. CO-58	0.000E+00	1.772E+03	3.164E+03	0.000E+00	0.000E+00	1.106E+06	3.437E+04
7. CO-60	0.000E+00	1.314E+04	2.264E+04	0.000E+00	0.000E+00	7.067E+06	9.620E+04
8. ZN-65	4.255E+04	1.132E+05	7.030E+04	0.000E+00	7.141E+04	9.953E+05	1.632E+04
9. RB-86	0.000E+00	1.983E+05	1.143E+05	0.000E+00	0.000E+00	0.000E+00	7.992E+03
10. SR-89	5.994E+05	0.000E+00	1.724E+04	0.000E+00	0.000E+00	2.157E+06	1.672E+05
11. SR-90/Y90	1.010E+08	0.000E+00	6.438E+06	0.000E+00	0.000E+00	1.502E+07	6.113E+05
12. Y-91	9.139E+05	0.000E+00	2.438E+04	0.000E+00	0.000E+00	2.629E+06	1.856E+05
13. ZR-95	1.898E+05	4.181E+04	3.700E+04	0.000E+00	5.957E+04	2.231E+06	6.105E+04
14. NB-95	2.350E+04	9.176E+03	[illegible].549E+03	0.000E+00	8.621E+03	6.142E+05	3.700E+04
15. RU-103	2.794E+03	0.000E+00	1.073E+03	0.000E+00	7.030E+03	6.623E+05	4.477E+04
16. RU-106	1.362E+05	0.000E+00	1.691E+04	0.000E+00	1.839E+05	1.432E+07	4.292E+05
17. AG-110M	1.687E+04	1.140E+04	9.139E+03	0.000E+00	2.124E+04	5.476E+06	1.003E+05
18. CD-115/115M	0.000E+00	2.927E+05	1.260E+04	0.000E+00	2.202E+05	2.305E+06	3.474E+05
19. SB-124	5.735E+04	7.400E+02	2.002E+04	1.262E+02	0.000E+00	3.241E+06	1.639E+05
20. SB-125	9.842E+04	7.585E+02	2.068E+04	9.102E+01	0.000E+00	2.320E+06	4.033E+04
21. TE-129M	1.920E+04	6.845E+03	3.041E+03	6.327E+03	5.032E+04	1.761E+06	1.817E+05
22. I-131	4.810E+04	4.810E+04	2.727E+04	1.624E+07	7.881E+04	0.000E+00	2.842E+04
23. I-133	1.658E+04	2.031E+04	7.696E+03	3.848E+06	3.378E+04	0.000E+00	5.476E+03
24. CS-134	6.512E+05	1.014E+06	2.246E+05	0.000E+00	3.304E+05	1.210E+05	3.848E+03
25. CS-136	6.512E+04	1.709E+05	1.162E+05	0.000E+00	9.546E+04	1.454E+04	4.181E+03
26. CS-137	9.065E+05	8.251E+05	1.284E+05	0.000E+00	2.823E+05	1.040E+05	3.619E+03
27. BA-140	7.400E+04	6.475E+01	4.329E+03	0.000E+00	2.113E+01	1.743E+06	1.018E+05
28. CE-141	3.922E+04	1.954E+04	2.897E+03	0.000E+00	8.547E+03	5.439E+05	5.661E+04
29. CE-144	6.771E+06	2.116E+06	3.615E+05	0.000E+00	1.173E+06	1.195E+07	3.885E+05
30. ND-147	1.080E+04	8.732E+03	6.808E+02	0.000E+00	4.810E+03	3.282E+05	8.214E+04

[1] Values for the dose parameters for all pathways are calculated by the PGandE "Tech. Spec." Code and based on Reg. Guide 1.109 or NUREG 0133.

[2] For Tritium and Carbon 14, the units of the dose parameters are mrem/yr per μCi/m³ for all pathways, and they must be multiplied by X/Q.

TABLE 3D

DOSE PARAMETERS[1], R_i OR P_i, FOR RADIOIODINES, RADIOACTIVE PARTICULATES, AND ANY RADIONUCLIDE OTHER THAN NOBLE GAS, GASEOUS EFFLUENTS, CHILD AGE GROUP, COW MILK PATHWAY

ORGAN (m^2 mrem/yr per μCi/sec)

RADIONUCLIDE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
1. H-3[2]	0.000E+00	1.570E+03	1.570E+03	1.570E+03	1.570E+03	1.570E+03	1.570E+03
2. C-14[2]	1.647E+06	3.294E+05	3.294E+05	3.294E+05	3.294E+05	3.294E+05	3.294E+05
3. CR-51	0.000E+00	0.000E+00	9.023E+04	5.049E+04	1.380E+04	9.219E+04	4.824E+06
4. MN-54	0.000E+00	1.671E+07	4.456E+06	0.000E+00	4.691E+06	0.000E+00	1.404E+07
5. FE-59	1.033E+08	1.672E+08	8.329E+07	0.000E+00	0.000E+00	4.847E+07	1.741E+08
6. CO-58	0.000E+00	1.009E+07	3.089E+07	0.000E+00	0.000E+00	0.000E+00	5.887E+07
7. CO-60	0.000E+00	3.421E+07	1.009E+08	0.000E+00	0.000E+00	0.000E+00	1.895E+08
8. ZN-65	3.722E+09	9.915E+09	6.166E+09	0.000E+00	6.248E+09	0.000E+00	1.741E+09
9. RB-86	0.000E+00	8.166E+09	5.021E+09	0.000E+00	0.000E+00	0.000E+00	5.253E+08
10. SR-89	5.663E+09	0.000E+00	1.617E+08	0.000E+00	0.000E+00	0.000E+00	2.192E+08
11. SR-90/Y90	9.276E+10	0.000E+00	2.352E+10	0.000E+00	0.000E+00	0.000E+00	1.888E+09
12. Y-91	3.288E+04	0.000E+00	8.794E+02	0.000E+00	0.000E+00	0.000E+00	4.381E+06
13. ZR-95	3.213E+03	7.063E+02	6.287E+02	0.000E+00	1.011E+03	0.000E+00	7.367E+05
14. NB-95	2.782E+05	1.084E+05	7.745E+04	0.000E+00	1.018E+05	0.000E+00	2.004E+08
15. RU-103	3.726E+03	0.000E+00	1.432E+03	0.000E+00	9.379E+03	0.000E+00	9.634E+04
16. RU-106	7.443E+04	0.000E+00	9.288E+03	0.000E+00	1.005E+05	0.000E+00	1.158E+06
17. AG-110M	1.741E+08	1.176E+08	9.399E+07	0.000E+00	2.190E+08	0.000E+00	1.399E+10
18. CD-115/115M	0.000E+00	3.752E+06	1.602E+05	0.000E+00	2.790E+06	0.000E+00	5.592E+07
19. SB-124	9.122E+07	1.183E+06	3.197E+07	2.013E+05	0.000E+00	5.062E+07	5.703E+08
20. SB-125	6.869E+07	5.295E+05	1.439E+07	6.360E+04	0.000E+00	3.828E+07	1.640E+08
21. TE-129M	2.567E+08	7.168E+07	3.985E+07	8.275E+07	7.537E+08	0.000E+00	3.131E+08
22. I-131	1.282E+09	6.444E+08	3.662E+08	2.131E+11	1.058E+09	0.000E+00	5.737E+07
23. I-133	1.762E+07	1.064E+07	4.027E+06	1.977E+09	1.774E+07	0.000E+00	4.289E+06
24. CS-134	1.783E+10	2.926E+10	6.172E+09	0.000E+00	9.067E+09	3.254E+09	1.577E+08
25. CS-136	9.625E+08	2.646E+09	1.712E+09	0.000E+00	1.409E+09	2.101E+08	9.259E+07
26. CS-137	2.603E+10	2.492E+10	3.678E+09	0.000E+00	8.120E+09	2.921E+09	1.560E+08
27. BA-140	1.120E+08	9.809E+04	6.535E+06	0.000E+00	3.193E+04	5.848E+04	5.673E+07
28. CE-141	1.924E+04	9.787E+03	1.426E+03	0.000E+00	4.211E+03	0.000E+00	1.198E+07
29. CE-144	1.283E+06	4.021E+05	6.845E+04	0.000E+00	2.226E+05	0.000E+00	1.048E+08
30. ND-147	4.235E+02	3.502E+02	2.712E+01	0.000E+00	1.921E+02	0.000E+00	5.547E+05

[1] Values for the dose parameters for all pathways are calculated by the PGandE "Tech. Spec." Code and based on Reg. Guide 1.109 or NUREG 0133.

[2] For Tritium and Carbon 14, the units of the dose parameters are mr[illegible]yr per $\mu Ci/m^3$ for all pathways, and they must be multiplied by X/Q.

TABLE 3E

DOSE PARAMETERS[1], R_i OR P_i, FOR RADIOIODINES, RADIOACTIVE PARTICULATES, AND ANY RADIONUCLIDE OTHER THAN NOBLE GAS, GASEOUS EFFLUENTS, CHILD AGE GROUP, ANIMAL MEAT PATHWAY

ORGAN (m^2 mrem/yr per μCi/sec)

RADIONUCLIDE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
1. H-3[2]	0.000E+00	2.341E+02	2.341E+02	2.341E+02	2.341E+02	2.341E+02	2.341E+02
2. C-14[2]	5.287E+05	1.057E+05	1.057E+05	1.057E+05	1.057E+05	1.057E+05	1.057E+05
3. CR-51	0.000E+00	0.000E+00	7.865E+03	4.366E+03	1.193E+03	7.971E+03	4.171E+05
4. MN-54	0.000E+00	6.391E+06	1.702E+06	0.000E+00	1.792E+06	0.000E+00	5.364E+06
5. FE-59	3.244E+08	5.250E+08	2.615E+08	0.000E+00	0.000E+00	1.522E+08	5.466E+08
6. CO-58	0.000E+00	1.367E+07	4.185E+07	0.000E+00	0.000E+00	0.000E+00	7.975E+07
7. CO-60	0.000E+00	5.489E+07	1.619E+08	0.000E+00	0.000E+00	0.000E+00	3.040E+08
8. ZN-65	3.380E+08	9.006E+08	5.601E+08	0.000E+00	5.675E+08	0.000E+00	1.582E+08
9. RB-86	0.000E+00	5.380E+08	3.308E+08	0.000E+00	0.000E+00	0.000E+00	3.461E+07
10. SR-89	4.153E+08	0.000E+00	1.186E+07	0.000E+00	0.000E+00	0.000E+00	1.608E+07
11. SR-90/Y90	8.633E+09	0.000E+00	2.189E+09	0.000E+00	0.000E+00	0.000E+00	1.757E+08
12. Y-91	1.521E+06	0.000E+00	4.068E+04	0.000E+00	0.000E+00	0.000E+00	2.026E+08
13. ZR-95	2.242E+06	4.928E+05	4.387E+05	0.000E+00	7.054E+05	0.000E+00	5.141E+08
14. NB-95	2.717E+06	1.058E+06	7.558E+05	0.000E+00	9.937E+05	0.000E+00	1.956E+09
15. RU-103	1.350E+08	0.000E+00	5.191E+07	0.000E+00	3.399E+08	0.000E+00	3.492E+09
16. RU-106	3.576E+09	0.000E+00	4.462E+08	0.000E+00	4.829E+09	0.000E+00	5.562E+10
17. AG-110M	7.000E+06	4.727E+06	3.779E+06	0.000E+00	8.805E+06	0.000E+00	5.624E+08
18. CD-115/115M	0.000E+00	1.530E+06	6.518E+04	0.000E+00	1.137E+06	0.000E+00	2.081E+07
19. SB-124	2.454E+07	3.183E+05	8.599E+06	5.416E+04	0.000E+00	1.362E+07	1.534E+08
20. SB-125	2.247E+07	1.732E+05	4.707E+06	2.081E+04	0.000E+00	1.252E+07	5.367E+07
21. TE-129M	1.701E+09	4.751E+08	2.641E+08	5.485E+08	4.995E+09	0.000E+00	2.075E+09
22. I-131	8.155E+06	8.202E+06	4.661E+06	2.712E+09	1.347E+07	0.000E+00	7.301E+05
23. I-133	2.901E-01	3.587E-01	1.357E-01	6.664E+01	5.978E-01	0.000E+00	1.446E-01
24. CS-134	7.262E+08	1.192E+09	2.514E+08	0.000E+00	3.693E+08	1.325E+08	6.424E+06
25. CS-136	1.538E+07	4.229E+07	2.736E+07	0.000E+00	2.252E+07	3.358E+06	1.486E+06
26. CS-137	1.077E+09	1.031E+09	1.521E+08	0.000E+00	3.359E+08	1.209E+08	6.454E+06
27. BA-140	4.197E+07	3.677E+04	2.450E+06	0.000E+00	1.197E+04	2.192E+04	2.114E+07
28. CE-141	1.956E+04	9.757E+03	1.449E+03	0.000E+00	4.278E+03	0.000E+00	1.217E+07
29. CE-144	1.830E+06	5.737E+05	9.768E+04	0.000E+00	3.177E+05	0.000E+00	1.496E+08
30. ND-147	1.152E+04	9.328E+03	7.223E+02	0.000E+00	5.118E+03	0.000E+00	1.478E+07

[1] Values for the dose parameters for all pathways are calculated by the PGandE "Tech. Spec." Code and based on Reg. Guide 1.109 or NUREG 0133.

[2] For Tritium and Carbon 14, the units of the dose parameters are m[illegible]/yr per μCi/m^3 for all pathways, and they must be multiplied by X/Q.

