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WASHINGTON PUBLIC POWER SUPPLY SYSTEM

WNP-2

OFFSITE DOSE CALCULATION MANUAL

OFFSITE DOSE CALCULATION MANUAL

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1.0 INTRODUCTION

The purpose of this manual is to provide the information and methodologies to be used by the Washington Public Power Supply System to ensure compliance with the dose requirements stated in the WNP-2 Effluents Technical Specifications.

2.0 LIQUID EFFLUENT DOSE CALCULATION

2.1 Introduction

Liquid radwaste released from WNP-2 will meet 10 CFR 20 limits at the point of discharge to the Columbia River. This design objective will be kept at all times. Based on the radionuclides mixture obtained from the WNP-2 GALE liquid computer run and Columbia River dilution flow, a theoretical, continuous concentration of radionuclides at 10 CFR 20 limits at the point of discharge to the Columbia River will result in compliance with 10 CFR 50 Appendix I limits in the unrestricted areas. Actual discharges of liquid radwaste effluents will only occur on a Batch Bases, and the average concentration at the point of discharge will be only a small percentage of the allowed limits.

The cumulative quarterly dose contributions due to radioactive liquid effluents released to the unrestricted areas will be determined once every 31 days using the NRC LADTAP computer code. The maximum exposed individual is assumed to be an adult whose exposure pathways include potable water and fish consumption. The choice of an adult as the maximum exposed individual is based on the highest fish and water consumption rates shown by that age group and the fact that most of the dose from the liquid effluent comes from these two pathways.

The dose contributions will be calculated for all radionuclides identified in the released effluent. The calculations are based on guidelines provided by the NRC Nureg-0133 and the LADTAP computer code.

The methods for calculating the doses are discussed in Section 2.4 of this manual.

2.2 Radwaste Liquid Effluent Radiation Monitoring System

This monitoring subsystem measures the radioactivity in the liquid effluent prior to its entering the cooling tower blowdown line.

All radwaste effluent passes through a four-inch line which has an off-line sodium iodide radiation monitor. The radwaste effluent flow, variable from 0 to 190 gpm, combines with the 36-inch cooling water blowdown line, variable from 0 to 7500 gpm, (average of 2690 gpm) and is discharged to the Columbia River with a total flow based on MPC_i total, and cooling water flushing needs.

The radiation monitor has a minimum sensitivity of 10^{-6} μCi/cc of C_s-137), and the radiation indicator has a range of seven decades. The radiation monitor is located on the 437' level of the Radwaste Building.

2.3 10 CFR 20 Release Rate Limits

The requirements pertaining to discharge of radwaste liquid effluents to the unrestricted area are specified in Technical Specification 3.11.1.1:

> "The concentration of radioactive material released from the site to unrestricted areas shall be limited to the concentrations specified in 10 CFR 20, Appendix B, Table II, Column 2 for radionuclides other than noble gases, and 2×10^{-4} μCi/ml total activity concentratra-tion for all dissolved or entrained noble gases."

In order to comply with the requirements stated above, limits will be set to assure that blowdown line concentrations do not exceed 10 CFR 20, Appendix B, Table II, Column 2 at any time.

2.3.1 Pre-Release Calculation

The activity of the radionuclide mixture will be determined in accordance with Supply System procedure PPM 12.5.3. Liquid effluent discharge is determined and calculated according to PPM New 12.11.1 Radiological Effluent Monitoring Report. The effluent concentration is determined by the following equation:

$$Con_{Ci} = \frac{Ci}{\left(\frac{Fw+FD}{Fw}\right)} \qquad (1)$$

where:

Con_{Ci} = Concentration of radionuclide i in the effluent at point of discharge - μCi/ml.

Ci = Concentration of radionuclide i in the batch to be released - μCi/ml.

Fw = Discharge flow rate from sample tank to the blowdown line - variable from 0 to 190 gpm.

Fd = Blowdown flow rate - variable from 0 to 7500 gpm.

The calculated concentration in the blowdown line must be less than the concentrations listed in 10 CFR 20, Appendix B. Before releasing the batch to the environment, the following equation must hold:

$$\sum_{i=1}^{m} (Con_{Ci}/MPC_i) \leq 1 \qquad (2)$$

where:

Con_{Ci} = The concentration of radionuclide i in the effluent at the point of discharge.

MPC_i = Maximum permissible concentration of nuclide i as listed in 10 CFR 20, Appendix B, Table II.

m = Total number of radionuclides in the batch.

2.3.2 Post-Release Calculation

The concentration of each radionuclide in the restricted area, following the batch release, will be calculated as follows:

The average activity of radionuclide i during the time period of the release is divided by the Plant Discharge Flow/Tank Discharge Flow ratio yielding the concentration at the point of discharge:

$$Con_{Cik} = \frac{Cik \times Fw}{Fw + FD} \qquad (3)$$

where:

Con_{Cik} = The concentration of radionuclide i in the effluent at the point of discharge during the release period k - (μCi/ml).

Cik = The concentration of radionuclide i in the batch during the release period k - (μCi/ml).

Fw = Discharge flow rate from sample tank to the blowdown line - variable from 0 to 190 gpm.

FD = Blowdown flow rate - variable from 0 to 7500 gpm.

To assure compliance with 10 CFR 20, the following relationships must hold:

$$\sum_{i=1}^{m} (Con_{Cik}/MPC_i) \leq 1 \qquad (4)$$

where the terms are as defined in Equation (2).

2.3.3 Continuous Release

Continuous release of liquid radwaste effluent is not planned for WNP-2. However, should it occur, the concentrations of various radionuclides in the

unrestricted area would be calculated according to Equation (3) and Equation (4). To show compliance with 10 CFR 20, the two equations must again hold.

2.4 10 CFR 50, Appendix I, Release Rate Limits

Standard Technical Specification 3.11.1.2 requires that the cumulative dose contributions be determined in accordance with the ODCM at least once per 31 days. It specifies that the dose to the individual from radioactive material in liquid effluents released to the unrestricted area should be limited to:

$\leq$ 1.5 mrem/Calendar Quarter - Total Body

and

$\leq$ 5.0 mrem/Calendar Quarter - Any Organ.

The cumulative dose for the calendar year shall be limited to:

$\leq$ 3 mrem - Total Body

and

$\leq$ 10 mrem - Any Organ.

The dose contribution will be calculated for all radionuclides identified in the liquid effluent released to the unrestricted area, using the following equation:

$$D_j = \sum_i \left(A_{ij} \sum_{\ell=1}^{m} T_l C_{il} F_\ell \right) \tag{5}$$

where:

D_j = The cumulative calendar quarter or yearly dose to any organ j from liquid effluent for the total release period - (in mrem).

T_l = The length of the lth release period over which C_i and F_l are averaged for liquid releases - (in hours).

m = The number of releases for the time period under consideration.

C_{il} = Average concentration of nuclide i in the liquid effluent at point of discharge during the release period T_l from any liquid release - (μCi/ml).

A_{ij} = The site-related ingestion dose factor to the total body or critical organ j for each identified nuclide listed in Table 2-2 (in mrem/hr per μCi/ml).

F_ℓ = The near field average dilution factor for C_{il} during any liquid waste release. Defined as the ratio of the average radwaste discharge flow during the release to the product of the average flow from the site structure to unrestricted receiving waters times 100. This is a conservative value since the average river flow is 120,000 cfs and blowdown rate is only 6 cfs.

$$\left(F_\ell = \frac{\text{Liquid Radwaste Flow}}{\text{Discharge Structure Exit x 100}}\right) \qquad (6)$$

The term A_{ij}, the ingestion dose factors for the total body and critical organs, are tabulated in Table 2-2. It embodies the dose factor, fish bioaccumulation factor, pathway usage factor, and the dilution factor for the plant diffuser pipe to the nearest potable water intake. The following equation was used to calculate the ingestion dose factors:

$$A_{ij} = K_o\left(\frac{U_w}{D_w} + U_F B_{Fi}\right)D_{Fi} \qquad (7)$$

where:

A_{ij} = The composite dose parameter for total body or critical organ of an adult for nuclide i (in mrem/hr per μCi/ml).

K_o = A conversion factor:
1.14E+05 = $\left[(10^6 \text{ pCi}/\mu\text{Ci}) \times (10^3 \text{ ml/liter})\right] \div 8760$ hr/yr.

U_w = 730 liter/yr - which is the annual water consumption by the maximum adult (Table E-4 of Regulatory Guide 1.109).

B_{Fi} = Bioaccumulation factor for radionuclide i in fish - (pCi/Kg per pci/liter) (Table A-1 of Regulatory Guide 1.109).

D_{Fi} = Adult ingestion dose conversion factor for nuclide i - Total body or critical organ - (mrem/pCi).

D_w = Dilution factor from near field area to the nearest potable water intake - 200.

U_F = Adult fish consumption, 21 kg/yr (Table E-4 of Regulatory Guide 1.109).

The values of BF_i and DF_i are listed in Table 2-1.

The quarterly limits mentioned before represent one-half of the annual design objective of Section II.A of 10 CFR 50, Appendix I. If any of the limits (either that of the calendar quarter or calendar year) are exceeded, a special report pursuant to Section IV.A of 10 CFR 50, Appendix I, shall be filed with the NRC.

2.4.1 Projection of Doses

The projected doses due to releases of WNP-2 radwaste liquid effluents will be calculated for each batch, using equation 5. If the sum of the accumulated dose to date for the month and the projected dose for the remainder of the month exceeds the technical specification 3.11.1.3 limits, then the liquid radwaste treatment system shall be used. This is to ensure compliance with Standard Technical Specification 3.11.1.3. This technical specification states that the liquid radwaste treatment system shall be maintained and the appropriate subsystem shall be used if the radioactive materials in liquid waste, prior to their discharge, when the dose, due to liquid effluent release to unrestricted areas when averaged over the month would exceed 0.06 mrem to total body or 0.2 mrem to any organ.

2.5 Radwaste Liquid Effluent Dilution Ratio and Alarm Setpoints Calculations

2.5.1 Introduction

The dilution alarm ratio and setpoints of the sample liquid effluent monitor are established to ensure that the limits of 10 CFR 20, Appendix B, Table II, Column 2, are not exceeded in the effluent at the discharge point (i.e., compliance with Standard Technical Specification 3.11.1.1, as discussed in section 2.3.1 of this manual).

The trip/alarm setpoint for the liquid radwaste effluent monitor is calculated from the results of the radiochemical analysis of the waste solution. The setpoint will be set into the radwaste monitor just prior to the release of each batch of radioactive liquid.