TABLE 3F

DOSE PARAMETERS[1], R_i OR P_i, FOR RADIOIODINES, RADIOACTIVE PARTICULATES, AND ANY RADIONUCLIDE OTHER THAN NOBLE GAS, GASEOUS EFFLUENTS, CHILD AGE GROUP, VEGETABLE PATHWAY

ORGAN (m^2 mrem/yr per µCi/sec)

RADIONUCLIDE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
1. H-3[2]	0.000E+00	4.008E+03	4.008E+03	4.008E+03	4.008E+03	4.008E+03	4.008E+03
2. C-14[2]	3.504E+06	7.008E+05	7.008E+05	7.008E+05	7.008E+05	7.008E+05	7.008E+05
3. CR-51	0.000E+00	0.000E+00	1.161E+05	6.442E+04	1.760E+04	1.176E+05	6.155E+06
4. MN-54	0.000E+00	6.536E+08	1.741E+08	0.000E+00	1.833E+08	0.000E+00	5.485E+08
5. FE-59	3.932E+08	6.363E+08	3.169E+08	0.000E+00	0.000E+00	1.844E+08	6.625E+08
6. CO-58	0.000E+00	6.279E+07	1.922E+08	0.000E+00	0.000E+00	0.000E+00	3.663E+08
7. CO-60	0.000E+00	3.770E+08	1.112E+09	0.000E+00	0.000E+00	0.000E+00	2.088E+09
8. ZN-65	1.029E+09	2.741E+09	1.705E+09	0.000E+00	1.727E+09	0.000E+00	4.814E+08
9. RB-86	0.000E+00	4.566E+08	2.808E+08	0.000E+00	0.000E+00	0.000E+00	2.937E+07
10. SR-89	3.622E+10	0.000E+00	1.035E+09	0.000E+00	0.000E+00	0.000E+00	1.402E+09
11. SR-90/Y90	1.381E+12	0.000E+00	3.500E+11	0.000E+00	0.000E+00	0.000E+00	2.810E+10
12. Y-91	1.830E+07	0.000E+00	4.893E+05	0.000E+00	0.000E+00	0.000E+00	2.438E+09
13. ZR-95	3.804E+06	8.363E+05	7.445E+05	0.000E+00	1.197E+06	0.000E+00	8.724E+08
14. NB-95	4.057E+05	1.580E+05	1.129E+05	0.000E+00	1.477E+05	0.000E+00	2.921E+08
15. RU-103	1.525E+07	0.000E+00	5.862E+06	0.000E+00	3.839E+07	0.000E+00	3.943E+08
16. RU-106	7.537E+08	0.000E+00	9.405E+07	0.000E+00	1.018E+09	0.000E+00	1.172E+10
17. AG-110M	3.464E+07	2.339E+07	1.870E+07	0.000E+00	4.357E+07	0.000E+00	2.783E+09
18. CD-115/115M	0.000E+00	1.405E+08	5.985E+06	0.000E+00	1.044E+08	0.000E+00	1.941E+09
19. SB-124	3.420E+08	4.437E+06	1.199E+08	7.549E+05	0.000E+00	1.898E+08	2.138E+09
20. SB-125	4.903E+08	3.780E+06	1.027E+08	4.540E+05	0.000E+00	2.732E+08	1.171E+09
21. TE-129M	9.989E+08	2.789E+08	1.551E+08	3.220E+08	2.933E+09	0.000E+00	1.218E+09
22. I-131	7.145E+07	7.186E+07	4.083E+07	2.376E+10	1.180E+08	0.000E+00	6.397E+06
23. I-133	1.760E+06	2.177E+06	8.237E+05	4.044E+08	3.628E+06	0.000E+00	8.772E+05
24. CS-134	1.562E+10	2.563E+10	5.407E+09	0.000E+00	7.943E+09	2.850E+09	1.382E+08
25. CS-136	8.158E+07	2.243E+08	1.451E+08	0.000E+00	1.194E+08	1.781E+07	7.881E+06
26. CS-137	2.499E+10	2.392E+10	3.530E+09	0.000E+00	7.794E+09	2.804E+09	1.498E+08
27. BA-140	2.762E+08	2.420E+05	1.612E+07	0.000E+00	7.877E+04	1.442E+05	1.399E+08
28. CE-141	6.466E+05	3.225E+05	4.788E+04	0.000E+00	1.414E+05	0.000E+00	4.023E+08
29. CE-144	1.218E+08	3.817E+07	6.498E+06	0.000E+00	2.113E+07	0.000E+00	9.951E+09
30. ND-147	7.256E+04	5.877E+04	4.551E+03	0.000E+00	3.225E+04	0.000E+00	9.310E+07

[1] Values for the dose parameters for all pathways are calculated by the PGandE "Tech. Spec." Code and based on Reg. Guide 1.109 or NUREG 0133.

[2] For Tritium and Carbon 14, the units of the dose parameters are mrem/yr per $\mu Ci/m^3$ for all pathways, and they must be multiplied by X/Q.

TABLE 3G

DOSE PARAMETERS[1], R_i OR P_i, FOR RADIOIODINES, RADIOACTIVE PARTICULATES, AND ANY RADIONUCLIDE OTHER THAN NOBLE GAS, GASEOUS EFFLUENTS, TEEN AGE GROUP, INHALATION PATHWAY

ORGAN (mrem/yr per $\mu Ci/m^3$)

RADIONUCLIDE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
1. H-3[2]	0.000E+00	1.272E+03	1.272E+03	1.272E+03	1.272E+03	1.272E+03	1.272E+03
2. C-14[2]	2.600E+04	4.872E+03	4.872E+03	4.872E+03	4.872E+03	4.872E+03	4.872E+03
3. CR-51	0.000E+00	0.000E+00	1.352E+02	7.496E+01	3.072E+01	2.096E+04	3.000E+03
4. MN-54	0.000E+00	5.112E+04	8.400E+03	0.000E+00	1.272E+04	1.984E+06	6.680E+04
5. FE-59	1.592E+04	3.696E+04	1.432E+04	0.000E+00	0.000E+00	1.528E+06	1.784E+05
6. CO-58	0.000E+00	2.072E+03	2.776E+03	0.000E+00	0.000E+00	1.344E+06	9.520E+04
7. CO-60	0.000E+00	1.512E+04	1.984E+04	0.000E+00	0.000E+00	8.720E+06	2.592E+05
8. ZN-65	3.856E+04	1.336E+05	6.240E+04	0.000E+00	8.640E+04	1.240E+06	4.664E+04
9. RB-86	0.000E+00	1.904E+05	8.400E+04	0.000E+00	0.000E+00	0.000E+00	1.768E+04
10. SR-89	4.344E+05	0.000E+00	1.248E+04	0.000E+00	0.000E+00	2.416E+06	3.712E+05
11. SR-90/Y90	1.080E+08	0.000E+00	6.680E+06	0.000E+00	0.000E+00	1.680E+07	1.324E+06
12. Y-91	6.608E+05	0.000E+00	1.768E+04	0.000E+00	0.000E+00	2.939E+06	4.088E+05
13. ZR-95	1.456E+05	4.584E+04	3.152E+04	0.000E+00	6.736E+04	2.688E+06	1.488E+05
14. NB-95	1.856E+04	1.032E+04	5.664E+03	0.000E+00	1.000E+04	7.512E+05	9.680E+04
15. RU-103	2.104E+03	0.000E+00	8.960E+02	0.000E+00	7.432E+03	7.832E+05	1.088E+05
16. RU-106	9.840E+04	0.000E+00	1.240E+04	0.000E+00	1.904E+05	1.608E+07	9.600E+05
17. AG-110M	1.384E+04	1.312E+04	7.992E+03	0.000E+00	2.504E+04	6.752E+06	2.728E+05
18. CD-115/115M	0.000E+00	2.794E+05	9.162E+03	0.000E+00	2.264E+05	2.578E+06	7.344E+05
19. SB-124	4.304E+04	7.936E+02	1.680E+04	9.760E+01	0.000E+00	3.848E+06	3.984E+05
20. SB-125	7.384E+04	8.080E+02	1.720E+04	7.040E+01	0.000E+00	2.736E+06	9.920E+04
21. TE-129M	1.392E+04	6.584E+03	2.248E+03	4.576E+03	5.192E+04	1.976E+06	4.048E+05
22. I-131	3.544E+04	4.912E+04	2.640E+04	1.464E+07	8.400E+04	0.000E+00	6.488E+03
23. I-133	1.216E+04	2.048E+04	6.224E+03	2.920E+06	3.592E+04	0.000E+00	1.032E+04
24. CS-134	5.024E+05	1.128E+06	5.488E+05	0.000E+00	3.752E+05	1.464E+05	9.760E+03
25. CS-136	5.152E+04	1.936E+05	1.368E+05	0.000E+00	1.104E+05	1.776E+04	1.088E+04
26. CS-137	6.704E+05	8.480E+05	3.112E+05	0.000E+00	3.040E+05	1.208E+05	8.480E+03
27. BA-140	5.472E+04	6.864E+01	3.520E+03	0.000E+00	2.[illegible]90E+01	2.032E+06	2.288E+05
28. CE-141	2.840E+04	1.896E+04	2.168E+03	0.000E+00	8.880E+03	6.136E+05	1.264E+05
29. CE-144	4.888E+06	2.024E+06	2.624E+05	0.000E+00	1.208E+06	1.336E+07	8.640E+05
30. ND-147	7.864E+03	8.560E+03	5.128E+02	0.000E+00	5.024E+03	3.720E+05	1.824E+05

[1] Values for the dose parameters for all pathways are calculated by the PGandE "Tech. Spec." Code and based on Reg. Guide 1.109 or NUREG 0133.

[2] For Tritium and Carbon 14, the units of the dose parameters are mrem/yr per $\mu Ci/m^3$ for all pathways, and they must be multiplied by X/Q.

TABLE 3H
DOSE PARAMETERS[1], R_i OR P_i, FOR RADIOIODINES, RADIOACTIVE PARTICULATES, AND ANY RADIONUCLIDE OTHER THAN NOBLE GAS, GASEOUS EFFLUENTS, TEEN AGE GROUP, COW MILK PATHWAY
ORGAN (m^2 mrem/yr per µCi/sec)

RADIONUCLIDE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
1. H-3[2]	0.000E+00	9.937E+02	9.937E+02	9.937E+02	9.937E+02	9.937E+02	9.937E+02
2. C-14[2]	6.699E+05	1.340E+05	1.340E+05	1.340E+05	1.340E+05	1.340E+05	1.340E+05
3. CR-51	0.000E+00	0.000E+00	4.460E+04	2.478E+04	9.774E+03	6.368E+04	7.495E+06
4. MN-54	0.000E+00	1.118E+07	2.217E+06	0.000E+00	3.335E+06	0.000E+00	2.293E+07
5. FE-59	4.456E+07	1.040E+08	4.015E+07	0.000E+00	0.000E+00	3.279E+07	2.459E+08
6. CO-58	0.000E+00	6.605E+06	1.522E+07	0.000E+00	0.000E+00	0.000E+00	9.106E+07
7. CO-60	0.000E+00	2.203E+07	4.962E+07	0.000E+00	0.000E+00	0.000E+00	2.859E+08
8. ZN-65	1.897E+09	6.585E+09	3.072E+09	0.000E+00	4.215E+09	0.000E+00	2.789E+09
9. RB-86	0.000E+00	4.402E+09	2.068E+09	0.000E+00	0.000E+00	0.000E+00	6.515E+08
10. SR-89	2.288E+09	0.000E+00	6.552E+07	0.000E+00	0.000E+00	0.000E+00	2.725E+08
11. SR-90/Y90	5.490E+10	0.000E+00	1.356E+10	0.000E+00	0.000E+00	0.000E+00	2.288E+09
12. Y-91	1.331E+04	0.000E+00	3.569E+02	0.000E+00	0.000E+00	0.000E+00	5.456E+06
13. ZR-95	1.383E+03	4.364E+02	3.001E+02	0.000E+00	6.412E+02	0.000E+00	1.007E+06
14. NB-95	1.233E+05	6.839E+04	3.764E+04	0.000E+00	6.629E+04	0.000E+00	2.925E+08
15. RU-103	1.575E+03	0.000E+00	6.734E+02	0.000E+00	5.554E+03	0.000E+00	1.316E+05
16. RU-106	3.023E+04	0.000E+00	3.809E+03	0.000E+00	5.830E+04	0.000E+00	1.450E+06
17. AG-110M	8.026E+07	7.595E+07	4.620E+07	0.000E+00	1.449E+08	0.000E+00	2.134E+10
18. CD-115/115M	0.000E+00	2.008E+06	6.489E+04	0.000E+00	1.606E+06	0.000E+00	6.899E+07
19. SB-124	3.855E+07	7.102E+05	1.504E+07	8.746E+04	0.000E+00	3.367E+07	7.769E+08
20. SB-125	2.884E+07	3.151E+05	6.744E+06	2.756E+04	0.000E+00	2.535E+07	2.244E+08
21. TE-129M	1.041E+08	3.865E+07	1.648E+07	3.361E+07	4.357E+08	0.000E+00	3.910E+08
22. I-131	2.641E+08	3.698E+08	1.987E+08	1.079E+11	1.274E+09	0.000E+00	7.351E+07
23. I-133	3.542E+06	6.010E+06	1.833E+06	8.389E+08	1.054E+07	0.000E+00	4.547E+06
24. CS-134	7.730E+09	1.819E+10	8.442E+09	0.000E+00	5.782E+09	2.207E+09	2.263E+08
25. CS-136	4.265E+08	1.678E+09	1.127E+09	0.000E+00	9.135E+08	1.440E+08	1.350E+08
26. CS-137	1.081E+10	1.438E+10	5.008E+09	0.000E+00	4.892E+09	1.901E+09	2.046E+08
27. BA-140	4.638E+07	5.684E+04	2.989E+06	0.000E+00	1.927E+04	3.822E+04	7.153E+07
28. CE-141	7.822E+03	5.222E+03	5.999E+02	0.000E+00	2.458E+03	0.000E+00	1.494E+07
29. CE-144	5.203E+05	2.153E+05	2.796E+04	0.000E+00	1.286E+05	0.000E+00	1.308E+08
30. ND-147	1.762E+02	1.916E+02	1.148E+01	0.000E+00	1.125E+02	0.000E+00	6.912E+05

[1] Values for the dose parameters for all pathways are calculated by the PGandE "Tech. Spec." Code and based on Reg. Guide 1.109 or NUREG 0133.

[2] For Tritium and Carbon 14, the units of the dose parameters are mrem/yr per µCi/m^3 for all pathways, and they must be multiplied by X/Q.