2.5.2 Methodology for Determining the Dilution Ratio

Prior to discharge, the tank is isolated and recirculated for at least two liquid volumes, and a representative sample is taken from the tank. An isotopic analysis of the batch will be made to determine the dilution ratio required to comply with 10 CFR 20 limits. Radwaste liquid effluents can only be discharged to the environment through the four-inch radwaste line. The maximum radwaste discharge flow rate is 190 gpm. Typical circulating water blowdown flow is approximately 2700 gpm, which would resulting in a dilution factor of 14 at the maximum radwaste flow.

From the sample analysis and the MPC_i values, a dilution ratio (D.R.) is calculated using the following equation:

$$D.R. = \sum_{i=1}^{m} \frac{Ci}{MPC_i} \qquad (8)$$

where:

D.R. = The dilution ratio required for compliance with 10 CFR 20, Appendix B, Table II, Column 2.

Ci = The undiluted concentration of radionuclide i in the batch to be released - μCi/mℓ

MPC_i = 10 CFR 20, Appendix B, Table II, Column 2, maximum permissible concentration for nuclide i - μCi/mℓ

m = The total number of radionuclides in the batch to be released.

If the dilution ratio is equal to or less than one:

$$D.R. \leqslant 1 \qquad (9)$$

Than the tank may be discharged at any circulating water or radwaste blow downrate.

If the dilution ratio (D.R.) exceeds unity (D.R. 1); discharge rates are set such that:

$$Fm \leqslant \frac{Fd}{D.R. - 1} \qquad (10)$$

where:

Fm = The maximum allowed discharge flow rate from the liquid waste storage tank - the maximum pump rate is 190 gpm.

Fd = The actual plant dilution flow rate - (circulating water blowdown flow rate).

5.2.3 Set Point Determinations

The calculation for the radiation monitor's alarm/trip point is as follows:

For D.R. ≥1:

$$\text{Setpoint (max.)} = \left[\left(\sum_{i=1}^{m} C_i \times E_{fi} + \text{Background}\right)\right] \times Fd/Fm \quad (12a)$$

For D.R.<1:

$$\text{Setpoint} = \left[\left(\sum_{i=1}^{m} C_i \times E_{fi} + \text{Background}\right)\right] \times Fd/Fw \quad (12b)$$

where:

C_i = undiluted concentration of radionuclide i in the batch to be released in μCi/ml.

E_{fi} is the radiation monitors response to nuclide i.

To assure of never exceeding the MPC_i limit, the setpoint will be set at 50 percent of the setpoint (max.).

2.6 Verification of Compliance with 10 CFR 50, Appendix I, and 10 CFR 20, Appendix B

Verification of compliance with 10 CFR 50, Appendix I, and 10 CFR 20, Appendix B, dose limits will be achieved by following WNP-2 Plant Operating Procedures for liquid discharge and a monthly run of LADTAP computer code.

2.7 Methods for Calculating Doses to Man From Liquid Effluent Pathways

Dose models presented in NRC Regulatory Guide 1.109, as incorporated in the LADTAP computer code, will be used for offsite dose calculation. The details of LADTAP, including the program listing and user instruction, are included in the Offsite Dose Calculation Reference Manual (ODCRM).

2.7.1 Radiation Doses

Radiation doses from potable water, aquatic food, shoreline deposit, and irrigated food pathways will be calculated by using the following equations:

a. Potable Water

$$R_{apj} = 1100 \frac{U_{ap}M_p}{F} \sum_i Q_i D_{aipj} \exp(-\lambda_i t_p) \qquad (13)$$

b. Aquatic Foods

$$R_{apj} = 1100 \frac{U_{ap}M_p}{F} \sum_i Q_i B_{ip} D_{aipj} \exp(-\lambda_i t_p) \qquad (14)$$

c. Shoreline Deposits

$$R_{apj} = 110{,}000 \frac{U_{ap}M_p W}{F} \sum_i Q_i T_i D_{aipj} \left[\exp(-\lambda_i t_p)\ (1 - \exp(-\lambda_i t_b)\right] \qquad (15)$$

d. Irrigated foods

For all radionuclides except tritium:

$$R_{apj} = U_{ap}^{veg} \sum_i d_i \exp(-\lambda_i t_h) D_{aipj} \left[\frac{r\left[1 - \exp(-\lambda_{Ei} t_e)\right]}{Y_v \lambda_{Ei}} + \frac{f_I B_{iv} \left[1 - \exp(-\lambda_i t_b)\right]}{P\lambda_i} \right]$$

$$+ U_{ap}^{animal} \sum_i F_{iA} D_{aipj} \left[Q_F d_i \exp(-\lambda_i t_h) \frac{r\left[1 - \exp(-\lambda_{Ei} t_e)\right]}{Y_v \lambda_{Ei}} \right.$$

$$\left. + \frac{f_I B_{iv} \left[1 - \exp(-\lambda_i t_b)\right]}{P\lambda_i} + C_{iAw} Q_{Aw} \right] \qquad (16)$$

For tritium:

$$R_{apj} = U_{ap}^{veg} C_v D_{apj} + U_{ap}^{animal} D_{apj} F_A (C_v Q_F + C_{Aw} Q_{Aw}) \quad (17)$$

where:

B_{ip} The equilibrium bioaccumulation factor for nuclide i in pathway p, expressed as the ratio of the concentration in biota (in pCi/kg) to the radionuclide concentration in water (in pCi/liter), in liters/kg.

B_{iv} The concentration factor for uptake of radionuclide i from soil by edible parts of crops, in pCi/kg (wet weight) per pCi/kg dry soil.

C_{iAw} The concentration of radionuclide i in water consumed by animals, in pCi/liter.

C_{iv} The concentration of radionuclide i in vegetation, in pCi/kg.

D_{aipj} The dose factor specific to a given age group a, radionuclide i, pathway p, and organ j, which can be used to calculate the radiation dose from an intake of a radionuclide, in mrem/pCi, or from exposure to a given concentration of a radionuclide in sediment, expressed as a ratio of the dose rate (in mrem/hr) and the areal radionuclide concentration (in pCi/m^2).

d_i — The deposition rate of nuclide i, in pCi/m^2 per hour.

F — The flow rate of the liquid effluent, in ft^3/sec.

f_I — The fraction of the year crops are irrigated, dimensionless.

F_{iA} — The stable element transfer coefficient that relates the daily intake rate by an animal to the concentration in an edible portion of animal product, in pCi/liter (milk) per pCi/day or pCi/kg (animal product) per pCi/day.

M_p — The mixing ratio (reciprocal of the dilution factor) at the point of exposure (or the point of withdrawal of drinking water or point of harvest of aquatic food), dimensionless.

P — The effective "surface density" for soil, in kg (dry soil)/m^2 (Table E-1, Regulatory Guide 1.109).

Q_{Aw} — The consumption rate of contaminated water by an animal, in liters/day.

Q_F — The consumption rate of contaminated feed or forage by an animal, in kg/day (wet weight).

Q_i — The release rate of nuclide i, in Ci/yr.

r — The fraction of deposited activity retained on crops, dimensionless (Table E-15, Regulatory Guide 1.109).

R_{apj} — The total annual dose to organ j of individuals of age group a from all of the nuclides i in pathway p, in mrem/yr.

t_b — The period of time for which sediment or soil is exposed to the contaminated water, in hours (Table E-15, Regulatory Guide 1.109).

t_e — The time period that crops are exposed to contamination during the growing season, in hours (Table E-15, Regulatory Guide 1.109).

t_h — A holdup time that represents the time interval between harvest and consumption of the food, in hours (Table E-15, Regulatory Guide 1.109).

T_i — The radioactive half life of nuclide i, in days.

t_p — The average transit time required for nuclides to reach the point of exposure. For internal dose, t_p is the total time elapsed between release of the nuclides and ingestion of food or water, in hours (Table E-15, Regulatory Guide 1.109).

U_{ap} — A usage factor that specifies the exposure time or intake rate for an individual of age group a associated with pathway p, in hr/yr, ℓ/yr, or kg/yr (Table E-5, Regulatory Guide 1.109).

W	The shoreline width factor, dimensionless (Table A-2, Regulatory Guide 1.109).
Y_v	The agricultural productivity (yield), in kg (wet weight) /m^2 (Table E-15, Regulatory Guide 1.109).
λ_{Ei}	The effective removal rate constant for radionuclide i from crops, in hr^{-1}, where $\lambda_{Ei} = \lambda_i + \lambda_w$, λ_i is the radioactive decay constant, and λ_w is the removal rate constant for physical loss by weathering (Regulatory Guide 1.109, Table B-15).
λ_i	The radioactive decay constant of nuclide i, in hr^{-1}.
1100	The factor to convert from $(Ci/yr)/(ft^3/sec)$ to pCi/liter.
110,000	The factor to convert from $(Ci/yr)/(ft^3/sec)$ to pCi/liter and to account for the proportionality constant used in the sediment radioactivity model.

These equations yield the dose rates to various organs of individuals from the exposure pathways mentioned above.

2:7.2 Plant Parameters

WNP-2 is a river shoreline site with a variable effluent discharge flow rate 0 to 7500 gpm (2690 gpm average). The population center nearest WNP-2 is the city of Richland, where drinking water withdrawal takes place. The applicable dilution factor is 20,000, using full river flow. The time required for released liquids to reach Richland, approximately 12 miles downstream, is estimated at 4.5 hours. Richland is the "realistic case" location, and doses calculated for the Richland location are typically applicable to the population as a whole. Individual and population doses based on Richland parameters are calculated for all exposure pathways.

Only the 75,000 population downstream of the WNP-2 site is affected by the liquid effluents released. There is no significant commercial fish harvest in the 50-mile radius region around WNP-2. Sportfish harvest is estimated at 14,000 kg/year.

For irrigated foods exposure pathways, it can be assumed that production within the 50-mile radius region around WNP-2 is sufficient to satisfy consumption requirements.

Other relevant parameters relating to the irrigated foods pathways are defined as follows:

Food Type	Irrigation Rate (liter/m^2/mo)	Productivity (kg/m^2)	Growing Period (Days)
Vegetation	150	5.0	70
Leafy Vegetation	200	1.5	70
Feed for Milk Cows	200	1.3	30
Feed for Beef Cattle	160	2.0	130

Source terms are measured based on sampled effluent.

Table 2-3 summarizes the LADTAP input parameters. Documentation and/or calculations of these parameters are discussed in detail in the WNP-2 ODCRM, and Rad. Prog. calculation Log 83-1.

2.8 Compliance with Technical Specification 3.11.1.4

2.8.1 Maximum Allowable Liquid Radwaste Activity in Temporary Radwaste Hold-Up Tanks

The use of temporary liquid radwaste hold-up tanks is planned for WNP-2. Technical Specification 3.11.1.4 limits the amount of liquid radwaste stored in the tanks to 10 curies, except for tritium and dissolved noble gases. The

surveillance requirements state that the quantity of radioactive material in the hold-up tank shall be determined at least once per seven days when radioactive material is added to the tank.