TABLE 3I

DOSE PARAMETERS[1], R_i OR P_i, FOR RADIOIODINES, RADIOACTIVE PARTICULATES, AND ANY RADIONUCLIDE OTHER THAN NOBLE GAS, GASEOUS EFFLUENTS, TEEN AGE GROUP, ANIMAL MEAT PATHWAY

ORGAN (mrem/yr per μCi/m³)

RADIONUCLIDE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
1. H-3[2]	0.000E+00	1.938E+02	1.938E+02	1.938E+02	1.938E+02	1.938E+02	1.938E+02
2. C-14[2]	2.812E+05	5.624E+04	5.624E+04	5.624E+04	5.624E+04	5.624E+04	5.624E+04
3. CR-51	0.000E+00	0.000E+00	5.044E+03	2.802E+03	1.105E+03	7.201E+03	8.476E+05
4. MN-54	0.000E+00	5.587E+06	1.108E+06	0.000E+00	1.667E+06	0.000E+00	1.146E+07
5. FE-59	1.830E+08	4.271E+08	1.649E+08	0.000E+00	0.000E+00	1.347E+08	1.010E+09
6. CO-58	0.000E+00	1.170E+07	2.697E+07	0.000E+00	0.000E+00	0.000E+00	1.614E+08
7. CO-60	0.000E+00	4.623E+07	1.041E+08	0.000E+00	0.000E+00	0.000E+00	6.021E+08
8. ZN-65	2.253E+08	7.824E+08	3.650E+08	0.000E+00	5.007E+08	0.000E+00	3.313E+08
9. RB-86	0.000E+00	3.793E+08	1.782E+08	0.000E+00	0.000E+00	0.000E+00	5.614E+07
10. SR-89	2.195E+08	0.000E+00	6.284E+06	0.000E+00	0.000E+00	0.000E+00	2.614E+07
11. SR-90/Y90	6.683E+09	0.000E+00	1.651E+09	0.000E+00	0.000E+00	0.000E+00	2.876E+08
12. Y-91	8.051E+05	0.000E+00	2.159E+04	0.000E+00	0.000E+00	0.000E+00	3.301E+08
13. ZR-95	1.262E+06	3.983E+05	2.739E+05	0.000E+00	5.852E+05	0.000E+00	9.191E+08
14. NB-95	1.573E+06	8.728E+05	4.804E+05	0.000E+00	8.460E+05	0.000E+00	3.733E+09
15. RU-103	7.468E+07	0.000E+00	3.192E+07	0.000E+00	2.633E+08	0.000E+00	6.238E+09
16. RU-106	1.899E+09	0.000E+00	2.393E+08	0.000E+00	3.663E+09	0.000E+00	9.108E+10
17. AG-110M	4.221E+06	3.994E+06	2.430E+06	0.000E+00	7.618E+06	0.000E+00	1.122E+09
18. CD-115/115M	0.000E+00	1.070E+06	3.454E+04	0.000E+00	8.564E+05	0.000E+00	3.389E+07
19. SB-124	1.356E+07	2.499E+05	5.292E+06	3.077E+04	0.000E+00	1.184E+07	2.733E+08
20. SB-125	1.234E+07	1.348E+05	2.886E+06	1.179E+04	0.000E+00	1.085E+07	9.603E+07
21. TE-129M	9.027E+08	3.351E+08	1.429E+08	2.913E+08	3.777E+09	0.000E+00	3.389E+09
22. I-131	4.397E+06	6.156E+06	3.307E+06	1.796E+09	1.060E+07	0.000E+00	1.218E+06
23. I-133	1.562E-01	2.649E-01	1.887E-01	3.698E+01	4.646E-01	0.000E+00	2.004E-01
24. CS-134	4.118E+08	9.693E+08	4.497E+08	0.000E+00	3.080E+08	1.176E+08	1.205E+07
25. CS-136	8.915E+06	3.508E+07	2.356E+07	0.000E+00	1.910E+07	3.010E+06	2.823E+06
26. CS-137	5.847E+08	7.779E+08	2.709E+08	0.000E+00	2.647E+08	1.028E+08	1.107E+07
27. BA-140	2.274E+07	2.787E+04	1.465E+06	0.000E+00	9.449E+03	1.874E+04	3.507E+07
28. CE-141	1.039E+04	6.938E+03	7.969E+02	0.000E+00	3.266E+03	0.000E+00	1.984E+07
29. CE-144	9.710E+05	4.018E+05	5.218E+04	0.000E+00	2.400E+05	0.000E+00	2.441E+08
30. ND-147	6.138E+03	6.674E+03	3.998E+02	0.000E+00	3.919E+03	0.000E+00	2.408E+07

[1] Values for the dose parameters for all pathways are calculated by the PGandE "Tech. Spec." Code and based on Reg. Guide 1.109 or NUREG 0133.

[2] For Tritium and Carbon 14, the units of the dose parameters are mrem/yr per μCi/m³ for all pathways, and they must be multiplied by X/Q.

TABLE 3J
DOSE PARAMETERS[1], R_i OR P_i, FOR RADIOIODINES, RADIOACTIVE PARTICULATES, AND ANY RADIONUCLIDE OTHER THAN NOBLE GAS, GASEOUS EFFLUENTS, TEEN AGE GROUP, VEGETABLE PATHWAY
ORGAN (m^2 mrem/yr per μCi/sec)

RADIONUCLIDE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
1. H-3[2]	0.000E+00	2.588E+03	2.588E+03	2.588E+03	2.588E+03	2.588E+03	2.588E+03
2. C-14[2]	1.454E+06	2.907E+05	2.907E+05	2.907E+05	2.907E+05	2.907E+05	2.907E+05
3. CR-51	0.000E+00	0.000E+00	6.110E+04	3.394E+04	1.339E+04	8.724E+04	1.027E+07
4. MN-54	0.000E+00	4.441E+08	8.807E+07	0.000E+00	1.325E+08	0.000E+00	9.108E+08
5. FE-59	1.774E+08	4.140E+08	1.599E+08	0.000E+00	0.000E+00	1.305E+08	9.791E+08
6. CO-58	0.000E+00	4.252E+07	9.798E+07	0.000E+00	0.000E+00	0.000E+00	5.861E+08
7. CO-60	0.000E+00	2.477E+08	5.579E+08	0.000E+00	0.000E+00	0.000E+00	3.226E+09
8. ZN-65	5.367E+08	1.864E+09	8.694E+08	0.000E+00	1.193E+09	0.000E+00	7.893E+08
9. RB-86	0.000E+00	2.764E+08	1.298E+08	0.000E+00	0.000E+00	0.000E+00	4.090E+07
10. SR-89	1.524E+10	0.000E+00	4.365E+08	0.000E+00	0.000E+00	0.000E+00	1.815E+09
11. SR-90/Y90	8.335E+11	0.000E+00	2.059E+11	0.000E+00	0.000E+00	0.000E+00	3.475E+10
12. Y-91	7.688E+06	0.000E+00	2.062E+05	0.000E+00	0.000E+00	0.000E+00	3.152E+09
13. ZR-95	1.697E+06	5.354E+05	3.682E+05	0.000E+00	7.866E+05	0.000E+00	1.236E+09
14. NB-95	1.892E+05	1.049E+05	5.777E+04	0.000E+00	1.022E+05	0.000E+00	4.507E+08
15. RU-103	6.781E+06	0.000E+00	2.899E+06	0.000E+00	2.391E+07	0.000E+00	5.664E+08
16. RU-106	3.126E+08	0.000E+00	3.939E+07	0.000E+00	6.029E+08	0.000E+00	1.501E+10
17. AG-110M	1.634E+07	1.547E+07	9.407E+06	0.000E+00	2.950E+07	0.000E+00	4.345E+09
18. CD-115/115M	0.000E+00	7.877E+07	2.542E+06	0.000E+00	6.301E+07	0.000E+00	2.539E+09
19. SB-124	1.500E+08	2.764E+06	5.853E+07	3.403E+05	0.000E+00	1.310E+08	3.023E+09
20. SB-125	2.101E+08	2.296E+06	4.914E+07	2.008E+05	0.000E+00	1.847E+08	1.635E+09
21. TE-129M	4.293E+08	1.593E+08	6.795E+07	1.385E+08	1.796E+09	0.000E+00	1.612E+09
22. I-131	3.841E+07	5.378E+07	2.889E+07	1.569E+10	9.258E+07	0.000E+00	1.064E+07
23. I-133	9.655E+05	1.638E+06	4.995E+05	2.286E+08	2.872E+06	0.000E+00	1.239E+06
24. CS-134	6.915E+09	1.628E+10	7.552E+09	0.000E+00	5.172E+09	1.974E+09	2.024E+08
25. CS-136	4.334E+07	1.705E+08	1.145E+08	0.000E+00	9.283E+07	1.445E+07	1.372E+07
26. CS-137	1.058E+10	1.408E+10	4.904E+09	0.000E+00	4.790E+09	1.861E+09	2.003E+08
27. BA-140	1.379E+08	1.689E+05	8.883E+06	0.000E+00	5.728E+04	1.136E+05	2.126E+08
28. CE-141	2.789E+05	1.862E+05	2.139E+04	0.000E+00	8.765E+04	0.000E+00	5.326E+08
29. CE-144	5.052E+07	2.091E+07	2.715E+06	0.000E+00	1.249E+07	0.000E+00	1.270E+10
30. ND-147	3.669E+04	3.989E+04	2.390E+03	0.000E+00	2.343E+04	0.000E+00	1.439E+08

[1] Values for the dose parameters for all pathways are calculated by the PGandE "Tech. Spec." Code and based on Reg. Guide 1.109 or NUREG 0133.

[2] For Tritium and Carbon 14, the units of the dose parameters are mrem/yr per $\mu Ci/m^3$ for all pathways, and they must be multiplied by X/Q.

TABLE 3K

DOSE PARAMETERS[1], R_i OR P_i, FOR RADIOIODINES, RADIOACTIVE PARTICULATES, AND ANY RADIONUCLIDE OTHER THAN NOBLE GAS, GASEOUS EFFLUENTS, ADULT AGE GROUP, INHALATION PATHWAY

ORGAN (mrem/yr per μCi/m³)

RADIONUCLIDE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
1. H-3[2]	0.000E+00	1.264E+03	1.264E+03	1.264E+03	1.264E+03	1.264E+03	1.264E+03
2. C-14[2]	1.816E+04	3.408E+03	3.408E+03	3.408E+03	3.408E+03	3.408E+03	3.408E+03
3. CR-51	0.000E+00	0.000E+00	1.000E+02	5.952E+01	2.280E+01	1.440E+04	3.320E+03
4. MN-54	0.000E+00	3.960E+04	6.296E+03	0.000E+00	9.840E+03	1.400E+06	7.736E+04
5. FE-59	1.176E+04	2.776E+04	1.056E+04	0.000E+00	0.000E+00	1.016E+06	1.880E+05
6. CO-58	0.000E+00	1.584E+03	2.072E+03	0.000E+00	0.000E+00	9.280E+05	1.064E+05
7. CO-60	0.000E+00	1.152E+04	1.480E+04	0.000E+00	0.000E+00	5.968E+06	2.848E+05
8. ZN-65	3.240E+04	1.032E+05	4.656E+04	0.000E+00	6.896E+04	8.640E+05	5.344E+04
9. RB-86	0.000E+00	1.352E+05	5.896E+04	0.000E+00	0.000E+00	0.000E+00	1.664E+04
10. SR-89	3.040E+05	0.000E+00	8.720E+03	0.000E+00	0.000E+00	1.400E+06	3.496E+05
11. SR-90/Y90	9.920E+07	0.000E+00	6.096E+06	0.000E+00	0.000E+00	9.770E+06	1.227E+06
12. Y-91	4.624E+05	0.000E+00	1.240E+04	0.000E+00	0.000E+00	1.706E+06	3.848E+05
13. ZR-95	1.072E+05	3.440E+04	2.328E+04	0.000E+00	5.416E+04	1.768E+06	1.504E+05
14. NB-95	1.408E+04	7.816E+03	4.208E+03	0.000E+00	7.736E+03	5.048E+05	1.040E+05
15. RU-103	1.528E+03	0.000E+00	6.584E+02	0.000E+00	5.832E+03	5.048E+05	1.104E+05
16. RU-106	6.912E+04	0.000E+00	8.720E+03	0.000E+00	1.336E+05	9.360E+06	9.120E+05
17. AG-110M	1.080E+04	1.000E+04	5.944E+03	0.000E+00	1.968E+04	4.632E+06	3.024E+05
18. CD-115/115M	0.000E+00	1.975E+05	6.389E+03	0.000E+00	1.589E+05	1.497E+06	6.944E+05
19. SB-124	3.120E+04	5.888E+02	1.240E+04	7.552E+01	0.000E+00	2.480E+06	4.064E+05
20. SB-125	5.336E+04	5.952E+02	1.264E+04	5.400E+01	0.000E+00	1.744E+06	1.008E+05
21. TE-129M	9.760E+03	4.672E+03	1.584E+03	3.440E+03	3.656E+04	1.160E+06	3.832E+05
22. I-131	2.520E+04	3.576E+04	2.048E+04	1.192E+07	6.128E+04	0.000E+00	6.280E+03
23. I-133	8.640E+03	1.480E+04	4.520E+03	2.152E+06	2.584E+04	0.000E+00	8.880E+03
24. CS-134	3.728E+05	8.480E+05	7.280E+05	0.000E+00	2.872E+05	9.760E+04	1.040E+04
25. CS-136	3.904E+04	1.464E+05	1.104E+05	0.000E+00	8.560E+04	1.200E+04	1.168E+04
26. CS-137	4.784E+05	6.208E+05	4.280E+05	0.000E+00	2.224E+05	7.520E+04	8.400E+03
27. BA-140	3.904E+04	4.904E+01	2.568E+03	0.000E+00	1.672E+01	1.272E+06	2.184E+05
28. CE-141	1.992E+04	1.352E+04	1.528E+03	0.000E+00	6.264E+03	3.616E+05	1.200E+05
29. CE-144	3.432E+06	1.432E+06	1.840E+05	0.000E+00	8.480E+05	7.776E+06	8.160E+05
30. ND-147	5.272E+03	6.096E+03	3.648E+02	0.000E+00	3.560E+03	2.208E+05	1.728E+05

[1] Values for the dose parameters for all pathways are calculated by the PGandE "Tech. Spec." Code and based on Reg. Guide 1.109 or NUREG 0133.

[2] For Tritium and Carbon 14, the units of the dose parameters are mrem/yr per μCi/m³ for all pathways, and they must be multiplied by X/Q.