2.8.2 Maximum Allowable Liquid Radwaste in Tanks That Are Not Surrounded by Liners, Dikes, or Walls

Although permanent outside liquid radwaste tanks which are not surrounded by liners, dikes, or walls are not planned for WNP-2, Equation 18 will be used should such tanks become necessary in the future.

$$A_T = \frac{K_d}{\sum_i \frac{fi}{MPC_i \; e^{-\lambda i t}}} \qquad (18)$$

where:

A_T = Total allowed activity in tank (curies).

MPC_i = Maximum permissible concentration of radionuclide i (10 CFR 20, Appendix B, Table II, Column 2).

λ_i = Decay constant ($years^{-1}$) radioisotope i.

t = Transit time of ground water from WNP-2 to WNP-1 well (WNP-2 FSAR Section 2.4) = 67 years.

fi = Fraction of radioisotope $i = \frac{A_i}{\sum Ai}$.

i = All radioisotopes in tank except tritium and noble gases.

K_d = Dispersion constant based on hydrological parameters.

= 2.4E+5 Ci per μCi/cc.

The total allowed activity (A_T) is based on limiting WNP-1 well water to less than 1 MPC_i of the entire liquid content of the tank spilled to ground and then migrated via ground water to the WNP-1 well. The WNP-1 well is the loca- tion of maximum concentration since it is the nearest source of ground water and conditions are such that no spill of liquid would reach surface water. The 70-85 foot depth of the water table and the low ambient moisture of the soil requires a rather large volume of spillage for the liquid to even reach the water table in less than several hundred years. However, allowed tank activity (A_T) is conservatively based on all liquid radwaste in the tank instantaneously reaching the water table.

The hydrological analysis performed for the WNP-2 FSAR (Section 2.4) determined that the transit time through the ground water from WNP-2 to the WNP-1 well is 67 years for Strontium and 660 years for Cesium. These two radionuclides are representative of the radionuclides found in liquid radwaste. Strontium is a moderate sorber and Cesium strongly sorbs to soil particles. This calculation conservatively treats all radionuclides as moderate sorbers with a transit time of 67 years.

The concentration of each radionuclide in the well (CW_i) is simply the concentration in the tank (CT_i) adjusted for radioactive decay during transit ($e^{-\lambda t}$) and divided by the concentration reduction factor (CFR min). Limiting well concentration to 1 MPC_i yields:

$$\sum \frac{CW_i}{MPC_i} = 1 = \sum \frac{CT_i \, e^{-\lambda t}}{CFR_{min} MPC_i} \quad \text{(From page 2.4 of WNP-2 FSAR.)} \qquad (19)$$

$$CFR_{min} = \frac{(4\pi L)^{3/2} \, (\alpha_x \, \alpha_Y \, \alpha_z)^{1/2}}{2V} \qquad (20)$$

where:

L = Migration distance = 1 mile.

V = Volume of tank.

$\alpha_X, \alpha_Y, \alpha_Z$ = Dispersion constants.

Combining Equations 2 and 3 yields:

$$1 = \sum \frac{CT_i \; 2V \; e^{-\lambda_i t}}{(4\pi L)^{3/2}(\alpha_X \; \alpha_Y \; \alpha_Z)^{1/2} MPC_i} \qquad (21)$$

Substituting A_i for CT_i V and reorganizing terms yields:

$$\frac{(4\pi L)^{3/2}(\alpha_X \; \alpha_Y \; \alpha_Z)^{1/2}}{2} = \sum \frac{A_i}{MPC_i \; e^{+\lambda_i t}} \qquad (22)$$

Making the following substitutions

$$A_i = f_i \; A_T$$

$$K_d = \frac{(4\pi L)^{3/2}(\alpha_X \; \alpha_Y \; \alpha_Z)^{1/2}}{2} \times 10^{-6} Ci/\mu Ci = 2.4 \times 10^{5} \text{ Ci per } \frac{\mu Ci}{cc} \qquad (23)$$

yields:

$$K_d = A_T \sum \frac{f_i}{MPC_i e^{-\lambda t}}$$

or

$$A_T = K_d \sum \frac{f_i}{MPC_i e^{-\lambda t}} \qquad \text{(Equation 18)}$$

Table 2-1

FISH BIOACCUMULATION FACTORS (BF_i)(1)
AND ADULT INGESTION DOSE CONVERSION FACTORS (DF_i)(2)

Nuclide	Fish Bioaccumulation Factor (BF_i) (PCi/kg per PCi/liter)	Dose Conversion Factor (DF_i)				
		Total Body	Bone	Thyroid	Liver	GI Tract
H-3	9.0E-01	1.1E-07	____(3)	1.1E-07	1.1E-07	1.1E-07
Na-24	1.0E+02	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06
P-32	1.0E+05	7.5E-06	1.9E-04	____(3)	1.2E-04	2.2E-05
Cr-51	2.0E+02	2.7E-09	____(3)	1.6E-09	____(3)	6.7E-07
Mn-54	4.0E+02	8.7E-07	____(3)	____(3)	4.6E-06	1.4E-05
Mn-56	4.0E+02	2.0E-08	____(3)	____(3)	1.2E-07	3.7E-06
Fe-55	1.0E+02	4.4E-07	2.8E-06	____(3)	1.9E-06	1.1E-06
Fe-59	1.0E+02	3.9E-06	4.3E-06	____(3)	1.0E-05	3.4E-05
Co-58	5.0E+01	1.7E-06	____(3)	____(3)	7.5E-07	1.5E-05
Co-60	5.0E+01	4.7E-06	____(3)	____(3)	2.1E-06	4.0E-05
Ni-65	1.0E+02	3.1E-08	5.3E-07	____(3)	6.9E-08	1.7E-06
Cu-64	5.0E+01	3.9E-08	____(3)	____(3)	8.3E-08	7.1E-06
Zn-65	2.0E+03	7.0E-06	4.8E-06	____(3)	1.5E-05	9.7E-06
Zn-69	2.0E+03	1.4E-09	1.0E-08	____(3)	2.0E-08	3.0E-09
Br-83	4.2E+02	4.0E-08	____(3)	____(3)	____(3)	5.8E-08
Br-84	4.2E+02	5.2E-08	____(3)	____(3)	____(3)	4.1E-13
Rb-89	2.0E+03	2.8E-08	____(3)	____(3)	4.0E-08	2.3E-21
Sr-89	3.0E+-1	8.8E-06	3.1E-04	____(3)	____(3)	4.9E-05
Sr-90	3.0E+01	1.9E-03	7.6E-03	____(3)	____(3)	2.2E-04

(1)NRC Regulatory Guide 1.109, Table A-1.

(2)NRC Regulatory Guide 1.109, Table E-11.

(3)No data listed in Regulatory Guide 1.109, Table E-11. (Use whole body dose conversion factor as an approximation.)

Table 2-1 (contd.)

Nuclide	Fish Bioaccumulation Factor (BF_i) (PCi/kg per PCi/liter)	Dose Conversion Factor (DF_i) Total Body	Bone	Thyroid	Liver	GI Tract
Sr-91	3.0E+01	2.3E-07	5.7E-06	____(3)	____(3)	2.7E-05
Sr-92	3.0E+01	9.3E-08	2.2E-06	____(3)	____(3)	4.3E-05
Y-90	2.5E+01	2.6E-10	9.7E-09	____(3)	____(3)	1.0E-04
Y-91m	2.5E+01	3.5E-12	9.1E-11	____(3)	____(3)	2.7E-10
Y-91	2.5E+01	3.8E-09	1.4E-07	____(3)	____(3)	7.8E-05
Y-92	2.5E+01	2.5E-11	8.5E-10	____(3)	____(3)	1.5E-05
Y-93	2.5E+01	7.4E-11	2.7E-09	____(3)	____(3)	8.5E-05
Mo-99	1.0E+01	8.2E-07	____(3)	____(3)	4.3E-06	1.0E-05
Tc-99m	1.5E+01	8.9E-09	2.5E-10	____(3)	7.0E-10	4.1E-07
Tc-101	1.5E+01	3.6E-09	2.5E-10	____(3)	3.7E-10	1.1E-21
Ru-103	1.0E+01	8.0E-08	1.9E-07	____(3)	____(3)	2.2E-05
Ru-105	1.0E+01	6.1E-09	1.5E-08	____(3)	____(3)	9.4E-06
Rh-105	____(3)	____(3)	____(3)	____(3)	____(3)	____(3)
Te-129m	4.0E+02	1.8E-06	1.2E-05	4.0E-06	4.3E-06	5.8E-05
Te-129	4.0E+02	7.7E-09	3.1E-08	2.4E-08	1.2E-08	2.4E-08
Te-131m	4.0E+02	7.1E-07	1.7E-06	1.3E-06	8.5E-07	8.4E-05
Te-131	4.0E+02	6.2E-09	2.0E-08	1.6E-08	8.2E-09	2.8E-09
Te-132	4.0E+02	1.5E-06	2.5E-06	1.8E-06	1.6E-06	7.7E-05
I-131	1.5E+01	3.4E-06	4.2E-06	2.0E-03	6.0E-06	1.6E-06
I-132	1.5E+01	1.9E-05	2.0E-07	2.0E-05	5.4E-07	1.0E-07
I-133	1.5E+01	7.5E-07	1.4E-06	3.6E-04	2.5E-06	2.2E-06
I-134	1.5E+01	1.0E-07	1.0E-07	5.0E-06	2.9E-07	2.5E-10
I-135	1.5E+01	4.3E-07	4.4E-07	7.7E-05	1.2E-06	1.3E-06
Cs-134	2.0E+03	1.2E-04	6.2E-05	____(3)	1.5E-04	2.6E-06
Cs-136	2.0E+03	1.9E-05	6.5E-06	____(3)	2.6E-05	2.9E-06
Cs-137	2.0E+03	7.1E-05	8.0E-05	____(3)	1.1E-04	2.1E-06
Cs-138	2.0E+03	5.4E-08	5.5E-08	____(3)	1.1E-07	4.7E-13
Ba-139	4.0E+0	2.8E-09	9.7E-08	____(3)	6.9E-11	1.7E-07

Table 2-1 (contd.)

Nuclide	Fish Bioaccumulation Factor (BF_i) (PCi/kg per PCi/liter)	Dose Conversion Factor (DF_i)				
		Total Body	Bone	Thyroid	Liver	GI Tract
Ba-140	4.0E+0	1.3E-06	2.0E-05	____(3)	2.6E-08	4.2E-05
La-140	2.5E+01	3.3E-10	2.5E-09	____(3)	1.3E-09	9.3E-05
La-141	2.5E+01	____(3)	____(3)	____(3)	____(3)	____(3)
La-142	2.5E+01	1.5E-11	1.3E-10	____(3)	5.8E-11	4.3E-07
Ce-141	1.0E+0	7.2E-10	9.4E-09	____(3)	6.3E-09	2.4E-05
Ce-143	1.0E+0	1.4E-10	1.7E-09	____(3)	1.2E-06	4.6E-05
Pr-143	2.5E+01	4.6E-10	9.2E-09	____(3)	3.7E-09	4.0E-05
W-187	1.2E+03	3.0E-08	1.0E-07	____(3)	8.6E-08	2.8E-05
Np-239	1.0E+01	6.5E-11	1.2E-09	____(3)	1.2E-10	2.4E-05

Table 2-2

INGESTION DOSE FACTORS (A_{ij}) FOR TOTAL BODY AND CRITICAL ORGAN
(in mrem/hr per μCi/ml)

Liquid Effluent*

Nuclide	Total Body	Bone	Thyroid	Liver	Gi Tract
H-3	2.8E-01	**	2.8E-01	2.8E-01	2.8E-01
Na-24	4.1E+02	4.1E+02	4.1E+02	4.1E+02	4.1E+02
P-32	1.8E+06	4.6E+07	**	2.9E+07	5.3E+06
Cr-51	1.3E+00	**	7.7E-01	**	3.2E+02
Mn-54	8.3E+02	**	**	4.4E+03	1.3E+04
Mn-56	1.9E+01	**	**	1.2E+02	3.6E+03
Fe-55	1.1E+02	6.7E+02	**	4.6E+02	2.6E+02
Fe-59	9.4E+02	1.0E+03	**	2.4E+03	8.2E+03
Co-58	2.0E+02	**	**	9.0E+01	1.8E+03
Co-60	5.7E+02	**	**	2.5E+02	4.8E+03
Ni-65	7.4E+00	1.3E+02	**	1.7E+01	4.1E+02
Cu-64	4.7E+00	**	**	1.0E+01	8.5E+02
Zn-65	3.4E+04	2.3E+05	**	7.2E+04	4.7E+04
Zn-69	6.7E+00	4.8E+01	**	9.65+01	1.4E+01
Br-83	4.0E+01	**	**	**	5.8E+01
Br-84	5.2E+01	**	**	**	4.1E-04
Rb-89	1.3E+02	**	**	1.9E+02	1.1E-10
Sr-89	6.4E+02	2.3E+04	**	**	3.5E+03
Sr-90	1.4E+05	5.5E+05	**	**	1.6E+04
Sr-91	1.7E+01	4.1E+02	**	**	2.0E+03
Sr-92	6.7E+00	1.6E+02	**	**	3.1E+03

*Based on conservative radionuclide mix obtained from GALE Liquid Code. Equation (7) was used to calculate the ingestion dose factors (A_{ij}).

**No Ingestion Dose Factor (DF_i) is listed in Table E-11 of Regulatory Guide 1.109. (Whole body dose factor value will be used as an approximation.)

Table 2-2 (contd.)

Nuclide	Total Body	Bone	Thyroid	Liver	Gi Tract
Y-90	1.7E-02	5.9E-01	**	**	6.0E+03
Y-91m	2.1E-04	5.5E-03	**	**	1.6E-02
Y-91	2.3E-01	8.4E+00	**	**	4.7E+03
Y-92	1.5E-03	5.1E-02	**	**	9.0E+02
Y-93	4.5E-03	1.6E-01	**	**	5.1E+03
Mo-99	2.0E+01	**	**	1.0E+02	2.4E+02
Tc-99m	3.2E-01	9.1E-03	**	2.5E-02	1.5E+01
Tc-101	1.3E-01	9.1E-03	**	1.3E-02	4.0E-14
Ru-103	1.9E+00	4.6E+00	**	**	5.4E+02
Ru-105	1.5E-01	3.7E-01	**	**	2.3E+02
Rh-105	**	**	**	**	**
Te-129m	1.7E+03	1.1E+04	3.8E+03	4.1E+03	5.6E+04
Te-129	7.4E+00	3.0E+01	2.3E+01	1.1E+01	2.3E+01
Te-131m	6.8E+02	1.6E+03	1.3E+03	8.1E+02	8.1E+04
Te-131	5.9E+00	1.9E+01	1.5E+01	7.9E+00	2.7E+00
Te-132	1.4E+03	2.4E+03	1.7E+03	1.5E+03	7.4E-04
I-131	1.2E+02	1.5E+02	7.3E+04	2.2E+02	5.8E+01
I-132	6.9E+02	7.3E+00	7.3E+02	2.0E+01	3.6E-00
I-133	2.7E+01	5.1E+01	1.3E+04	9.1E+01	8.0E+02
I-134	3.6E+00	3.6E+00	1.8E+02	1.1E+01	9.1E-03
I-135	1.6E+01	1.6E+01	2.8E+03	4.4E+01	4.7E+01
Cs-134	5.8E+05	3.0E+05	**	7.2E+05	1.2E+04
Cs-136	9.9E+04	3.1E+04	**	1.2E+05	1.4E+04
Cs-137	3.4E+05	3.8E+05	**	5.3E+05	1.0E+04
Cs-138	2.6E+02	2.6E+02	**	5.3E+02	2.3E-03
Ba-139	2.8E-02	9.7E-01	**	6.9E-04	1.7E+00
Ba-140	1.3E+01	2.0E+02	**	2.6E-01	4.2E+02
La-140	2.0E-02	1.5E-01	**	7.8E-02	5.6E+03
La-141	**	**	**	**	**
La-142	9.0E-04	7.8E-03	**	3.5E-03	2.6E+01
Ce-141	2.0E-03	2.6E-02	**	1.8E-02	6.7E+01

Table 2-2 (contd.)

Nuclide	Total Body	Bone	Thyroid	Liver	Gi Tract
Ce-143	3.9E-04	4.8E-03	**	3.4E+00	1.3E+02
Pr-143	2.8E-02	5.5E-01	**	2.2E-01	2.4E+03
W-187	8.6E+01	2.9E+02	**	2.5E+02	8.0E+04
Np-239	1.6E-03	2.9E-02	**	2.9E-03	5.8E+02

TABLE 2-3
INPUT PARAMETERS USED TO CALCULATE MAXIMUM INDIVIDUAL DOSE FROM LIQUID EFFLUENTS

Drinking Water

River Dilution:	20,000	
River Transit Time:	12 hours	
Water Treatment and Delivery Time:	24 hours	
Usage Factors:	Adult = 814 l/yr	Teenager = 567 l/yr
	Child = 567 l/yr	Infant = 344 l/yr

Fish

River Dilution:	20,000 for Richland	2,000 for WNP-2 Slough
Time To Consumption:	24 hours	
Usage Factors:	Adult = 48 kg/yr	Teenager = 36 kg/yr
	Child = 15 kg/yr	Infant = 0

Recreation

River Dilution:	20,000	
Shoreline Width Factor:	0.2	
Usage Factors:	Shoreline Activities:	Adult = 298 hr/yr
		Teenager = 1665 hr/yr
		Child = 349 hr/yr
		Infant = 0
	Swimming:	Adult = 59 hr/yr
		Teenager = 336 hr/yr
		Child = 68 hr/yr
	Boating:	Adult = 145 hr/yr
		Teenager = 31 hr/yr
		Child = 0 hr/yr
		Infant = 0

Irrigated Foodstuffs

River Dilution: 20,000
River Transit Time: 12 hours

	Vegetables	Milk	Meat	Leafy Vegetables
Food Delivery Time:	60 days	48 hours	20 days	24 hours
Usage Factors:				
Adult	529 kg/yr	224 l/yr	119 kg/yr	29 kg/yr
Teenager	670 kg/yr	408 l/yr	74 kg/yr	36 kg/yr
Child	559 kg/yr	346 l/yr	46 kg/yr	29 kg/yr
Infant	0	346	0	0
Monthly Irrigation Rate:	150 l/m^2	200 l/m^2	160 l/m^2	200 l/m^2
Annual Yield:	5 l/m2	1.3 l/m2	2.0 kg/m2	1.5 kg/m2
Annual Growing Period:	70 days	30 days	130 days	70 days
Annual 50-Mile Production:	1.5E+07	7.3E+06	2.6E+06	8.0E+05

3.0 GASEOUS EFFLUENTS DOSE CALCULATIONS

3.1 Introduction

WNP-2 gaseous effluents are released on a continuous basis; in addition, batch releases also occur when containment and mechanical vacuum pump purges are performed and when the OFF-GAS treatment system operates in the charcoal bypass mode. The gaseous effluents released from WNP-2 will meet instantaneous technical specification requirement at the site boundary.

Figure 3-1 delineates the WNP-2 Site boundary. There are several low occupancy unrestricted locations within the site boundary. These locations, with the exception of the WNP-2 visitor center, are not continuously controlled by the Supply System. The special locations are:

1. Wye burial site - normally controlled by DOE.

2. DOE train - two railroad lines pass through the site (approximately 3 miles of line). According to DOE, the train makes one round trip a day, through the site at an average speed of 20 mph, 5 days a week, 52 weeks/year.

3. BPA Ashe Substation - occupied 2080 hours/year. These people are not normally controlled by the Supply System but are involved in activities directly in support of WNP-2.

4. WNP-2 - Supply System Visitor Center - assumed occupied 8 hrs/yr by non-Supply System individuals.

5. WNP-1 - occupied 2080 hrs/yr. This location is controlled by the Supply System. However, activities are not in direct support of WNP-2.

6. WNP-4 - occupied 2080 hrs/yr. This location is controlled by the Supply System. However, activities are not in direct support of WNP-2.

All other locations listed in Figure 3-1 support WNP-2 activities and are controlled by the Supply System.

Air doses and doses to individuals at these locations were calculated based on the NRC GALE code design base mixture, location specific estimated occupancy, and X/Qs from XOQDOQ. (Note: Desert Sigmas were used in calculating X/Q and D/Q values, and are listed in Table 3-10 to 3-12). These doses are listed in Tables 3-16 and 3-17 along with the doses to the maximum exposed individual. The maximum exposed individual is currently an infant residing in Taylor Flats (4.2 miles SE of WNP-2). This is the closest residential area with the highest X/Q and D/Q values. Maximum occupied air doses inside the site are only a fraction of the site boundary air dose for continuous occupancy.

3.2 Gaseous Effluent Radiation Monitoring System

3.2.1 Main Plant Release Point

The Main Plant Release is instrument monitored for gaseous radioactivity prior to discharge to the environment via the main plant vent release point. Particulates and iodine activity are accumulated in filters which will be changed and analyzed at least weekly per Technical Specification 3.3.7.12. The effluent is supplied from: the gland seal exhauster, mechanical vacuum pumps, treated off gas, standby gas treatment, and exhaust air from the entire reactor building's ventilation.