TABLE 3L
DOSE PARAMETERS[1], R_i OR P_i, FOR RADIOIODINES, RADIOACTIVE PARTICULATES, AND ANY RADIONUCLIDE OTHER THAN NOBLE GAS, GASEOUS EFFLUENTS, ADULT GROUP, COW MILK PATHWAY
ORGAN (m^2 mrem/yr per µCi/sec)

RADIONUCLIDE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
1. H-3[2]	0.000E+00	7.629E+02	7.629E+02	7.629E+02	7.629E+02	7.629E+02	7.629E+02
2. C-14[2]	3.632E+05	7.263E+04	7.263E+04	7.263E+04	7.263E+04	7.263E+04	7.263E+04
3. CR-51	0.000E+00	0.000E+00	2.554E+04	1.527E+04	5.626E+03	3.389E+04	6.423E+06
4. MN-54	0.000E+00	6.712E+06	1.281E+06	0.000E+00	1.998E+06	0.000E+00	2.056E+07
5. FE-59	2.553E+07	6.000E+07	2.300E+07	0.000E+00	0.000E+00	1.677E+07	2.000E+08
6. CO-58	0.000E+00	3.923E+06	8.795E+06	0.000E+00	0.000E+00	0.000E+00	7.952E+07
7. CO-60	0.000E+00	1.300E+07	2.867E+07	0.000E+00	0.000E+00	0.000E+00	2.442E+08
8. ZN-65	1.235E+09	3.930E+09	1.776E+09	0.000E+00	2.628E+09	0.000E+00	2.475E+09
9. RB-86	0.000E+00	2.416E+09	1.125E+09	0.000E+00	0.000E+00	0.000E+00	4.763E+08
10. SR-89	1.241E+09	0.000E+00	3.562E+07	0.000E+00	0.000E+00	0.000E+00	1.991E+08
11. SR-90/Y90	3.885E+10	0.000E+00	9.534E+09	0.000E+00	0.000E+00	0.000E+00	1.645E+09
12. Y-91	7.235E+03	0.000E+00	1.934E+02	0.000E+00	0.000E+00	0.000E+00	3.982E+06
13. ZR-95	7.910E+02	2.537E+02	1.717E+02	0.000E+00	3.981E+02	0.000E+00	8.040E+05
14. NB-95	7.230E+04	4.022E+04	2.162E+04	0.000E+00	3.975E+04	0.000E+00	2.441E+08
15. RU-103	8.858E+02	0.000E+00	3.816E+02	0.000E+00	3.381E+03	0.000E+00	1.034E+05
16. RU-106	1.643E+04	0.000E+00	2.080E+03	0.000E+00	3.173E+04	0.000E+00	1.064E+06
17. AG-110M	4.855E+07	4.490E+07	2.667E+07	0.000E+00	8.829E+07	0.000E+00	1.833E+10
18. CD-115/115M	0.000E+00	1.101E+06	3.518E+04	0.000E+00	8.734E+05	0.000E+00	5.032E+07
19. SB-124	2.161E+07	4.084E+05	8.569E+06	5.242E+04	0.000E+00	1.683E+07	6.137E+08
20. SB-125	1.613E+07	1.802E+05	3.839E+06	1.640E+04	0.000E+00	1.244E+07	1.775E+08
21. TE-129M	5.694E+07	2.124E+07	9.012E+06	1.956E+07	2.377E+08	0.000E+00	2.867E+08
22. I-131	1.456E+08	2.082E+08	1.193E+08	6.824E+10	3.569E+08	0.000E+00	5.494E+07
23. I-133	1.939E+06	3.374E+06	1.028E+06	4.958E+08	5.887E+06	0.000E+00	3.032E+06
24. CS-134	4.452E+09	1.059E+10	8.661E+09	0.000E+00	3.429E+09	1.138E+09	1.854E+08
25. CS-136	2.505E+08	9.888E+08	7.118E+08	0.000E+00	5.502E+08	7.541E+07	1.124E+08
26. CS-137	5.960E+09	8.151E+09	5.339E+09	0.000E+00	2.767E+09	9.198E+08	1.578E+08
27. BA-140	2.569E+07	3.228E+04	1.683E+06	0.000E+00	1.097E+04	1.848E+04	5.291E+07
28. CE-141	4.266E+03	2.885E+03	3.273E+02	0.000E+00	1.340E+03	0.000E+00	1.103E+07
29. CE-144	2.827E+05	1.182E+05	1.518E+04	0.000E+00	7.010E+04	0.000E+00	9.559E+07
30. ND-147	9.156E+01	1.058E+02	6.332E+00	0.000E+00	6.186E+01	0.000E+00	5.080E+05

[1] Values for the dose parameters for all pathways are calculated by the PGandE "Tech. Spec." Code and based on Reg. Guide 1.109 or NUREG 0133.

[2] For Tritium and Carbon 14, the units of the dose parameters are mrem/yr per µCi/m^3 for all pathways, and they must be multiplied by X/Q.

TABLE 3M
DOSE PARAMETERS[1], R_i OR P_i, FOR RADIOIODINES, RADIOACTIVE PARTICULATES, AND ANY RADIONUCLIDE OTHER THAN NOBLE GAS, GASEOUS EFFLUENTS, ADULT AGE GROUP, ANIMAL MEAT PATHWAY
ORGAN (m^2 mrem/yr per µCi/sec)

RADIONUCLIDE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
1. H-3[2]	0.000E+00	3.248E+02	3.248E+02	3.248E+02	3.248E+02	3.248E+02	3.248E+02
2. C-14[2]	3.329E+05	6.658E+04	6.658E+04	6.658E+04	6.658E+04	6.658E+04	6.658E+04
3. CR-51	0.000E+00	0.000E+00	6.307E+03	3.770E+03	1.389E+03	8.370E+03	1.586E+06
4. MN-54	0.000E+00	7.323E+06	1.397E+06	0.000E+00	2.179E+06	0.000E+00	2.243E+07
5. FE-59	2.290E+08	5.381E+08	2.063E+08	0.000E+00	0.000E+00	1.503E+08	1.794E+09
6. CO-58	0.000E+00	1.518E+07	3.403E+07	0.000E+00	0.000E+00	0.000E+00	3.077E+08
7. CO-60	0.000E+00	5.958E+07	1.314E+08	0.000E+00	0.000E+00	0.000E+00	1.119E+09
8. ZN-65	3.204E+08	1.019E+09	4.608E+08	0.000E+00	6.819E+08	0.000E+00	6.421E+08
9. RB-86	0.000E+00	4.545E+08	2.118E+08	0.000E+00	0.000E+00	0.000E+00	8.962E+07
10. SR-89	2.600E+08	0.000E+00	7.462E+06	0.000E+00	0.000E+00	0.000E+00	4.170E+07
11. SR-90/Y90	1.033E+10	0.000E+00	2.534E+09	0.000E+00	0.000E+00	0.000E+00	4.374E+08
12. Y-91	9.558E+05	0.000E+00	2.556E+04	0.000E+00	0.000E+00	0.000E+00	5.260E+08
13. ZR-95	1.576E+06	5.055E+05	3.422E+05	0.000E+00	7.933E+05	0.000E+00	1.602E+09
14. NB-95	2.015E+06	1.121E+06	6.025E+05	0.000E+00	1.108E+06	0.000E+00	6.803E+09
15. RU-103	9.169E+07	0.000E+00	3.950E+07	0.000E+00	3.499E+08	0.000E+00	1.071E+10
16. RU-106	2.255E+09	0.000E+00	2.853E+08	0.000E+00	4.353E+09	0.000E+00	1.459E+11
17. AG-110M	5.575E+06	5.157E+06	3.063E+06	0.000E+00	1.014E+07	0.000E+00	2.105E+09
18. CD-115/115M	0.000E+00	1.282E+06	4.090E+04	0.000E+00	1.017E+06	0.000E+00	5.395E+07
19. SB-124	1.661E+07	3.137E+05	6.583E+06	4.027E+04	0.000E+00	1.293E+07	4.715E+08
20. SB-125	1.507E+07	1.684E+05	3.587E+06	1.532E+04	0.000E+00	1.162E+07	1.659E+08
21. TE-129M	1.078E+09	4.021E+08	1.706E+08	3.702E+08	4.499E+09	0.000E+00	5.427E+09
22. I-131	5.292E+06	7.569E+06	4.338E+06	2.480E+09	1.297E+07	0.000E+00	1.997E+06
23. I-133	1.867E-01	3.247E-01	9.900E-02	4.772E+01	5.666E-01	0.000E+00	2.919E-01
24. CS-134	5.179E+08	1.232E+09	1.008E+09	0.000E+00	3.988E+08	1.324E+08	2.157E+07
25. CS-136	1.143E+07	4.514E+07	3.249E+07	0.000E+00	2.512E+07	3.443E+06	5.129E+06
26. CS-137	7.041E+08	9.630E+08	6.308E+08	0.000E+00	3.269E+08	1.087E+08	1.864E+07
27. BA-140	2.751E+07	3.456E+04	1.802E+06	0.000E+00	1.175E+04	1.978E+04	5.664E+07
28. CE-141	1.238E+04	8.369E+03	9.493E+02	0.000E+00	3.887E+03	0.000E+00	3.200E+07
29. CE-144	1.152E+06	4.816E+05	6.186E+04	0.000E+00	2.857E+05	0.000E+00	3.895E+08
30. ND-147	6.965E+03	8.050E+03	4.817E+02	0.000E+00	4.706E+03	0.000E+00	3.865E+07

[1] Values for the dose parameters for all pathways are calculated by the PGandE "Tech. Spec." Code and based on Reg. Guide 1.109 or NUREG 0133.
[2] For Tritium and Carbon 14, the units of the dose parameters are mrem/yr per µCi/m³ for all pathways, and they must be multiplied by X/Q.

TABLE 3N
DOSE PARAMETERS[1], R_i OR P_i, FOR RADIOIODINES, RADIOACTIVE PARTICULATES, AND ANY RADIONUCLIDE OTHER THAN NOBLE GAS, GASEOUS EFFLUENTS, ADULT AGE GROUP, VEGETABLE PATHWAY
ORGAN (m^2 mrem/yr per µCi/sec)

RADIONUCLIDE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
1. H-3[2]	0.000E+00	2.260E+03	2.260E+03	2.260E+03	2.260E+03	2.260E+03	2.260E+03
2. C-14[2]	8.966E+05	1.793E+05	1.793E+05	1.793E+05	1.793E+05	1.793E+05	1.793E+05
3. CR-51	0.000E+00	0.000E+00	4.599E+04	2.749E+04	1.013E+04	6.103E+04	1.157E+07
4. MN-54	0.000E+00	3.076E+08	5.870E+07	0.000E+00	9.154E+07	0.000E+00	9.424E+08
5. FE-59	1.246E+08	2.929E+08	1.123E+08	0.000E+00	0.000E+00	8.183E+07	9.762E+08
6. CO-58	0.000E+00	2.997E+07	6.718E+07	0.000E+00	0.000E+00	0.000E+00	6.074E+08
7. CO-60	0.000E+00	1.665E+08	3.673E+08	0.000E+00	0.000E+00	0.000E+00	3.128E+09
8. ZN-65	4.018E+08	1.279E+09	5.778E+08	0.000E+00	8.551E+08	0.000E+00	8.053E+08
9. RB-86	0.000E+00	2.215E+08	1.032E+08	0.000E+00	0.000E+00	0.000E+00	4.366E+07
10. SR-89	1.001E+10	0.000E+00	2.873E+08	0.000E+00	0.000E+00	0.000E+00	1.605E+09
11. SR-90/Y90	6.713E+11	0.000E+00	1.647E+11	0.000E+00	0.000E+00	0.000E+00	2.843E+10
12. Y-91	5.014E+06	0.000E+00	1.341E+05	0.000E+00	0.000E+00	0.000E+00	2.759E+09
13. ZR-95	1.157E+06	3.710E+05	2.511E+05	0.000E+00	5.822E+05	0.000E+00	1.176E+09
14. NB-95	1.407E+05	7.825E+04	4.207E+04	0.000E+00	7.735E+04	0.000E+00	4.749E+08
15. RU-103	4.741E+06	0.000E+00	2.042E+06	0.000E+00	1.809E+07	0.000E+00	5.535E+08
16. RU-106	1.949E+08	0.000E+00	2.466E+07	0.000E+00	3.763E+08	0.000E+00	1.260E+10
17. AG-110M	1.136E+07	1.051E+07	6.241E+06	0.000E+00	2.066E+07	0.000E+00	4.289E+09
18. CD-115/115M	0.000E+00	5.327E+07	1.701E+06	0.000E+00	4.227E+07	0.000E+00	2.307E+09
19. SB-124	1.008E+08	1.094E+06	3.996E+07	2.444E+05	0.000E+00	7.848E+07	2.862E+09
20. SB-125	1.341E+08	1.498E+06	3.190E+07	1.363E+05	0.000E+00	1.034E+08	1.475E+09
21. TE-129M	2.978E+08	1.111E+08	4.714E+07	1.023E+08	1.243E+09	0.000E+00	1.500E+09
22. I-131	4.036E+07	5.773E+07	3.309E+07	1.892E+10	9.897E+07	0.000E+00	1.523E+07
23. I-133	1.039E+06	1.808E+06	5.511E+05	2.657E+08	3.155E+06	0.000E+00	1.625E+06
24. CS-134	4.546E+09	1.082E+10	8.844E+09	0.000E+00	3.501E+09	1.162E+09	1.893E+08
25. CS-136	4.237E+07	1.673E+08	1.204E+08	0.000E+00	9.307E+07	1.276E+07	1.901E+07
26. CS-137	6.641E+09	9.082E+09	5.949E+09	0.000E+00	3.083E+09	1.025E+09	1.758E+08
27. BA-140	1.283E+08	1.611E+05	8.404E+06	0.000E+00	5.478E+04	9.225E+04	2.641E+08
28. CE-141	1.943E+05	1.314E+05	1.491E+04	0.000E+00	6.104E+04	0.000E+00	5.024E+08
29. CE-144	3.151E+07	1.317E+07	1.692E+06	0.000E+00	7.814E+06	0.000E+00	1.066E+10
30. ND-147	3.367E+04	3.891E+04	2.328E+03	0.000E+00	2.275E+04	0.000E+00	1.868E+08

[1] Values for the dose parameters for all pathways are calculated by the PGandE "Tech. Spec." Code and based on Reg. Guide 1.109 or NUREG 0133.

[2] For Tritium and Carbon 14, the units of the dose parameters are mrem/yr per µCi/m^3 for all pathways, and they must be multiplied by X/Q.

TABLE 30
DOSE PARAMETERS[1], R_i FOR RADIOIODINES, RADIOACTIVE PARTICULATES, AND ANY RADIONUCLIDE OTHER THAN NOBLE GAS, GASEOUS EFFLUENTS, ANY AGE GROUP, GROUND PLANE PATHWAY
(m^2 mrem/yr per µCi/sec)

RADIONUCLIDE	R (GROUND)
1. H-3	0.000E+00
2. C-14	0.000E+00
3. CR-51	4.668E+06
4. MN-54	1.342E+09
5. FE-59	2.756E+08
6. CO-58	3.799E+08
7. CO-60	2.149E+10
8. ZN-65	7.501E+08
9. RB-86	9.005E+06
10. SR-89	2.230E+04
11. SR-90/Y90	4.482E+05
12. Y-91	1.183E+06
13. ZR-95	2.493E+08
14. NB-95	1.366E+08
15. RU-103	1.087E+08
16. RU-106	4.200E+08
17. AG-110M	3.482E+09
18. CD-115/115M	4.500E+06
19. SB-124	5.949E+08
20. SB-125	2.286E+09
21. TE-129M	2.001E+07
22. I-131	1.722E+07
23. I-133	2.474E+06
24. CS-134	6.833E+09
25. CS-136	1.491E+08
26. CS-137	1.030E+09
27. BA-140	2.054E+07
28. CE-141	1.360E+07
29. CE-144	6.958E+07
30. ND-147	8.481E+06

[1] Values for the dose parameters for all pathways are calculated by the PGandE "Tech. Spec." Code and based on Reg. Guide 1.109 or NUREG 0133.