Two 100-percent capacity vanaxial fans supply 98,000 CFM ventilation air. One is normally operating, the other is in standby. The radiation monitors are located on the ventilation exhaust plenum.

Effluent monitoring consists of beta scintillators and two ion chamber LOCA monitors. The beta scintillator has a four inch thick lead shielded chamber and has an estimated response of 50 cpm/pCi/ml to Kr-85.

The read out meter and recorder is located in the main control room panel BD-RAD-24. The analogue count rate meter has a range of $10-10^6$ cpm. Power

is provided from 125 VDC divisional buses. This monitor has no control function but annunciates in the main control room. The alarm will initiate proper action as defined in the WNP-2 Plant Procedures.

3.2.2 Radwaste Building Ventilation Exhaust Monitor

The radwaste building ventilation exhaust monitoring system monitors the radioactivity in the exhaust air prior to discharge. Radioactivity can originate from: radwaste tank vents, laboratory hoods, and various cubicles housing liquid process treatment equipment and systems.

The radwaste building exhaust system has three 50 percent capacity exhaust filter units of 42,000 cfm capacity. Each exhaust unit has a medium-efficiency prefilter, a high efficiency particulate air filter (HEPA and two centrifugal fans. Total exhaust flow will vary as the combined exhaust unit maintains a radwaste building Δp of-0.25 inches H_2O to the environment.

Particulate and iodine air sample filters are changed weekly for laboratory analysis. After the particulate and iodine filters, the air sample streams are combined in a manifold prior to being monitored by a beta scintillator.

The beta scintillator, on radwaste 487' level southwest corner is mounted in a three inch lead shielded chamber and has an estimated response of 50 cpm/pCi/ml to Kr-85. The readout meter and recorder is located in the main control room panel BD-RAD-24. The analog count rate meter has a range of 10 to 10^6 cpm. Power is provided from 125 VDC divisional buses. This monitor has no control functions but annunciates in the main control room. The alarm will initiate proper action as defined in the WNP-2 plant procedures.

3.2.3 Turbine Building Ventilation Exhaust Monitor

This monitoring system detects fission and the activation products from the turbine building air which may be present due to leaks from the turbine and other primary components in the building.

The turbine building main exhaust system consists of four roof-mounted centrifugal fans which draw air from a central exhaust plenum. Three fans operate continuously, with one in standby to provide a flow of 260,000 cfm.

A representative sample is extracted from the exhaust vent and passed through a particulate and charcoal filter. The air sample then passes to a beta scintillator.

The beta scintillator is mounted in a three inch lead shielded chamber and has an estimated response of 50 cpm/pCi/ml to Kr-85. The monitor is on the 525' level of the radwaste building and the readout meters and the records are in the main control room BD-RAD-24. The analog count rate meter has a range of 10 to 10^6 cpm, power is provided from the 125 VDC divisional buses. This monitor has no control functions but annunciates in the main control room. The alarm will initiate proper action as defined in the WNP-2 plant procedures.

3.3 10 CFR 20 Release Rate Limits

Limits for release of airborne effluents to the unrestricted area are stated in Technical Specification 3.11.2.1. The dose rate in unrestricted areas due to radioactive materials released in gaseous effluents from the site shall be limited to the following values:

(a) "The dose rate limit for noble gases shall be $\leq$500 mrem/yr to the total body and $\leq$ 3000 mrem/yr to the skin.

(b) "The dose rate limit for all radioiodines and for all radioactive materials in particulate form and radionuclides other than noble gases with half-lives greater than eight days shall be $\leq$1500 mrem/yr to any organ."

3.3.1 Noble Gases

In order to comply with Technical Specification 3.11.2.1, the following equations must hold:

Whole body:

$$\sum_{1}^{m} Ki\left[(\overline{X/Q})_m \dot{Q}_{i_m} + (\overline{X/Q})_g \dot{Q}_g)\right] \leq 500 \text{ mrem/yr} \quad (1)$$

Skin

$$\sum_{1}^{m} \left[(L_i + 1.1M_i)((\overline{X/Q})_m \dot{Q}_m + (\overline{X/Q}_g \dot{Q}_g)\right] \leq 3000 \text{mrem/yr} \quad (2)$$

3.3.2 Radioiodines and Particulates

Part "b" of Technical Specification 3.11.2.1 requires that the release rate limit for all radioiodines and radioactive materials in particulate form and radionuclides other than noble gases must meet the following relationship:

Any organ:

$$\sum_{i}^{m} P_i \left[W_M \dot{Q}_{iM} + W_g \dot{Q}_{ig} \right] \leq 1500 \text{ mrem/yr} \quad (3)$$

The terms used in equations 1 through 3 are defined as follows:

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

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

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

P_i = The dose parameter for all radionuclides other than noble gases for inhalation pathway, (mrem/yr per $\mu Ci/m^3$) and for food and ground contamination pathways, ($m^2 \cdot$ mrem/yr per $\mu Ci/sec$). The dose factors are based on the critical individual organ and the most restrictive age group, which is infant (see Section 3.3.2.1).

$\dot{Q}_{im}$ = The release rate of radionuclide i in gaseous effluent from mixed mode release. The main plant release point is a partially elevated mixed mode release.

$\dot{Q}_{ig}$ = The release rate of radionuclide i in gaseous effluent from all ground-level releases ($\mu Ci/sec$).

$(\overline{X/Q})_m$ = (sec/m^3). For partially elevated mixed mode releases from the main plant vent release point. The highest calculated partially elevated annual average relative concentration for any area at or beyond the site boundary.

$(\overline{X/Q})_g$ = (sec/m^3). For all Turbine Building and Radwaste releases. The highest calculated ground level annual average relative concentration for any area at or beyond the site boundary.

W_g = The highest calculated annual average dispersion parameter for estimating the dose to an individual at the controlling location due to all ground level releases.

W_g = (sec/m^3). For the inhalation pathway. The location is the site boundary in the sector of maximum concentration.

W_g = m^{-2}. For ground plane pathways. The location is the site boundary in the sector of maximum concentration.

W_m = The highest calculated annual average dispersion parameter for estimating the dose to an individual at the controlling location due to partially elevated releases:

W_M = sec/m^3. For inhalation pathway. The location is the site boundary in the sector of maximum concentration.

W_M = m^{-2}. For ground plane pathways. The location is the site boundary in the sector of maximum concentration.

The factors, L_i and M_i, relate the radionuclide airborne concentrations to various dose rates assuming a semi-infinite cloud. These factors are listed in Table B-1 of Regulatory Guide 1.109 and in Table 3-1 of this manual.

The $\overline{X/Q}$ values used in the equations for the implementation of Technical Specification 3.11.2.1 are based upon the maximum long-term annual average at the site boundary. The distances between the nearest unrestricted area and the WNP-2 site are listed in Table 3-2. The distances between WNP-2 and the nearest vegetable garden, milk cow, and beef animal are tabulated in Table 3-3, along with representative X/Q and D/Q values.

The X/Q and D/Q values listed in Tables 3-10 through 3-12 reflect correct acquired meteorological data up to 1983 and were utilized in the initial GASPAR Computer runs. Subsequent reports will use updated X/Q and D/Q averages Characteristics of WNP-2 gaseous effluent release points are listed in Table 3-13.

3.3.2.1 Dose Parameter for Radionuclide i (P_i).

Analysis of GALE Code release mixtures show that thyroid doses from radioiodine inhalation are much larger than all other doses. Therefore, routine assessment of compliance with Equation 3 will be performed only for child thyroid dose from radioiodine inhalation.

The dose parameters used in Equation 3 are based on:

1. Inhalation and ground plane. (Note: Food pathway is not applicable to WNP-2 since no food is grown at or near the restricted area boundary.)

2. The annual average continuous release meteorology at the site boundary.

3. The critical organ for each radionuclide (thyroid for radioiodine).

4. The most restrictive age group.

Calculation of P_i^I (Inhalation): The following equation will be used to calculate P_i^I (Inhalation).

$$P_i^I \text{ (Inhalation)} = K^A(BR)\, DFA_i \text{ (mrem/yr per } \mu Ci/m^3) \qquad (5)$$

where:

KA = A constant of conversion, 10^6 pCi/μCi.

BR = The breathing rate of the child age group, (m^3/yr) = m^3/yr.

DFA_i = The critical organ inhalation dose factor for the child age group for the ith radionuclide in mrem/pCi. The total body is considered as an organ in the selection of DFA_i.

The inhalation dose factor for DFA_i for the child age group is listed in Table E-9 of Regulatory Guide 1.109 and Tables 3-4 of this manual. Resolving the units yields:

$$P_i^I = \text{(Inhalation)} = (1.4 \times 10^9)(DFA_i) \text{ (mrem/yr per } \mu\text{Ci/m}^3) \qquad (6)$$

The P_i^I (Inhalation) values for the child age group are tabulated in Table 3-4 of this manual.

3.4 10 CFR 50 Release Rate Limits

The requirements pertaining to 10 CFR 50 release rate limits are specified in Technical Specifications 3.11.2.2 and 3.11.2.3.

Technical Specification 3.11.2.2 deals with the air dose from noble gases and requires that the air dose at or beyond the site boundary due to noble gases released in gaseous effluents shall be limited to the following:

(a) "During any calendar quarter, to $\leq$5 mrad for gamma radiation and to $\leq$10 mrad for beta radiation."

(b) "During any calendar year, to $\leq$10 mrad for gamma radiation and $\leq$20 mrad for beta radiation."

Technical Specification 3.11.2.3 deals with radioiodines and radioactive materials in particulate form, and requires that the dose to an individual from radioiodines, radioactive materials in particulate form, and radionuclides other than noble gases with half-lives greater than eight days in gaseous effluents released to unrestricted areas shall be limited to the following:

(a) "During any calendar quarter, to $\leq$7.5 mrem."

(b) "During any calendar year, to $\leq$15 mrem."

3.4.1 Noble Gases (Technical Specification 3.11.2.2)

The air dose at or beyond the site boundary due to noble gases released in the gaseous effluent will be determined by using the following equations.

a. During any calendar quarter, for gamma radiation:

$$3.17 \times 10^{-8} \sum_i M_i \left[(\overline{X/Q})_g Q_{ig} + (X/q)_g q_{ig} + (\overline{X/Q})_M Q_{im} + (X/q) q_m \right] \leq 5 \text{ mrad} \quad (8)$$

During any calendar quarter, for beta radiation:

$$3.17 \times 10^{-8} \sum_i N_i \left[(\overline{X/Q})_g Q_{ig} + (X/q)_g q_{ig} + (\overline{X/Q})_m Q_{im} + (X/q)_M q_{im} \right] \leq 10 \text{ mrad} \quad (9)$$

b. During any calendar year, for gamma radiation:

$$3.17 \times 10^{-8} \sum_i M_i \left[(\overline{X/Q})_g Q_{ig} + (X/q)_g q_{ig} + (\overline{X/Q})_M P_i m + (X/q)_m q_{im} \right] \leq 10 \text{ mrad} \quad (10)$$

During any calendar year, for beta radiation:

$$3.17 \times 10^{-8} \sum_i N_i \left[(\overline{X/Q})_v Q_{iv} + (X/q)_v q_{iv} + (\overline{X/Q})_m Q_{im} + (X/q)_m q_{im}\right] \leq 20 \text{ mrad} \quad (11)$$

where:

M_i = The air dose factor due to gamma emmissions for each identified noble gas radionuclide, in mrad/yr per $\mu Ci/m^3$ (M_i values are listed in Table 3-1).

N_i = The air dose factor due to beta emissions for each identified noble gas radionuclide, in mrad/yr per $\mu Ci/m^3$ (N_i values are listed in Table 3-1).

$(\overline{X/Q})_g$ = For ground level release points. The highest calculated annual average relative concentration for area at or beyond the site area boundary for long-term releases (greater than 500 hr/yr). (Sec/m^3)

$(X/q)_g$ = For ground level release points. The relative concentration for areas at or beyond the site area boundary for short-term releases (equal to or less than 500 hr/yr). (Sec/m^3)

$(\overline{X/Q})_m$ = For partially elevated release points. The highest calculated annual average relative concentration for areas at or beyond the site boundary for long-term releases (greater than 500 hr/yr). (Sec/m^3)

$(X/q)_m$ = For partially elevated release points. The relative concentration for areas at or beyond the site boundary for short-term releases (equal to or less than 500 hr/yr). (Sec/m^3)

q_{im} = The average release of noble gas radionuclides in gaseous effluents, i, for short-term releases (equal to or less than 500 hr/yr) from the main plant release point, in μCi. Releases shall be cumulative over the calendar quarter or year, as appropriate.

q_{ig} = The average release of noble gas radionuclides in gaseous effluents, i, for short-term releases (equal to or less than 500 hr/yr) from Radwaste and Turbine Building, in μCi. Releases shall be cumulative over the calendar quarter or year, as appropriate.

Q_{iM} = The average release of noble gas radionuclides in gaseous releases, i, for long-term releases (greater than 500 hr/yr) from the main plant release point, in μCi. Release shall be cumulative over the calendar quarter or year, as appropriate.

Q_{ig} = The average release of noble gas radionuclides in gaseous effluents, i, for long-term releases (greater than 500 hr/yr) from Radwaste and Turbine Building, in μCi. Releases shall be cumulative over the calendar quarter or year, as appropriate.

3.17×10^{-8} = The inverse of the number of seconds in a year.

3.4.2 Radioiodines and Particulates (Technical Specification 3.11.2.3)

The following equation calculates the dose to an individual from radioiodines, radioactive material in particulate form, and radionuclides other than noble gases with half-lives greater than eight days in gaseous effluents released to the unrestricted areas:

a. During any calendar quarter:

$$3.17 \times 10^{-8} \sum_i R_i \left[W_m Q_{im} + w_m q_{im} + W_g Q_{ig} + w_g q_{ig} \right] \leq 7.5 \text{ mrem} \quad (12)$$

b. During any calendar year:

$$3.17 \times 10^{-8} \sum_i R_i \left[W_m Q_{im} + w_s q_{im} + W_g Q_{ig} + w_g q_{ig} \right] \leq 15 \text{ mrem} \quad (13)$$

where:

Q_i = The releases of radionuclides, radioactive materials in particulate form, and radionuclides other than noble gases in gaseous effluents, i, for long-term releases greater than 500 hr/yr, in μCi. Releases shall be cumulative over the calendar quarter or year, as appropriate.

q_i = The releases of radionuclides, radioactive materials in particulate form, and radionuclides other than noble gases in gaseous effluents, i, for short-term releases equal to or less than 500 hr/yr, in μCi. Releases shall be cumulative over the calendar quarter or year as appropriate.

W_{m}, W_{g} = The dispersion parameter for estimating the dose to an individual at the controlling location for long-term (>500 hr.) releases (m is for mixed mode releases, g is for ground level releases).

$W = (\overline{X/Q})$ for the inhalation pathway, in sec/m^3.

$W = (\overline{D/Q})$ for the food and ground plane pathways in $meters^{-2}$.

w_{m}, w_{g} = The dispersion parameter for estimating the dose to an individual at the controlling location for short-term (<500 hr.) releases (m is for mixed mode releases, g is for ground level releases)

$w = (\overline{X/q})$ for the inhalation pathway, in sec/m^3.

$w = (\overline{D/q})$ for the food and ground plane pathways in $meters^{-2}$.

3.17×10^{-8} = The inverse of the number of seconds in a year.

R_i = The dose factor for each identified radionuclide, i, in m^2(mrem/yr) per μCi/sec or mrem/yr per $\mu Ci/m^3$.

n = Total number of radionuclides (noble gases) in the effluent.

3.4.2.1 Dose Parameter for Radionuclide i (R_i)

The R_i values used in equations 12 and 13 of this section are calculated separately for each of the following potential exposure pathways:

- Inhalation
- Ground plane contamination
- Grass-cow/goat-milk pathway
- Grass-cow-meat pathway
- Vegetation pathway

Based on GALE Code release projections, the infant age group is expected to be the most restrictive. However, monthly dose assessments for WNP-2 gaseous effluent will be done for all age groups.

Calculation of R_i^I (Inhalation Pathway Factor)

$$R_i^I \text{ (Inhalation)} = K^1 \, (BR)_a \, (DFA_i)_a \text{ (mrem/yr per } \mu Ci/m^3) \qquad (14)$$

where:

R_i^I = The inhalation pathway factor (mrem/yr per $\mu Ci/m^3$).

$K1$ = A constant of unit conversion, 10^6 pCi/μCi.

$(BR)_a$ = The breathing rate of the receptor of age group (a) in meter^3/yr. (Infant = 1400, child = 3,700, teen = 8,000, adult = 8,000. From P.32 NUREG-0133).

$(DFA_i)_a$ = The maximum organ inhalation dose factor for receptor of age group (a) for the ith radionuclide (mrem/pCi). The total body is considered as an organ in the selection of $(DFA_i)_a$. The $(DFA_i)_a$ values for the infant age group were used. They are listed in Table E-10 of Regulatory Guide 1.109 manual. Values of R_i^I are listed in Table 3-5.

Calculation of R_i^G (Ground Plane Pathway Factor)

$$R_i^G(\text{Ground Plane}) = K^A K^B\ (SF)(DFG_i)\ (1-e^{-\lambda_i t})/\lambda_i\ (m^2 \times \text{mrem/yr per } \mu\text{Ci/sec}) \quad (15)$$

where:

R_i^G = Ground plane pathway factor (m^2 x mrem/yr per μCi/sec).

K^A = A conversion constant of 10^6 pCi/μCi.

K^B = A conversion constant - 8760 hr/yr.

i = The decay constant for the ith radionuclide (sec^{-1}).

t = Exposure time, 4.73×10^8 sec (= 15 years).

DFG_i = The ground plane dose conversion factor for the ith radionuclide, as listed in Table E-6 of Regulatory Guide 1.109 (mrem/hr per pCi/m^2).

SF = Shielding Factor (dimensionless)--0.7, as suggested in Table E-15 of Regulatory Guide 1.109.

The values of R_i^G are listed in Table 3-5 of this manual.

Calculation of R_i^C (Grass-Cow/Goat-Milk Pathway Factor)

R_i^C (Grass-Cow/Goat-Milk Factor) =

$$K' \frac{Q_F(U_{ap})}{\lambda_i + \lambda_w} F_m(r)(DFL_i)_a \left[\frac{f_p f_s}{Y_p} + \frac{(1-f_p f_s)e^{-\lambda_i t_h}}{Y_s}\right] e^{-\lambda_i t_f} \qquad (16)$$

(m^2 x mrem/yr per μCi/sec)

where:

K' = A constant of unit conversion, 10^6 pCi/μCi.

Q_F = The cow/goat consumption rate, in kg/day (wet weight).

U_{ap} = The receptor's milk consumption rate for age (a), in liters/yr.

Y_p = The agricultural productivity by unit area of pasture feed grass, in kg/m^2.

Y_s = The agricultural productivity by unit area of stored feed, in kg/m^2.

F_m = The stable element transfer coefficients, in days/liter.

r = Fraction of deposited activity retained on feed grass.

$(DFL_i)_a$ = The maximum organ ingestion dose factor for the ith radionuclide for the receptor in age group (a), in mrem/pCi (Tables E-11 to E-14 of Regulatory Guide 1.109).

λ_i = The decay constant for the ith radionuclide, in sec^{-1}.

λ_w = The decay constant for removal of activity on leaf and plant surfaces by weathering, 5.73×10^{-7} sec^{-1} (corresponding to a 14-day half-life).

t_f = The transport time from pasture to animal, to milk, to receptor, in sec.

t_h = The transport time from pasture, to harvest, to animal, to milk, to receptor, in sec.

f_p = Fraction of the year that the cow/goat is on pasture (dimensionless) = 0.5

f_s = Fraction of the cow/goat feed that is pasture grass while the cow is on pasture (dimensionless) = 1.0

The input parameters used for calculating R_i^m are listed in Table 3-7 and the R_i^C values are tabulated in Table 3-6.

For Tritium:

In calculating R_T^C, pertaining to tritium in milk, the airborne concentration rather than the deposition will be used:

R_T^C (Grass-Cow/Goat-Milk Factor) =

$$K^A K^C F_m Q_F U_{ap} (DFL_i)_a \left[0.75(0.5/H)\right] \quad (mrem/yr\ per\ \mu Ci/m^3) \qquad (17)$$

where:

K^A = A constant unit conversion, 10^6 pCi/μCi.

K^C = A constant of unit conversion, 10^3 gm/kg.

H = Absolute humidity of the atmosphere, in gm/m^3.

0.75 = The fraction of total feed that is water.

0.5 = The ratio of the specific activity of the feed grass water to the atmospheric water.

Calculation of R_i^M (Grass-Cow-Meat Pathway Factor)

R_i^M (Grass-Cow-Meat Factor) =

$$K' \frac{Q_F(U_{ap})}{\lambda_i + \lambda_w} F_f(r)(\overline{DFL_i})_a \left[\frac{f_p f_s}{Y_p} + \frac{(1-f_p f_s)e^{-\lambda_i t_h}}{Y_s}\right] e^{-\lambda_i t_f} \quad (18)$$

(m^2 x mrem/yr per μCi/sec)

where:

K' = A constant unit conversion, 10^6pCi/μCi.