TABLE 3P
DOSE PARAMETERS[1], P_i FOR RADIOIODINES, RADIOACTIVE PARTICULATES, AND ANY RADIONUCLIDE OTHER THAN NOBLE GAS, GASEOUS EFFLUENTS, ANY AGE GROUP, GROUND PLANE PATHWAY
(m^2 mrem/yr per µCi/sec)

RADIONUCLIDE	P (GROUND)
1. H-3	0.000E+00
2. C-14	0.000E+00
3. CR-51	6.667E+06
4. MN-54	1.098E+09
5. FE-59	3.922E+08
6. CO-58	5.272E+08
7. CO-60	4.400E+09
8. ZN-65	6.894E+08
9. RB-86	1.286E+07
10. SR-89	3.160E+04
11. SR-90/Y90	6.403E+03
12. Y-91	1.669E+06
13. ZR-95	3.487E+08
14. NB-95	1.956E+08
15. RU-103	1.551E+08
16. RU-106	2.992E+08
17. AG-110	3.143E+09
18. CD-115/115M	6.300E+06
19. SB-124	8.374E+08
20. SB-125	7.552E+08
21. TE-129M	2.856E+07
22. I-131	2.460E+07
23. I-133	3.502E+06
24. CS-134	2.813E+09
25. CS-136	2.129E+08
26. CS-137	1.147E+09
27. BA-140	2.934E+07
28. CE-141	1.942E+07
29. CE-144	5.855E+07
30. ND-147	1.212E+07

[1] Values for the dose parameters for all pathways are calculated by the PGandE "Tech. Spec." Code and based on Reg. Guide 1.109 or NUREG 0133.

TABLE 4A

DOSE PARAMETERS[1], $\overline{R_i}$ OR $\overline{P_i}$,
FOR RADIOIODINES, RADIOACTIVE PARTICULATE, AND
ANY NON-NOBLE GASES

SUPER AGE GROUP, CRITICAL ORGAN
INHALATION, COW-MILK-INGESTION, PATHWAYS

RADIONUCLIDE	INHALATION (MREM/YR PER μCi/M³)	MILK (M², MREM/YR PER μCi/SEC)
H 3[2]	1.3E+03 (teen total body)	2.4E+03[2] (inf. total body)
C 14[2]	3.6E+04 (child bone)	3.2E+06[2] (inf. bone)
Cr 51	2.1E+04 (teen lung)	7.5E+06 (teen GI-LLI)
Mn 54	2.0E+06 (" ")	3.1E+07 (inf. liver)
Fe 59	1.5E+06 (" ")	3.4E+08 (" ")
Co 58	1.3E+06 (" ")	9.1E+07 (teen GI-LLI)
Co 60	8.7E+06 (" ")	2.9E+08 (" ")
Zn 65	1.2E+06 (" ")	1.7E+10 (inf. liver)
Rb 86	2.0E+05 (child liver)	2.1E+10 (" ")
Sr 89	2.4E+06 (teen lung)	1.1E+10 (inf. bone)
Sr 90/Y90	1.1E+08 (teen bone)	1.0E+11 (" ")
Y91M/Y91	2.9E+06 (teen lung)	5.5E+06 (teen GI-LLI)
Zr 95	2.7E+06 (" ")	1.0E+06 (" ")
Nb 95M/95	7.5E+05 (" ")	2.9E+08 (" ")
Ru 103	7.8E+05 (" ")	1.3E+05 (" ")
Ru 106/Rh106M	1.6E+07 (" ")	1.5E+06 (" ")
Ag 110M	6.8E+06 (" ")	2.1E+10 (" ")

[1] Values for the dose parameters for all pathways are calculated by the PGandE "Tech. Spec." Code based on Reg. Guide 1.109 or NUREG 0133.

[2] For tritium and carbon-14, the units of the dose parameters are mrem/yr per μCi/m³ for all pathways, and they must be multiplied by X/Q.

TABLE 4A (cont'd)

DOSE PARAMETERS[1], $\overline{R_i}$ OR $\overline{P_i}$,
FOR RADIOIODINES, RADIOACTIVE PARTICULATE, AND
ANY NON-NOBLE GASES

SUPER AGE GROUP, CRITICAL ORGAN
INHALATION, COW-MILK-INGESTION, PATHWAYS

RADIONUCLIDE	INHALATION (MREM/YR PER µCi/M³)	MILK (M², MREM/YR PER µCi/SEC)
Cd 115/Cd 115M/ In 115M	2.8E+06 (teen lung/GI-LLI)	6.9E+07 (teen GI-LLI)
Sb 124	3.9E+06 (teen lung)	7.8E+08 (" ")
Sb 125	2.7E+06 (" ")	2.2E+08 (" ")
Te 129M	2.0E+06 (" ")	1.3E+09 (inf. kidney)
Cs 134	1.1E+06 (teen liver)	5.4E+10 (inf. liver)
Cs 136	1.9E+05 (" ")	5.5E+09 (" ")
Cs 137	9.1E+05 (child bone)	4.9E+10 (" ")
Ba 140	2.0E+06 (teen lung)	2.3E+08 (inf. bone)
Ce 141	6.1E+05 (" ")	1.5E+07 (teen GI-LLI)
Ce 144	1.3E+07 (" ")	1.3E+08 (" ")
Nd 147	3.7E+05 (" ")	6.9E+05 (" ")
Unidentified	1.1E+08	1.0E+11
I 131	1.6E+07 (child thyroid)	5.2E+11 (inf. thyroid)
I 133	3.8E+06 (" ")	4.8E+09 (" ")

[1] Values for the dose parameters for all pathways are calculated by the PGandE "Tech. Spec." Code based on Reg. Guide 1.109 or NUREG 0133.

[2] For tritium and carbon-14, the units of the dose parameters are mrem/yr per µCi/m³ for all pathways, and they must be multiplied by X/Q.

TABLE 4A (cont'd)

DOSE PARAMETERS[1], $\overline{R_i}$ OR $\overline{P_i}$,
FOR RADIOIODINES, RADIOACTIVE PARTICULATE, AND
ANY NON-NOBLE GASES

SUPER AGE GROUP, CRITICAL ORGAN
FARM-ANIMAL-MEAT-INGESTION, VEGETABLE-INGESTION PATHWAYS

RADIONUCLIDE	ANIMAL (MEAT) (M^2, MREM/YR PER µCi/SEC)	VEG (M^2, MREM/YR PER µCi/SEC)
H 3[2]	3.2E+02[2] (adult total body)	4.0E+03[2] (child tot body)
C 14[2]	5.3E+05[2] (child bone)	3.5E+06[2] (child bone)
Cr 51	1.6E+06 (adult GI-LLI)	1.2E+07 (adult GI-LLI)
Mn 54	2.2E+07 (" ")	9.4E+08 (" ")
Fe 59	1.8E+09 (" ")	9.8E+08 (teen GI-LLI)
Co 58	3.1E+08 (" ")	6.1E+08 (adult GI-LLI)
Co 60	1.1E+09 (" ")	3.2E+09 (teen GI-LLI)
Zn 65	1.0E+09 (adult liver)	2.7E+09 (child liver)
Rb 86	5.4E+08 (child liver)	4.6E+08 (" ")
Sr 89	4.2E+08 (child bone)	3.6E+10 (child bone)
Sr 90/Y90	1.0E+10 (adult bone)	1.4E+12 (" ")
Y91M/Y91	5.3E+08 (adult GI-LLI)	3.2E+09 (teen GI-LLI)
Zr 95	1.6E+09 (" ")	1.2E+09 (" ")
Nb 95M/95	6.8E+09 (" ")	4.7E+08 (adult GI-LLI)
Ru 103	1.1E+10 (" ")	5.7E+08 (teen GI-LLI)
Ru 106/Rh106M	1.5E+11 (" ")	1.5E+10 (" ")
Ag 110M	2.1E+09 (" ")	4.4E+09 (" ")

[1] Values for the dose parameters for all pathways are calculated by the PGandE "Tech. Spec." Code based on Reg. Guide 1.109 or NUREG 0133.

[2] For tritium and carbon-14, the units of the dose parameters are mrem/yr per $\mu Ci/m^3$ for all pathways, and they must be multiplied by X/Q.

TABLE 4A (cont'd)

DOSE PARAMETERS[1], $\overline{R_i}$ OR $\overline{P_i}$,
FOR RADIOIODINES, RADIOACTIVE PARTICULATE, AND
ANY NON-NOBLE GASES

SUPER AGE GROUP, CRITICAL ORGAN
FARM-ANIMAL MEAT-INGESTION, VEGETABLE-INGESTION PATHWAYS

RADIONUCLIDE	ANIMAL (MEAT) (M², MREM/YR PER µCi/SEC)	VEG (M², MREM/YR PER µCi/SEC)
Cd 115/Cd 115M/ In 115M	5.4E+07 (adult GI-LLI)	2.5E+09 (teen GI-LLI)
Sb 124	4.7E+08 (" ")	3.0E+09 (" ")
Sb 125	1.7E+08 (" ")	1.6E+09 (" ")
Te 129M	5.4E+09 (" ")	2.9E+09 (child kidney)
Cs 134	1.2E+09 (adult liver)	2.6E+10 (child liver)
Cs 136	4.5E+07 (" ")	2.2E+08 (" ")
Cs 137	1.1E+09 (child bone)	2.5E+10 (child bone)
Ba 140	5.7E+07 (adult GI-LLI)	2.8E+08 (" ")
Ce 141	3.2E+07 (" ")	5.3E+08 (teen GI-LLI)
Ce 144	3.9E+08 (" ")	1.3E+10 (" ")
Nd 147	3.9E+07 (" ")	1.9E+08 (adult GI-LLI)
Unidentified	1.5E+11	1.4E+12
I 131	2.7E+09 (child thyroid)	2.4E+10 (child thyroid)
I 133	6.7E+01 (" ")	4.1E+08 (" ")

[1] Values for the dose parameters for all pathways are calculated by the PGandE "Tech. Spec." Code based on Reg. Guide 1.109 or NUREG 0133.

[2] For tritium and carbon-14, the units of the dose parameters are mrem/yr per µCi/m³83 for all pathways, and they must be multiplied by X/Q.

TABLE 4B

DOSE PARAMETERS[1], $\overline{R_i}$ AND $\overline{P_i}$,

FOR RADIOIODINES, RADIOACTIVE PARTICULATE, AND
ANY RADIOACTIVE NON-NOBLE GASEOUS EFFLUENTS SUPER AGE GROUP,
CRITICAL ORGAN GROUND PLANE PATHWAY

RADIONUCLIDE	$\overline{R_i}$ ($\frac{M^2, MREM/YR}{UCI/SEC}$)	$\overline{P_i}$ ($\frac{M^2, MREM/YR}{UCI/SEC}$)
H 3	0	0
C 14	0	0
Cr 51	4.7E6	6.7E6
Mn 54	1.3E9	1.1E9
Fe 59	2.8E8	3.9E8
Co 58	3.8E8	5.3E8
Co 60	2.1E10	4.4E9
Zn 65	7.5E8	6.9E8
Rb 86	9.0E6	1.3E7
Sr 89	2.2E4	3.2E4
Sr 90/Y90	4.5E5	6.4E5
Y 91	1.2E6	1.7E6
Zr 95	2.5E8	3.5E8
Nb 95	1.4E8	2.0E8
RU 103	1.1E8	1.6E8
RU 106/Rh106M	4.2E8	3.0E8
Ag 110M	3.5E9	3.1E9
Cd 115/115M	4.5E6	6.3E6
Sb 124	6.0E8	8.4E8
Sb 125	2.3E9	7.6E8
Te 129M	2.0E7	2.9E7
Cs 134	6.8E9	2.8E9
Cs 136	1.5E8	2.1E8
Cs 137	1.0E9	1.1E9
Ba 140	2.1E7	2.9E7
Ce 141	1.4E7	1.9E7
Ce 144	7.0E7	5.9E7
Nd 147	8.5E6	1.2E7
I 131	1.7E7	2.5E7
I 133	2.5E6	3.5E6

[1] Values for the dose parameters for all pathways are calculated by the PGandE "Tech. Spec." Code based on Reg. Guide 1.109 or NUREG 0133.