F_f = The stable element transfer coefficients, in days/kg.

U_{ap} = The receptor's meat consumption rate for age (a), in kg/yr.

t_f = The transport time from pasture to receptor, in sec.

t_h = The transport time from crop field to receptor, in sec.

The input parameters needed for solving equation 18 are listed in Table 3-7.

For Tritium:

In calculating the R_T^M for tritium in meat, the airborne concentration is used rather than the deposition rate. The following equation is used to calculate the R_T^M values for tritium:

R_T^M (Grass-Cow-Meat Pathway) =

$$K^A K^C \left[F_f Q_F U_{ap} \, (DFL_i)_a \right] \left[0.75(0.5/H) \right] \quad (\text{mrem/yr per } \mu\text{Ci/m}^3) \qquad (19)$$

Where the terms are as defined in equations 17-19, R_i^M values for tritium pertaining to the infant age group is zero since there is no meat consumption by this age group.

Calculation of R_i^V (Vegetation Pathway Factor)

R_i^V (Vegetation Pathway Factor) =

$$K' \left[\frac{(r)}{Y_v(\lambda_i + \lambda_w)} \, (DFL_i)_a \right] \left[U_a^L f_L e^{-\lambda_i t_L} + U_a^S f_g e^{-\lambda_i t_h} \right] \qquad (20)$$

$$(\text{m}^2 \times \text{mrem/yr per } \mu\text{Ci/sec})$$

where:

K' = A constant of unit conversion, 10^6pCi/μCi.

U_a^L = The consumption rate of fresh leafy vegetation by the receptor in age group (a), in kg/yr.

U_a^S = The consumption rate of stored vegetation by the receptor in age group (a), in kg/yr.

f_L = The fraction of the annual intake of fresh leafy vegetation grown locally.

f_g = The fraction of the annual intake of stored vegetation grown locally.

t_L = The average time between harvest of leafy vegetation and its consumption, in seconds.

t_h = The average time between harvest of stored vegetation and its consumption, in seconds.

Y_v = The vegetation area density, in kg/m^2.

All other items are as defined in equations 16-18.

For Tritium:

In calculating the R_T^V for tritium, the concentration of tritium in vegetation is based on airborne concentration rather than the deposition rate. The following equation is used to calculate R_T^V for tritium:

R_T^V (Vegetation Pathway Factor) =

$$K^A K^C \left[U_a^L f_L + U_a^S f_g \quad (DFL_i)_a \right] \left[0.75(0.5/H) \right] \text{ (mrem/yr per } \mu Ci/m^3) \quad (21)$$

Where all terms have been defined above and in equations 16-18, the R_i^V value for tritium is zero for the infant age group due to zero vegetation consumption rate by that age group. The input parameters needed for solving equations 20 and 21 are listed in Table 3-8.

3.5 Compliance with Standard Technical Specification 3.11.2.4

Standard Technical Specification 3.11.2.4 states:

> "The GASEOUS RADWASTE TREATMENT SYSTEM shall be in operation in either the normal or charcoal bypass mode. The charcoal bypass mode shall not be used unless the offgas post-treatment radiation monitor is OPERABLE as specified in Table 3.3.7.11-1."
>
> "APPLICABILITY: Whenever the main condenser steam jet air ejector (evacuation) system is in operation."

Prior to placing the Gaseous Radwaste Treatment System in the charcoal bypass mode, the alarm setpoints on the main plant vent release monitor shall be set to account for the increased percentages of short-lived noble gases. Noble gas percentages shall be based either on actual measured values or on primary coolant design base noble gas concentration percentages adjusted for 30-minute decay. Table 3-15 lists the percentage values for 30-minute decay.

3.6 Calculation of Gaseous Effluent Monitor Alarm Setpoints

3.6.1 Introduction

The following procedure used to ensure that the dose rate in the unrestricted areas due to noble gases in the WNP-2 gaseous effluent do not exceed 500

mrem/yr to the whole body or 3000 mrem/yr to the skin. The initial setpoints determination is calculated using a conservative radionuclide mix obtained from the WNP-2 GALE code. Once the plant is operating, the actual radionuclide mix is used to calculate the alarm setpoint.

3.6.2 Setpoint Determination for all Gaseous Release Paths

The setpoints for gaseous effluent are based on an instantaneous noble gas dose rates. A monthly analysis of radioiodines and radionuclides in particulate form will be performed to ensure compliance with 10 CFR 20 and 10 CFR 50 Appendix I limits. The three release points will be partitioned such that their sum does not exceed 100 percent of the limit. Originally, the setpoints will be set at 40 percent for the reactor building, 40 percent for the turbine building and 20 percent for the radwaste building. These percentages could vary at the plant discretion, should the operational conditions warrant such change. However, the combined releases due to variations in the setpoints will not result in doses which exceed the limit stated in technical specification. Both skin dose and whole body setpoints will be calculated and the lower limit will be used.

3.6.2.1 Setpoints Calculations Based on Whole Body Dose Limits

The fraction (π_i) of the total gaseous radioactivity in each gaseous effluent release path (j) for each noble gas radionuclide i will be determined by using the following equation:

$$\pi_{ij} = \frac{C_{ij}}{C_{Tj}} \text{ (dimensionless)} \qquad (22)$$

where:

C_{ij} = The measured individual concentration of radionuclide i in the gaseous effluent release path j (μCi/cc).

C_{Tj} = The measured total concentration of all noble gases identified in the gaseous effluent release path j (μCi/cc).

Based on Technical Specification 3.11.1.2, the maximum acceptable release rate of all noble gases in the gaseous effluent release path j is calculated by using the following equation:

$$Q_{TJ} = \frac{Fj\ 500}{X/Q_j \sum_{i=1}^{m} (K_i)(\pi_{ij})} \ (\mu Ci/sec) \qquad (23)$$

where:

Q_{TJ} = The maximum acceptable release rate (μCi/sec) of all noble gases in the gaseous effluent release path j (μCi/cc).

Fj = Fraction of total dose allocated to release path j.

500 = Whole body dose rate limit of 500 mrem/yr as specified in Technical Specification 3.11.2.1a.

X/Q_j = Maximum normalized diffusion coefficient of effluent release path j at the site boundary (sec/m^3). Turbine Building and Radwaste Building values are based on average annual ground level values. Main plant vent release values are for mixed mode and may be either short term or average annual value dependent upon type of release.

K_i = The total whole body dose factor due to gamma emission from noble gas nuclide i (mrem/yr per μCi/m^3) (as listed in Table B-1 of Regulatory Guide 1.109).

π_{ij} = As defined in equation 22.

m = Total number of radionuclides in the gaseous effluent.

j = Different release pathways.

The total maximum acceptable concentration (C_{Tj}) of noble gas radionuclides in the gaseous effluent release path j (μCi/cc) will be calculated by using the following equation:

$$C_{Tj} = \frac{Q_{Tj}}{R_j} \; (\mu Ci/cc) \qquad (24)$$

where:

C_{Tj} = The total allowed concentration of all noble gas radionuclides in the gaseous effluent release path i (μCi/cc).

Q_{Tj} = The maximum acceptable release rate (μCi/sec) of all noble gases in the gaseous effluent release path i.

R_j = The effluent release rate at the point of release.

To determine the maximum acceptable concentration (C_{iA}) of noble gas radionuclide i in the gaseous effluent for each individual noble gas in the gaseous effluent (μCi/cc), the following equation will be used:

$$C_{ij} = \pi_{ij} C_{Tj} \; (\mu Ci/cc) \qquad (25)$$

where:

π_{ij} and C_{TJ} are as defined in equations 22 and 24 respectively, the gaseous effluent monitor alarm setpoint will then be calculated as follows:

$$C.R.j = \sum_{i=1}^{m} C_{ij}E_{ij}(\text{cpm}) \qquad (26)$$

where:

C.R.j = Count rate above background (cpm) for gaseous release path j.

C_{ij} = The maximum acceptable concentration of noble gas nuclide i in the gaseous effluent release path j. μCi/cc.

E_{ij} = Detection efficiency of the gaseous effluent monitor j for noble gas i (cpm/μCi/cc).

3.6.2.2 Setpoints Calculations Based on Skin Dose Limits

The method for calculating the setpoints to ensure compliance with the skin dose limits specified in Technical Specification 3.11.2.1a is similar to the one described for whole body dose limits (Section 3.6.2.1 of this manual), except Eq. 27 will be used instead of Eq. 23 for determining maximum acceptable release rate (Q_{Tj}).

$$Q_{TJ} = \frac{Fj \quad 3000}{(X/Q_j)\sum_{i=1}^{m} (L_i + 1.1M_i)(\pi_{ij})}(\mu\text{Ci/sec}) \qquad (27)$$

where:

Q_{TJ} = The maximum acceptable release rate of all noble gases in the gaseous effluent release path j in Ci/sec.

X/Qj = The maximum annual normalized diffusion coefficient for release path j at the site boundary (sec/m^3).

F_j = Fraction of total allowed dose.

L_i = The skin dose factor due to beta emission for each identified noble gas radionuclide i in mrem/yr per μCi/m^3 (from Table B-1 of Regulatory Guide 1.109).

M_i = The air dose factor due to gamma emmissions for each identified noble gas radionuclide, in mrad/yr per μCi/m^3 (M_i values are listed in Table 3-1).

1.1 = A conversion factor to convert dose in mrad to dose equivalent in mrem.

3000 = Skin dose rate limit of 3000 mrem/yr as specified in Technical Specification 3.11.2.1.

Table 3-1
DOSE FACTORS FOR NOBLE GASES AND DAUGHTERS*

Radionuclide	Total Body Dose Factor K_i (mrem/yr per μCi/m^3)	Skin Dose Factor L_i (mrem/yr per μCi/m^3)	Gamma Air Dose Factor M_i (mrad/yr per μCi/m^3)	Beta Air Dose Factor N_i (mrad/yr per μCi/m^3)
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

*The listed dose factors are for radionuclides that may be detected in gaseous effluents.

**7.56E-02 = 7.56×10^{-2}.

The values listed above were taken from Table B-1 of NRC Regulatory Guide 1.109. The values were multiplied by 10^6 to convert picocuries^{-1} to microcuries^{-1}.

Table 3-2

DISTANCES (MILES) TO CONTROLLING LOCATIONS
AS MEASURED FROM CENTER OF WNP-2 CONTAINMENT BUILDING*

Location	Distance (miles)	Sector	Comments
Site Boundary	1.2	SE	Air dose measurement.
Taylor Flats	4.2	SE	The nearest significant residence in the southern direction with vegetable gardens, milk, and meat production.
Ringold	4.0	ENE	The nearest significant residence in the northern direction with vegetable gardens, milk, and meat production.