TABLE 5A

DISPERSION PARAMETER, $\overline{X/Q}$ (sec/m^3), HISTORICAL "FIVE YEAR AVERAGE[1]

(Applies only to real and hypothetical individuals)

Distance ↓ / Sector →	NW	NNW	N	NNE	NE	ENE	E	ESE	SE
0.5 mi(0.8km) site boundary	3.79×10^{-6}	3.00×10^{-6}	1.55×10^{-6}	9.61×10^{-7}	-	-	-	-	-
0.68mi(1.08km) site boundary	-	-	-	-	7.45×10^{-7}	-	-	-	-
0.73mi(1.2km) site boundary	-	-	-	-	-	7.85×10^{-7}	-	-	-
1.06mi(1.69km) site boundary	-	-	-	-	-	-	8.38×10^{-7}	2.28×10^{-6}	-
1.19mi(1.9km) site boundary	-	-	-	-	-	-	-	-	2.22×10^{-6}
1.55mi(2.5km) residence	-	4.38×10^{-7} (333°)	-	-	-	-	-	-	-
2.0mi(3.2km) vegetable Farm	-	-	-	-	-	-	-	9.02×10^{-7} (122°)	-
3.3mi(5.3km) residence	-	-	-	4.46×10^{-8} (018.5°)	-	-	-	-	-
3.7mi(5.9km) residence	1.51×10^{-7} (326°)	-	-	-	-	-	-	-	-
4.4mi(7.1km) residence	-	-	3.23×10^{-8} (008°)	-	-	3.51×10^{-8} (062.5°)	-	-	-
4.5mi(7.26km) residence	-	-	-	-	-	-	6.82×10^{-8} (096.5°)	-	-
5.0mi(8.06km) imag milk cows	2.14×10^{-7}	1.82×10^{-7}	1.03×10^{-7}	5.08×10^{-8}	6.44×10^{-8}	7.85×10^{-8}	1.24×10^{-7}	3.06×10^{-7}	3.27×10^{-7}
5.1mi(8.2km) residence	-	-	-	-	2.41×10^{-8} (037°)	-	-	-	-

1 Based on hourly meteorological data from 1/1/82 to 12/31/86

TABLE 58

DISPERSION PARAMETER, $\overline{D/Q}$ (m^{-2}), HISTORICAL "FIVE YEAR AVERAGE[1]

(Applies to real, virtual and hypothetical (ground plane) individuals only)

Sector → Distance ↓	NW	NNW	N	NNE	NE	ENE	E	ESE	SE
0.5mi(0.8km) s.b.cattle,gnd	1.47×10^{-8}	7.49×10^{-9}	3.76×10^{-9}	2.49×10^{-9}	-	-	-	-	-
0.68mi(1.08km) s.b.cattle,gnd	-	-	-	-	1.59×10^{-9}	-	-	-	-
0.73mi(1.2km) s.b.cattle,gnd	-	-	-	-	-	1.81×10^{-9}	-	-	-
1.06mi(1.69km) s.b.cattle,gnd	-	-	-	-	-	-	1.90×10^{-9}	3.76×10^{-9}	-
1.19mi(1.9km) s.b.cattle,gnd	-	-	-	-	-	-	-	-	1.81×10^{-8}
1.55mi(2.5km) res. meat, gnd	-	8.66×10^{-10} (333°)	-	-	-	-	-	-	-
2.0mi(3.2km)½res. veg. meat, gnd	-	-	-	-	-	-	-	5.53×10^{-9}	-
3.3mi(5.3km) res. meat, gnd	-	-	-	9.84×10^{-11} (018.5°)	-	-	-	-	-
3.7mi(5.9km) res. meat, gnd	4.02×10^{-10} (326°)	-	-	-	-	-	-	-	-
4.4mi(7.1km) res. meat, gnd	-	-	5.95×10^{-11} (008°)	-	-	8.67×10^{-11} (062.5°)	-	-	-
4.5mi(7.26km) res. meat, gnd	-	-	-	-	-	-	1.67×10^{-10} (096.5°)	-	-
5.0mi(8.08km) imag milk cows	-	1.40×10^{-10}	7.06×10^{-11}	4.67×10^{-11}	4.96×10^{-11}	6.77×10^{-11}	1.28×10^{-10}	4.62×10^{-10}	
5.1mi(8.2km) res. meat, gnd	-	-	-	-	4.52×10^{-11} (037°)	-	-	-	-

1 Based on hourly meteorological data from 1/1/82 to 12/31/86

TABLE 6

LOCATIONS FOR CANDIDATE DOSE (R_1) AND DOSE RATE (P_1) RECIPIENTS

Distance \ Sector	NW	NNW	N	NNE	NE	ENE	E	ESE	SE
0.5mi(0.8km)	site boundary[1]	site boundary[1]	site boundary[1]	site boundary[1]		X	X	X	X
0.68mi(1.08km)	-	-	-	-	site boundary[1]				
0.73mi(1.2km)	-	-	-	-	-	site boundary[1]	X	X	X
1.04mi(1.68km)	-	-	-	-	-	-	site boundary[1]	site boundary[1]	X
1.18mi(1.9km)	-	-	-	-	-	-	-	-	site boundary[1]
1.55mi(2.5km)	-	residence[2] (az=333°)	-	-	-	-	-	-	-
2.0mi(3.2km)	-	-	-	-	-	-	-	vegetable farm[3]	-
3.3mi(5.3km)	-	-	-	residence[2] (az=018.5°)	-	-	-	-	-
3.7mi(5.9km)	residence[2] (az=326°)	-	-	-	-	-	-	-	-
4.4mi(7.1km)	-	-	residence[2] (az=008°)		-	residence[2] (az=062.5°)	-	-	-
4.5mi(7.26km)	-	-	-	-	-	-	residence[2] (az=084.5°)	-	-
5.0mi(8.06km)	X	imaginary milk cows[4]	imaginary milk cows[4]	imaginary milk cows[4]	imaginary milk cows[4]	imaginary milk cows[4]	imaginary milk cows[4]	imaginary milk cows[4]	X
5.1mi(8.2km)	X	X	X	X	residence[2] (az=037°)	X	X	X	X

[1]Site boundary locations encompass the entire sector azimuth-wise, but are at the distance to the sector center-line-site boundary intersection. At these locations, the candidate dose and dose rate recipients for airborne radioactive iodines and particulates are: the hypothetical individuals exposed to only the inhalation and ground plane pathways as well as virtual individuals exposed to only the cattle-meat-animal pathway. Also at these locations, the hypothetical individual can simultaneously be exposed to the noble gas, whole body and skin dose rate while dose-wise the noble gas gamma air dose and beta air dose serve as the Tech. Spec. surrogate.

[2]Residence locations contain real individuals which can simultaneously be exposed to not only noble gas, whole body (and skin) doses as well as dose rates, but also to inhalation, ground plane, (meat) animal and possible vegetable pathway doses, as well as dose rates. Here the meteorological dispersion parameters X/Q and D/Q are computed not just to the distance in the containing sector, but also to the residence azimuth location.

[3]A vegetable farm in the ESE sector at 2 miles is occupied by migrant workers (real individuals - all age groups) with an occupancy factor of 0.5 applied to external doses (and dose rates) received from the noble gases and non-nobles via the ground plane deposition pathway plus the inhalation diffusion pathway. However, these individuals are also assumed to receive non noble meat and vegetable ingestion pathway doses (and dose rates) with an occupancy factor of 1. Additionally the virtual individual, recipient only to indirect vegetable injestion dose (and dose rates), exists independently here. This type of individual is so defined since although not present to receive the direct noble gas external exp[illegible] non-noble ground plane and inhalation doses (or dose rates), can none-the-less receive indirectly doses from th[illegible] grown proximate to the plant and conceivably shipped away.

[4]Milk cows, although not evidenced by the land use census within 5 miles (of plant site) are none-the-less represented here fictitiously as a default dose contributor (as desired by the NRC) at 5 miles in all land sectors. Like at the vegetable farm and site boundary grazing meat animals, this dose source manifests itself through creation of the virtual individual as defined in footnote 3," above.

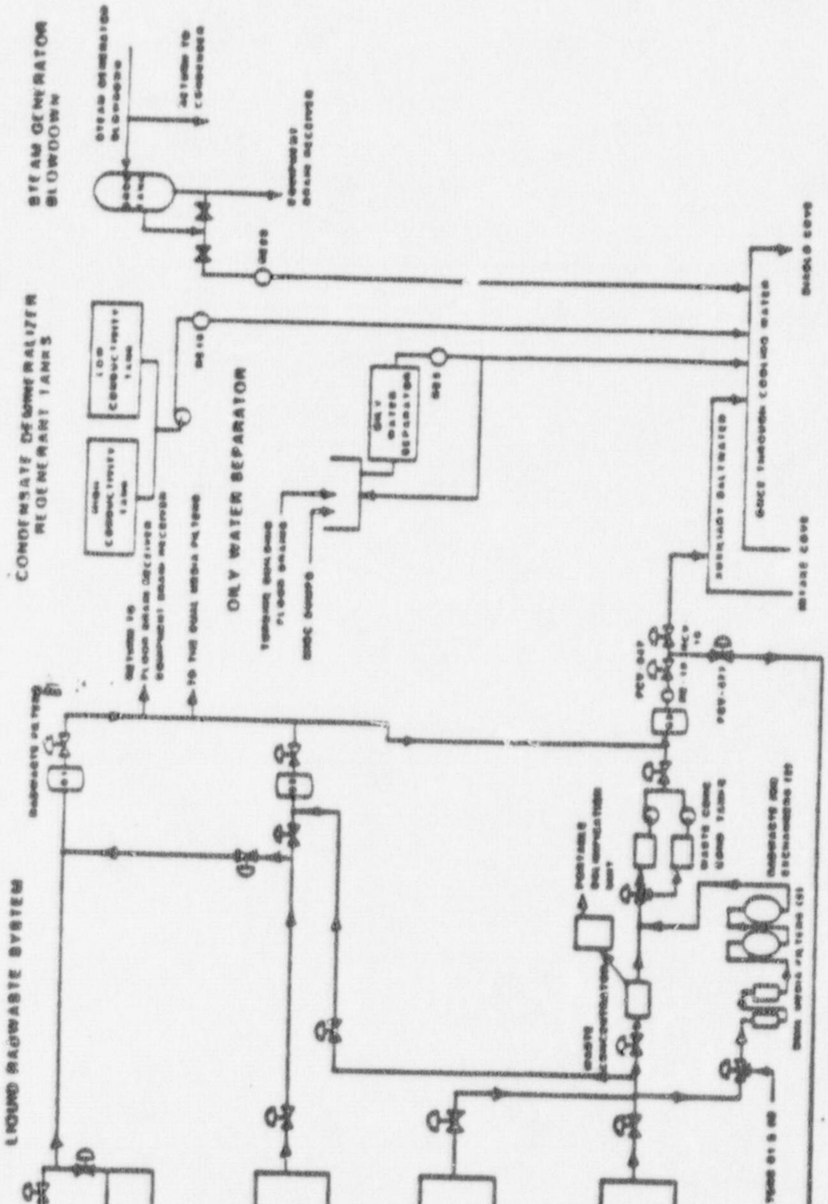


FIGURE 1
LIQUID DISCHARGES MONITORED FOR RADIOACTIVITY

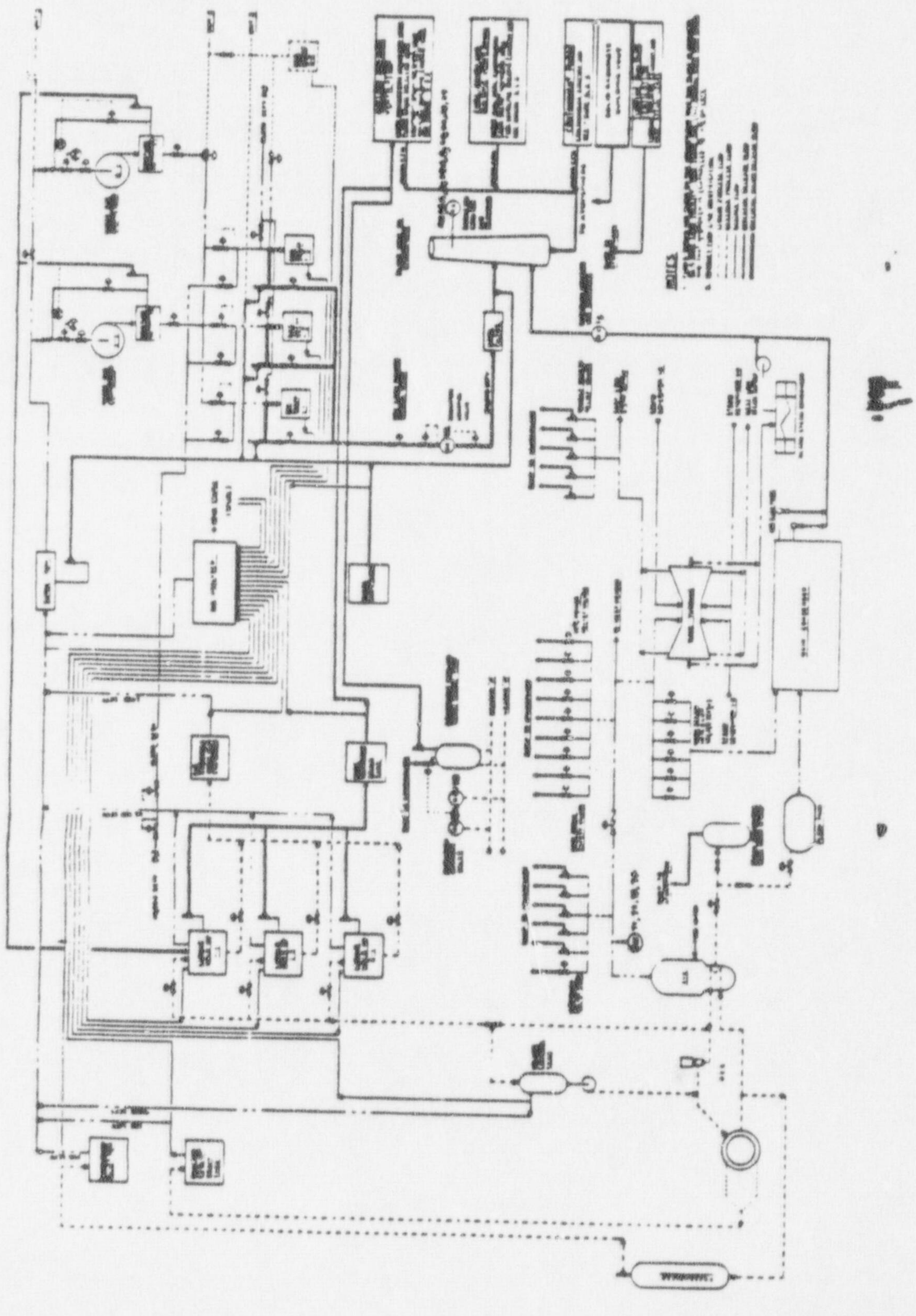
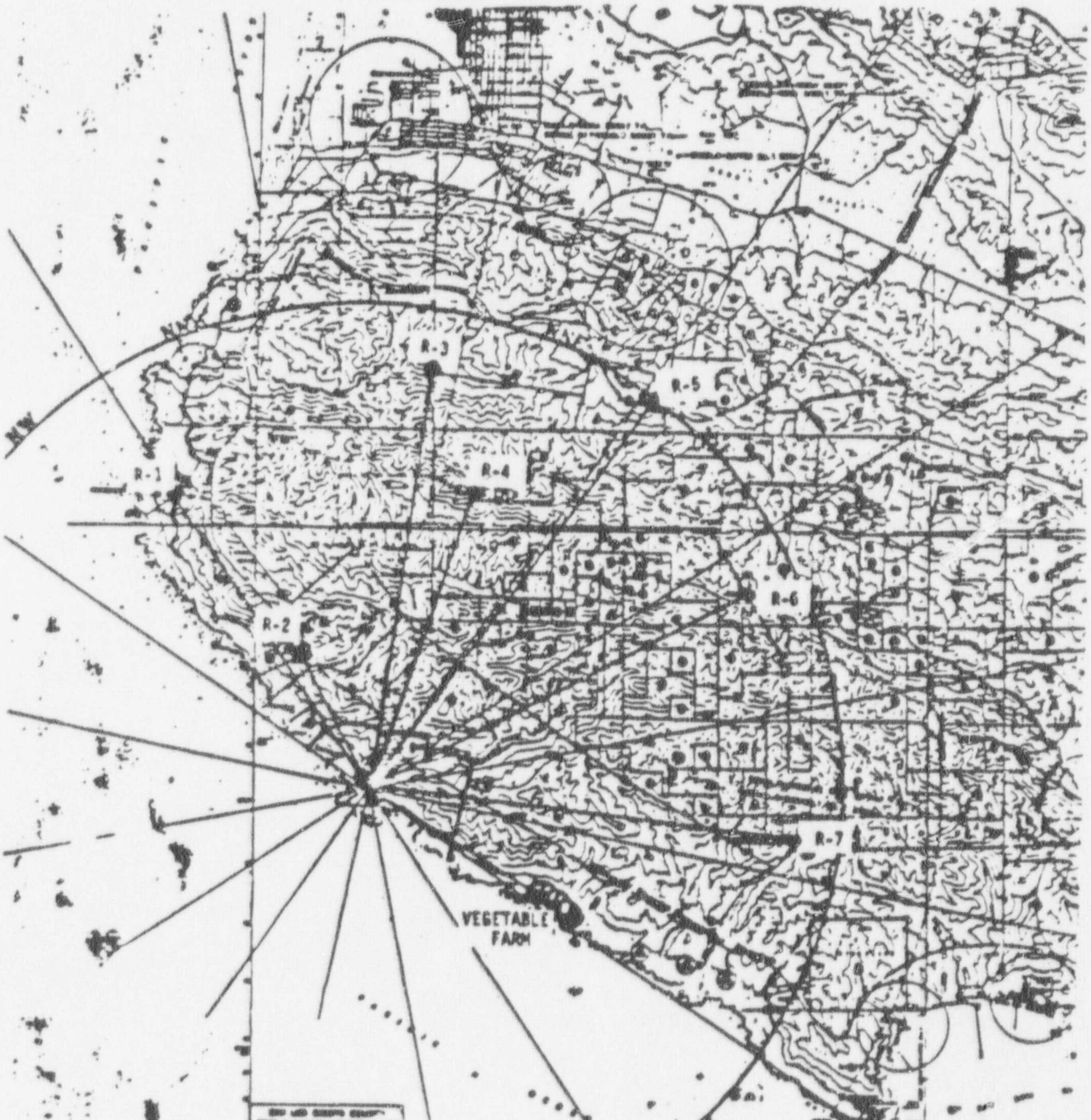


FIGURE 2
GASEOUS RELEASES MONITORED FOR RADIOACTIVITY

FIGURE 3

SECTOR MAP SHOWING RECEPTOR LOCATIONS



APPENDIX 1

Here the constituents, ΔF, to the Liquid Effluent radiation monitor high alarm set point expressions as displayed in 1.c. are expounded upon in more detail. From these, it is relatively effortless to see how equations (2) through (7) were derived.

1. RE-18 (Subscript "b")

   The ΔF_b term is assembled from the other sources, as,

$$\Delta F_b = \sum_{\substack{j=1 \\ j \neq b}}^{5} \frac{C_j F_j}{MPC_j}$$

   The C&RP Engineer will specify the ΔF_b made up of choices on $\frac{C_j}{MPC_j}$ and F_j. The choices are as follows:

   a. If there is a discharge already in progress from any (or all) of the other potential sources ($j \neq b$), then use the actual values of $\frac{C_j}{MPC_j}$ and F_j.

   b. If there is a planned discharge from any of the other potential sources ($j \neq b$) which might occur during batch "b" discharge and wherein pre-release analysis data also provides a $\frac{C_j}{MPC_j}$, then use this value and the maximum default value of F_j.

APPENDIX 1 (Continued)

c. In the absence of any pre-release data, yet there is possibility of a discharge from these other sources ($j \neq b$) occurring during batch "b's" discharge, then select a max conservative value of the $\left(\frac{C_j}{MPC_j}\right)$ from a recent history of such values also the maximum default value of F_j.

d. With the assurance that no "jth" discharge will occur during the batch "b's" discharge, then select $\left(\frac{C_j}{MPC_j}\right) = 0$ for that other "jth" potential source.

2. RE-23 (Subscript "1" for Unit 1 - Subscript "2" for Unit 2)

As in 1. (above), assemble the $\Delta F_{1(2)}$ term as:

$$\Delta F = \sum_{\substack{j=b,3,4,5,2(1) \\ j \neq 1(2)}} \left(\frac{C_j F_j}{MPC_j}\right)$$

Again as in 1., the C&RP Engineer will specify the $\Delta F_{1(2)}$ makeup of the following choices on $\left(\frac{C_j}{MPC_j}\right)$ and F_j:

a. If there is a discharge from any (or all) of the other potential sources already in progress, then use the actual values of $\left(\frac{C_j}{MPC_j}\right)$ and F_j in these discharges $j \neq b$. For the $\left(\frac{C_b}{MPC_b}\right)$ contribution, the C&RP Engineer can select from a recent history (within 2 weeks) of such values the maximum (hence most conservative) along with F_j = max default value.

APPENDIX 1 (Continued)

b. If there is a proposed "jth" discharge ($j \neq b$) which may coincide or overlap with this discharge and for which a pre-release analysis gives the values of $\frac{C_j}{MPC_j}$, then use these values along with the max default F_j. For the $\frac{C_b}{MPC_b}$ and F_b contributions, use the same as instructed in 2.a. above.

c. If there are no discharges from the "jth" sources ($j \neq b$) and no pre-release data on $j \neq b$, then enter "0" for these contributions to the $\Delta F_{1(2)}$. For the $\frac{C_b}{MPC_b}$ and F_b contributions, use the same as instructed in 2.a. and/or 2.b. above.

3. RE-3 (Subscript "3")

As in 2. above, the ΔF_3 is generated by exactly the same instructions with the exception of merely permuting the subscript "3" with the subscripts "1" (or "2"), namely:

$$\Delta F_3 = \sum_{\substack{j=b,1,2,4,5 \\ j \neq 3}} \left(\frac{C_j F_j}{MPC_j} \right)$$

4. RE-16 (Subscript "4" for Unit 1 - Subscript "5" for Unit 2)

As in 2. above, the $\Delta F_{4(5)}$ are generated by exactly the same instructions as in 2. with the exception of merely permuting the subscripts "4(5)" with the subscripts "1(2)", namely:

$$\Delta F_{4(5)} = \sum_{\substack{j=b,1,2,3,5,(4) \\ j \neq 4(5)}} \left(\frac{C_j F_j}{MPC_j} \right)$$

5. Allowable flowrates and/or Batch Volumes as a Liquid Radwaste Release Limiting Criteria

a. M.P.C. or Maximum Allowable Flowrate (MAF) Limiting - T.S. 3/4.11.1.1(10CFR20)

Appendix 1 (Continued)

$$^{MAF}F_j = \frac{F(j) - \Delta F_j}{C_j/MPC_j} \quad \text{(from 1., 2., 3. or 4. above)}$$

NOTE: because F contains F_c and F_j, one can either use $F_j = F_j'$, the rated flowrate for the pump in stream of "j^{th}" release or simply $F \simeq F_c(j)$ since $F_c >> F_j$, in any case. This also applies to b. and c. below.

b. H.A.S.P. Limiting Flowrate (i.e., "turning" the procedure's main body equation (2) through (7) "inside out")

$$^{HASP}F_j = (F-\Delta F_j)\left\{\frac{^jHASP_{calc}(existing) - {}^jBkgd}{\gamma\, k_j}\left[\frac{1}{RCS_{C_\gamma}'}\sum_{\beta \neq H3}\frac{RCS_{C_\beta}}{MPC_\beta} + \frac{1}{RCS_{MPC_\gamma'}}\right] + \frac{RCS_{C_{H3}}}{MPC_{H3}} + \frac{C_j}{MPC_j}\right\}^{-1}$$

Note: $^{j=b,3}HASP_{calc}(existing) = 10^{(\log_{10}Actual\ HASP + 0.3)}$ and $^{j=1,2}HASP_{calc}(existing) = \frac{Actual\ HASP}{0.7}$

Also the bracketed "[ ]" term as well as $^{RCS}C_{H3}/MPC_{H3}$ is a slowly varying constant and at most calculated quarterly.

Here, as seen in 1.c. of the procedure's main body, one has

$$^{RCS}MPC_\gamma' \equiv \left(\sum {}^{RCS}f_{\gamma i}' / MPC_i\right)^{-1}, \text{ where } {}^{RCS}f_{\gamma i}' = \frac{RCS_{C_i}\, e^{-\lambda_i (1\ day)}}{RCS_{C_\gamma'}} \quad (i = \gamma\text{'s only}).$$

$$\text{and } {}^{RCS}C_\gamma' \equiv \sum_{\substack{i \neq H3 \\ i \neq \beta}} {}^{RCS}C_i\, e^{-\lambda_i (1\ day)}, \quad (\beta \text{ usually} = \text{Sr 89 and Sr 90/Y90})$$

c. *31-Day-Dose Projection Limiting Volume - T.S. 3./4.11.1.3.

$$^{31DDP}V_{MAX\ j} = \frac{V_j'}{_{(0,1,2)}d_\tau}\left[\frac{1}{31}\left\{\begin{matrix}0.2mrem, (\neq w.b.) \\ or \\ 0.06mrem, (= w.b.)\end{matrix}\right\}(T+\tau) - {}_{(0,1,2)}PM_{D_\tau} - {}_{(0,1,2)}d_\tau\right] \text{(from 1.d. of procedure)}$$

Note: $V_j' \equiv F_j' \Delta t_j(max)$, where F_j' is the rated flowrate of "j^{th}" release pump and

$\Delta t_j(max)$ = maximum time proposed for release, or alternately

$V_j' \equiv$ maximum capacity of tank for proposed "j^{th}" release

APPENDIX 2

1. NOBLE GASES

Two important entities are generated for triggering the effluents engineer and the attendant rad monitor's valving automatics to allow or disallow a radioactive gaseous batch release. Concerned here are the only two gaseous batch release sources, the Gas Decay Tanks and the Containment Purge (or venting), which efflux through the plant vent. The expressions controlling these decision entities are found in the main body of this procedure through equations (9)-and (10). Equation (9) is preferentially selected over equation (10) since, almost without exception, the whole body dose rate calculation always seems to predominate over the skin dose rate calculation (i.e., with regard to the most conservative dose rate limitation). Although the Technical specification assigns a 500 mrem/yr (whole body dose rate) overall limitation to both units, the calculation here will conservatively assign a 250 mrem/yr limit per Unit in this procedure's equation (9).

These key entities are the percent release rate limit (P.R.R.L.) and attendant rad monitor high alarm set point (H.A.S.P). Although the local attendant rad monitors for noble gas releases from the gas decay tanks and containment are respectively RE-22 and RE-12 the final attendant effluent rad monitor is RE-14A and RE-14B. Consequently for each batch release from either containment or gas decay tank whether a projected HASP for RE-12 or RE-22 is calculated, a projected HASP for RE-14A and RE-14B must also always be calculated. Lastly, since the procedure partitions 99% of all gaseous releases to the plant vent and 1% to the steam generator blowdown tank vent (at least with regard to dose rates) then equation (9)'s usage will have a 0.99 multiplication factor.

Now the analytics implementing all of this is as follows.

a. % Release Rate Limit (P.R.R.L.) and High Alarm Set Point (H.A.S.P.)

Define the batch flow rate F*, which adds to the existing plant vent flow rate (F_{pv}). This can be from either the containment ($F^* = F_{ct}$, usually 55000cfm) or from the gas decay tanks ($F^* = F_{GDT}$, usually 31 cfm). This means that during a batch release (whether from containment or gas decay tank) the new plant vent flow rate will be $F_{pv} + F^*$.

Now looking at some other definitions needed, one has the set $C_i'(NG)$ and their total $C_T'(NG)$ where, $C_i'(NG)$ is the concentration of noble gas isotope "i" (in µCi/cc) in the plant vent just prior to discharge of the batch, (containment or gas decay tank), with $C_T'(NG) = \Sigma C_i'(NG)$ The C_i's come from the last known sample analysis as scaled by RE-14 ratios. Additionally there is the set $C_i''(NG)$ and its total, $C_T''(NG) = \Sigma C_i''(NG)$, which define isotopic noble gas concentrations (and total) in the batch about to be released (i.e., containment or gas decay tank). The C_i'''s come from the batch's pre-release sample analysis. Companion to these are the relative isotopic fractions, namely:

$$f_i' = C_i'/C_T' \text{ and } f_i'' = C_i''/C_T'' \tag{1}$$

Now during the discharge the new plant vent concentration, $C_i(NG)$, will be the following sum, with the batch addition dilution scaled (by flowrate ratios) i.e.:

$$C_i = \left(\frac{F_{pv}}{F_{pv} + F^*}\right) C_i' + \left(\frac{F^*}{F_{pv} + F^*}\right) C_i'' \quad (\mu Ci/cc) \tag{2}$$

Similarly from this set (equation2) the new plant vent total concentration of noble gases is $C_T(NG) = \Sigma C_i$, and the relative isotopic fractions:

$$f_i(NG) = C_i/C_T = \frac{F_{pv}\, C_i' + F^* C_i''}{F_{pv}\, C_T' + F^* C_T''}$$

This is easily seen, since

$$C_T = \left(\frac{1}{F_{pv} + F^*}\right)\left(F_{pv}\, C_T' + F^*\, C_T''\right)$$

At this point one calls equation (9) from the main body of this procedure and rearranges it in view of the earlier (above) constraints and equation (3)
along with the fact that, $\dot{Q}_i$ (μCi/sec) = 472 F (cfm) C_i(μCi/cc), namely:

$$^{MAX}C_T \ (NG) = \frac{0.99 \times 250 \text{ mrem/yr}}{472\ (F_{pv} + F^*)(\overline{X/Q})_{C/L\ MAX} \sum_i K_i\ f_i\ (NG)} \qquad (4)$$

where: K_i is the noble gas "i" whole body dose factor and

$(\overline{X/Q})_{C/L\ MAX}$ is the maximum historical "five year" running average "controlling location's" (usually-sector-center-line-at-site boundary) meteorological diffusion dispersion factor - See Tables 2 and 5A of this procedure.

NOTE: One can see that since $^{MAX}C_i(NG) = {}^{MAX}C_T(NG)\ f_i(NG)$

and the fact that F_{pv} and F* as well as $(\overline{X/Q})$ are independent of i, then they can be factored out from under the "$\sum_i$" sign.

Obviously from equation (4), $^{MAX}C_T(NG)$ sets the limit on what can be

released for all the relative isotopic mixes involved with this particular batch release. From this it is an easy matter to express simple percent for what is actually released (assuming all the f_i's, f_i's and f_i's hold fixed).

For this, using a knowledge of C''_T, C'_T, C_T and equation (4), one has:

$$\text{P.R.R.L.*} = \frac{C''_T(NG)}{^{MAX}C''_T(NG)} \times 100 = \frac{C_T(NG)}{^{MAX}C_T(NG)} \times 100 \leq 100\% \qquad (5)$$

or finally

$$\text{P.R.R.L.*} = 191(F_{pv}\ C'_T + F^*\ C''_T)\ (\overline{X/Q})_{C/L\ MAX} \sum_i K_i\ f_i\ (NG) \qquad (6)$$

A note of clarification is in order. By examination of equation (6), the P.R.R.L.* is the percent that $\dot{C}_T$ (NG) represents out of a potential limit ${}^{MAX}\dot{C}_T$ (NG), which this discharge can impose as it is added to an already existing and radiologically restrained effluent stream. To see that those are, indeed, release rates being compared, one only has to multiply both numerator and denominator of the R.H.S. of (5) by

$472F^*$ to get $\dot{Q}_T$ / ${}^{MAX}\dot{Q}_T$.

Now for the H.A.S.P. one simply has

$$H.A.S.P._{RE22\ (or\ RE12)} = Bkg_{RE22\ (or\ RE12)} + k_{RE22\ (or\ RE12)}\ {}^{MAX}C''_T(NG)$$

where:

$$k_{RE22\ (or\ RE12)} = \Sigma\ f''_i\ (NG)\ k_i\ (RE22\ or\ RE12),$$

and ${}^{MAX}C''_T(NG)$ = ${}^{MAX}C_T(NG)\ C''_T(NG)/C_T(NG)$ in addition

to using equation (1) and CAP D-19 values for k_i (RE22 or RE12)

Likewise:

$$HASP_{RE14} = Bkg_{RE14} + k_{RE14}\ {}^{MAX}C_T(NG)$$

Using equation (3) and again CAP D-19 values for k_i(RE14)

$$k_{RE14} = \sum_i f_i\ (NG)\ k_i\ (RE14)$$

Finally from these calculated values of the HASP (RE22, RE12, or RE14), a usable high alarm set point is needed for the actual setting or comparing with what is already physically on the instrument (rad monitor) itself. This is called projected HASP and take into account the I&C uncertainty factor correction. It is given as:

$$proj.\ HASP \le 10^{(\log_{10} HASP\ (calc)\ -0.3)}$$

and must be entered on the release permit as called for in this procedure. This applies to RE22, RE12, RE14A and 14B.

All of the above is performed automatically by the computer software per each pre-release analysis. The software also calculates a projected reading of the radiation monitor

vis-a-'vis the C_i'' (or C_i') and $^{22}k_i$ (or $^{12}k_i$, or $^{14}k_i$).

Generally if the proj. HASP is greater than the existing setting (from previous releases) then no action is taken. That is, Operations and I&C do not have to change the HASP on the monitor unless the projected reading calculation shows that, although less than proj. HASP, it is yet larger than the existing HASP. In this case the HASP should be changed upward to the proj. HASP so the release can be legally discharged. On the other hand should the proj. HASP be less than the existing HASP, then the release cannot be discharged until the HASP is changed to the proj. HASP.

2. IODINES, PARTICULATES AND TRITIUM

As with noble gases in section 1. of Appendix 2 we are concerned with a similar entity, in the so called P.R.R.L. except it is being applied only to containment. It is assumed that the only significant nuclides for the gas decay tank are the noble gases. Also only the P.R.R.L. will be developed but no H.A.S.P., this is because there is no iodine rad monitor on containment nor does the plant vent iodine monitor possess any automatics to isolate containment. Equation (13) from the main body of this procedure is the controlling expression here, which comes directly under T.S. (L.C.O.) 3.11.2.1.b. Although the Technical Specifications assigns a 1500 mrem/yr dose to any organ limitation to be applied to the site's both units, the calculation here will conservatively assign 750 mrem/yr limit per unit. Also to simplify the calculation and at the same time maintain conservatism, the formulae will use the so-called super-age group/critical-organ dose rate factors $\overline{P}_i$, found in table 4 of this procedure. This in effect selects the highest dose rate factor across the seven (7) major organs amongst the four (4) principle age groups, all for each radionuclide (I.P.T.).

Similarly, as with noble gases in 1. above, one defines F_{ct} as the containment purge (or vent) flow rate (usually 55000 cfm), and F_{pv} as the plant vent flow rate prior to containment purge.

Also C_i'(I.P.T.) is the concentration of the radioparticulate isotope, or radioiodine or tritium (in µCi/cc) found in the plant vent just prior to containment purge. The C_i''s come from the last plant vent sample analysis. Similarly C_i'' (I.P.T.) is that same I.P.T. isotope found in containment before the purge and comes from the pre-release analysis for I.P.T.'s in containment

As described above:

$$f_i'(IPT) = \frac{C_i'(IPT)}{C_T'(IPT)}, \text{ with } C_T'(IPT) = \sum_i C_i'(IPT) \text{ and } f_i''(IPT) = \frac{C_i''(IPT)}{C_T''(IPT)}, \text{ with } C_T''(IPT) = \sum_i C_i''(IPT)$$

$$\text{Also } C_i(IPT) = \left(\frac{F_{pv}}{F_{pv} + F_{ct}}\right) C_i' + \left(\frac{F_{ct}}{F_{pv} + F_{ct}}\right) C_i'' \text{ with } C_T(IPT) = \sum_i C_i(IPT)$$

and $f_i(IPT) = C_i(IPT)/C_T(IPT)$

From this one also sees that

$$C_T(IPT) = \frac{1}{(F_{pv} + F_{ct})} \left[F_{pv}C_T'(IPT) + F_{ct}\, C_T''(IPT)\right]$$

$$\text{and } \frac{C_T''(IPT)}{C_T(IPT)} = (F_{pv} + F_{ct}) \left[\frac{C_T''(IPT)}{F_{pv}C_T'(IPT) + F_{ct}\, C_T''(IPT)}\right]$$

At this point, one recalls equation (13) from the main body of this procedure and rearranges it in view of the above constraints and the definition of F_i(IPT) along with the fact that $\dot{Q}_i$(µCi/sec) = 472 F(cfm)C_i(µCi/cc):

$$ {}^{mx}C_{IPT} = {}^{mx}_{SB}C_T(IPT) = \frac{750}{472\,(F_{pv} + F_{ct})\left(\left[{}^{inh}\bar{P}_{H3}f_{H3} + {}^{inh}\bar{P}_{I131}\,f_{I131} + {}^{inh}\bar{P}_{I133}\,f_{I133} + \sum_p {}^{inh}\bar{P}_p\,f_p\right]\bar{X}/Q^{(MAX)}_{c/ISB} + \left[{}^{gp}\bar{P}_{I131}\,f_{I131} + {}^{gp}\bar{P}_{I133}\,f_{I133} + \sum_p {}^{gp}\bar{P}_p f_f\right]\bar{D}/Q_{c/ISB}\right)} \quad (7) $$

$$ {}^{mx}C_{IPT} = {}^{mx}_{VF}C_T(IPT) = \frac{750}{472\,(F_{pv} + F_{ct})\left\{\left(1/2\left[{}^{inh}\bar{P}_{H3}f_{H3} + {}^{inh}\bar{P}_{I131}f_{I131} + {}^{inh}\bar{P}_{I133}f_{I133} + \sum_p {}^{inh}\bar{P}_p f_p\right] + \left[\left({}^{am}\bar{P}_{H3} + {}^{v}\bar{P}_{H3}\right)f_{H3}\right]\right)\bar{X}/Q_{VF} + \left[\left({}^{am}\bar{P}_{I131} + {}^{v}\bar{P}_{I131} + 1/2\;{}^{gp}\bar{P}_{I131}\right)f_{I131} + \left({}^{am}\bar{P}_{I133} + {}^{v}\bar{P}_{I133} + 1/2\;{}^{gp}\bar{P}_{I133}\right)f_{I133} + \sum_p\left({}^{am}\bar{P}_p + {}^{v}\bar{P}_p + 1/2\;{}^{gp}\bar{P}_p\right)f_p\right]\bar{D}/Q_{VF}\right\}} \quad (8) $$

$$ {}^{mx}C_{IPT} = {}^{mx}_{SMID}C_T(IPT) = \frac{750}{472\,(F_{pv} + F_{ct})\left({}^{cm}\bar{P}_{H3}f_{H3}\;\bar{X}/Q^{(MAX)}_{SMID} + \left[{}^{cm}\bar{P}_{I131}f_{I131} + {}^{cm}\bar{P}_{I133}f_{I133} + \sum_p {}^{cm}\bar{P}_p f_p\right]\bar{D}/Q_{SMID}\right)} \quad (9) $$

From the 3 leading candidates for "controlling location" above, choose smallest ${}^{MX}C_T(IPT)$ and call it ${}^{mx}_{(MIN)}C_T(IPT)$

Then ${}^{MAX}C_T''(IPT) = \frac{C_T''(IPT)}{C_T(IPT)} \; {}^{mx}_{(MIN)}C_T(IPT)$

and $(P.R.R.L.)_{IPT} = \frac{C_T''(IPT)}{{}^{MAX}C_T''(IPT)} \times 100\%$

i	${}^{inh}\bar{P}_i$	${}^{cm}\bar{P}_i$	${}^{gp}\bar{P}_i$	${}^{a,v,g}\bar{P}_i = {}^{am}\bar{P}_i + {}^{v}\bar{P}_i + \frac{1}{2}\,{}^{gp}\bar{P}_i$
H 3	1.3E3	2.4E3	0	4.32E3
Cr 51	2.1E4	7.5E6	6.7E6	1.70E7
Mn 54	2.0E6	3.1E7	1.1E9	1.51E9
Fe 59	1.5E6	3.4E8	3.9E8	2.98E9
Co 58	1.3E6	9.1E7	5.3E8	1.19E9
Co 60	8.7E6	2.9E8	4.4E9	6.50E9
Zn 65	1.2E6	1.7E10	6.9E8	4.05E9
Rb 86	2.0E5	2.1E10	1.3E7	1.00E9
Sr 89	2.4E6	1.1E10	3.2E4	3.64E10
SR 90/Y 90	1.1E8	1.0E11	6.4E3	1.41E12
Y91m/Y91	2.9E6	5.5E6	1.7E6	3.73E9
Zr 95	2.7E6	1.0E6	3.5E8	2.98E9
Nb 95M/Nb 95	7.5E5	2.9E8	2.0E8	7.37E9
Ru 103	7.8E5	1.3E5	1.6E6	1.16E10
Ru 106/Rh 106m	1.6E7	1.5E6	3.0E8	1.65E11
Ag 110m	6.8E6	2.1E10	3.1E9	8.05E9
Cd 115m/Cd115/ In115m	2.8E6	6.9E7	6.3E6	3.56E9
Sb 124	3.9E6	7.8E8	8.4E8	3.89E9
Sb 125	2.7E6	2.2E8	7.6E8	2.15E9
Te 129M	2.0E6	1.3E9	2.9E7	8.32E9
Cs 134	1.1E6	5.4E10	2.8E9	2.86E10
Cs 136	1.9E5	5.5E9	2.1E8	3.70E8
Cs 137	9.1E5	4.9E10	1.1E9	2.67E10
Ba 140	2.0E6	2.E38	2.9E7	3.52E8
Ce 141	6.1E5	1.5E7	1.9E7	5.72E8
Ce 144	1.3E7	1.3E8	5.9E7	1.35E10
Nd 147	3.7E5	6.9E5	1.2E7	2.35E8
UnId	1.1E8	1.0E11	3.1E9	1.55E12
I-131	1.6E7	5.2E11	2.5E7	2.67E10
I-133	3.8E6	4.8E9	3.5E6	4.12E8

Equation (7), (8) and (9) in view of the values for $\bar{P}_i$'s and current met data from tables 5A and 5B simplify to the following:

$$ {}^{mx}C_{SB\ T(IPT)} = \frac{1}{(F_{pv} + F_{ct})[0.0031 f_{H3} + 38.4 f_{I131} + 9.06 f_{I133} + \sum_{p} (2.39E\text{-}6\ {}^{inh}\bar{P}_p + 0.925E\text{-}8\ {}^{gp}\bar{P}_p) f_p]} \qquad (10) $$

or

$$ {}^{mx}C_{VF\ T(IPT)} = \frac{1}{(F_{pv} + F_{ct})[0.00282 f_{H3} + 97.4 f_{I131} + 2.51 f_{I133} + \sum_{p} (2.84E\text{-}7\ {}^{inh}\bar{P}_p + 3.48E\text{-}9\ {}^{a.v.gp}\bar{P}_p) f_p]} \qquad (11) $$

or

$$ {}^{mx}C_{SMID\ T(IPT)} = \frac{1}{(F_{pv} + F_{ct})\,[0.000462 f_{H3} + 151 f_{I131} + 1.40 f_{I133} + 2\text{[illegible]-}10 \sum_{p} {}^{cm}\bar{P}_p\, f_p]} \qquad (12) $$

In view of the foregoing expressions and equations (10), (11) and (12) one finally has,

$$ SB_{(P.R.R.L.)_{IPT}} = 100[F_{pv} C_T^{'}(IPT) + F_{ct} C_T^{*}(IPT)][0.0031 f_{H3} + 38.4 f_{I131} + 9.06 f_{I133} + \sum_{p} (2.39E\text{-}6\ {}^{inh}\bar{P}_p + 0.925E\text{-}8\ {}^{gp}\bar{P}_p) f_p] \qquad (13) $$

or

$$ VF_{(P.R.R.L.)_{IPT}} = 100[F_{pv} C_T^{'}(IPT) + F_{ct} C_T^{*}(IPT)][0.00282 f_{H3} + 97.4 f_{I131} + 2.51 f_{I133} + \sum_{p} (2.84E\text{-}7\ {}^{inh}\bar{P}_p + 3.48E\text{-}9\ {}^{a.v.gp}\bar{P}_p) f_p] \qquad (14) $$

or

$$ SMID_{(P.R.R.L.)_{IPT}} = 100[F_{pv} C_T^{'}(IPT) + F_{ct} C_T^{*}(IPT)][0.000462 f_{H3} + 151 f_{I131} + 1.40 f_{I133} + 2.91E\text{-}10 \sum_{p} {}^{cm}\bar{P}_p\, f_p] \qquad (15) $$

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