*Selection of location sector is based on the highest annual average X/Q values.

Table 3-3

WNP-2 ANNUAL AVERAGE DISPERSION (X/Q)
AND DEPOSITION (D/Q) VALUES FOR SPECIAL LOCATIONS

Location	Sector	Distance (miles)	Point of Release	X/Q No Decay No Depletion (sec/m^3)	X/Q 2.3 Days Decay No Depletion (sec/m^3)	X/Q 8.0 Days Decay Depleted (sec/m^3)	D/Q (m^{-2})
Site Boundary	SE	1.2	Containment Bldg.	1.8E-06	1.8E-06	1.6E-06	1.0E-08
			Turbine Bldg.	1.1E-05	1.1E-05	1.0E-05	8.3E-08
			Radwaste Bldg.	1.1E-05	1.1E-05	1.0E-05	8.3E-08
Taylor Flats	SE	4.2	Containment Bldg.	4.1E-07	4.1E-07	3.8E-07	8.2E-10
			Turbine Bldg.	8.9E-07	8.7E-07	6.8E-07	7.2E-10
			Radwaste Bldg.	8.9E-07	8.7E-07	6.8E-07	7.2E-10
Ringold	ENE	4.0	Containment Bldg.	2.5E-07	2.5E-07	1.9E-07	3.3E-10
			Turbine Bldg.	3.9E-07	3.8E-07	3.0E-07	3.3E-10
			Radwaste Bldg.	3.9E-07	3.8E-07	3.0E-07	3.3E-10
BPA Ashe Substation	N	0.5	Containment Bldg.	6.4E-06	6.4E-06	5.8E-06	3.7E-08
			Turbine Bldg.	3.0E-05	2.9E-05	2.7E-05	7.8E-08
			Radwaste Bldg.	3.0E-05	2.9E-05	2.7E-05	7.8E-08

Table 3-4

DOSE RATE PARAMETERS
IMPLEMENTATION OF 10 CFR 20, AIRBORNE RELEASES

Nuclide	λ sec^{-1}	Child Dose Factor* DFA_i mrem/pCi	Child Dose Factor* DFG_i mrem/hr / pCi/m^2	P_i^I Inhalation mrem/yr / μCi/m^3
H-3	1.8E-09	3.0E-07	0.0	1.1E+03
I-131	1.0E-06	4.4E-03	3.4E-09	1.6E+07
I-133	9.2E-06	1.0E-03	4.5E-09	3.7E+06
Cr-51	2.9E-07	4.6E-06	2.6E-10	1.7E+04
Mn-54	2.6E-08	4.3E-04	6.8E-09	1.6E+06
Fe-55	8.5E-09	3.0E-05	0.0	1.1E+05
Fe-59	1.8E-07	3.4E-04	9.4E-09	1.3E+06
Co-58	1.1E-07	3.0E-04	8.2E-09	1.3E+06
Co-60	4.2E-09	1.9E-03	2.0E-08	7.0E+06
Zn-65	3.3E-08	2.7E-04	4.6E-09	1.0E+06
Sr-89	1.5E-07	5.8E-04	6.5E-13	2.2E+06
Sr-90	7.9E-10	2.7E-02	--	1.0E+08
Zr-95	1.2E-07	6.3E-04	5.8E-09	2.3E+06
Cs-134	1.1E-08	2.7E-04	1.4E-08	1.0E+06
Cs-137	7.3E-010	2.5E-04	4.9E-09	9.3E+05
Ba-140	6.3E-07	4.7E-04	2.4E-09	1.7E+06

*Maximum Organ

Table 3-5a

DOSE RATE PARAMETERS--IMPLEMENTATION OF 10 CFR 50, AIRBORNE RELEASES

Age Group: Infant

		Dose Parameters (Maximum Organ)			
		Inhalation R_i^I	Ground R_i^G	Milk (Cow) R_i^C	Milk (Goat) R_i^C
Nuclide	sec^{-1}	mrem/yr (per (μCi/m^3)	m^2 x mrem/yr (per (μCi/sec)	m^2 x mrem/yr (per (μCi/sec)	m^2 x mrem/yr (per (μCi/sec)
H-3	1.8E-9	6.5E+2	0.0	3.4E+3	7.0E+3
I-131	1.0E-6	1.5E+7	1.0E+7	2.4E+11	4.3E+11
I-133	9.2E-6	3.6E+6	1.5E+6	2.2E+9	4.0E+9
Cr-51	2.9E-7	1.3E+4	5.5E+6	2.0E+6	3.5E+5
Fe-55	8.5E-9	8.7E+4	0.0	7.0E+7	7.1E+6
Fe-59	1.8E-7	1.0E+6	3.2E+8	1.7E+8	3.2E+7
Mn-54	2.6E-8	9.9E+5	1.6E+9	2.0E+7	2.9E+6
Co-58	1.1E-7	7.8E+5	4.4E+8	2.8E+7	4.5E+6
Co-60	4.2E-9	4.5E+6	2.5E+10	1.1E+8	1.4E+7
Sr-89	1.5E-7	2.0E+6	2.5E+4	5.6E+9	1.6E+10
Sr-90	7.9E-10	4.1E+7	0.0	7.1E+10	1.7E+11
Cs-134	1.1E-8	7.0E+5	8.0E+9	3.6E+10	1.3E+11
Cs-136	5.9E-7	5.6E+4	1.7E+8	2.6E+9	1.2E+10
Cs-137	7.3E-10	6.1E+5	1.2E+10	3.4E+10	1.2E+11
Ba-140	6.3E-7	1.6E+6	2.3E+7	1.1E+8	1.9E+7

Table 3-5b

DOSE RATE PARAMETERS--IMPLEMENTATION OF 10 CFR 50, AIRBORNE RELEASES

Age Group: Child

		Dose Parameters (Maximum Organ)					
		Inhalation R_i^I	Ground R_i^G	Milk (Cow) R_i^C	Milk (Goat) R_i^C	Vegetables R_i^V	Meat R_i^M
Nuclide	sec^{-1}	mrem/yr (per ($\mu Ci/m^3$)	m^2 x mrem/yr (per (μCi/sec)	m^2 x mrem/yr (per (μCi/sec)	m^2 x mrem/yr (per (μCi/sec)	m^2 x mrem/yr (per (μCi/sec)	m^2 x mrem/yr (per (μCi/sec)
H-3	1.8E-9	1.1E+3	0.0	2.3E+3	4.6E+3	5.6E+3	3.4E+2
I-131	1.0E-6	1.6E+7	1.0E+7	9.9E+10	1.8E+11	1.1E+10	1.3E+9
I-133	9.2E-6	3.8E+6	1.5E+6	9.2E+8	1.7E+9	1.7E+8	3.0E+1
Cr-51	2.9E-7	1.7E+4	5.5E+6	2.3E+6	4.1E+5	5.3E+6	2.0E+5
Fe-55	8.5E-9	1.1E+5	0.0	5.8E+7	9.1E+6	3.9E+8	2.4E+8
Fe-59	1.8E-7	1.3E+6	3.2E+8	9.0E+7	1.6E+7	6.0E+8	2.8E+8
Mn-54	2.6E-8	1.6E+6	1.6E+9	1.1E+7	1.6E+6	6.3E+8	4.1E+6
Co-58	1.1E-7	1.1E+6	4.4E+8	3.2E+7	5.2E+6	3.4E+8	4.4E+7
Co-60	4.2E-9	7.1E+6	2.5E+10	1.3E+8	1.8E+7	2.0E+9	2.1E+8
Sr-89	1.5E-7	2.2E+6	2.5E+4	3.0E+9	8.6E+9	3.3E+10	2.2E+8
Sr-90	7.9E-10	1.0E+8	0.0	6.5E+10	1.6E+11	1.3E+12	6.1E+9
Cs-134	1.1E-8	1.0E+6	8.0E+9	2.0E+10	7.0E+10	2.5E+10	7.9E+8
Cs-136	5.9E-7	1.7E+5	1.7E+8	1.2E+9	5.6E+9	1.5E+8	2.0E+7
Cs-137	7.3E-10	9.1E+5	1.2E+10	1.8E+10	6.4E+10	2.4E+10	7.5E+8
Ba-140	6.3E-7	1.7E+6	2.3E+7	5.2E+7	9.4E+6	1.8E+8	2.0E+7

Table 3-5c

DOSE RATE PARAMETERS--IMPLEMENTATION OF 10 CFR 50, AIRBORNE RELEASES

Age Group: Teen

		Dose Parameters (Maximum Organ)					
		Inhalation R_i^I	Ground R_i^G	Milk (Cow) R_i^C	Milk (Goat) R_i^C	Vegetables R_i^V	Meat R_i^M
Nuclide	sec^{-1}	mrem/yr (per (μCi/m^3)	m^2 x mrem/yr (per (μCi/sec)	m^2 x mrem/yr (per (μCi/sec)	m^2 x mrem/yr (per (μCi/sec)	m^2 x mrem/yr (per (μCi/sec)	m^2 x mrem/yr (per (μCi/sec)
H-3	1.8E-9	1.3E+3	--	1.4E+3	2.9E+3	3.5E+3	2.8E+2
I-131	1.0E-6	1.5E+7	1.0E+7	5.1E+10	9.1E+10	7.0E+9	8.4E+8
I-133	9.2E-6	2.9E+6	1.5E+4	3.9E+8	7.0E+8	9.4E+7	1.7E+1
Cr-51	2.9E-7	2.1E+4	5.5E+4	3.6E+6	6.4E+5	8.5E+6	4.1E+5
Fe-55	8.5E-9	1.2E+5	--	1.6E+7	3.6E+6	3.0E+8	8.8E+7
Fe-59	1.8E-7	1.5E+6	3.2E+8	1.3E+8	2.3E+7	8.7E+8	5.2E+8
Mn-54	2.6E-8	2.0E+6	1.6E+9	1.5E+7	2.2E+6	8.7E+8	7.4E+6
Co-58	1.1E-7	1.3E+6	4.4E+8	5.0E+7	8.1E+6	5.4E+8	8.9E+7
Co-60	4.2E-9	8.7E+6	2.5E+10	2.0E+8	2.8E+7	3.1E+9	4.1E+8
Sr-89	1.5E-7	2.4E+6	2.5E+4	1.2E+9	3.5E+9	1.3E+10	1.1E+8
Sr-90	7.9E-10	1.1E+8	--	3.8E+10	9.4E+10	7.9E+11	4.7E+9
Cs-134	1.1E-8	5.5E+5	8.0E+9	1.2E+10	4.4E+10	1.5E+10	6.5E+8
Cs-136	5.9E-7	1.9E+5	1.7E+8	7.9E+8	3.5E+9	1.0E+10	1.6E+7
Cs-137	7.3E-10	8.5E+5	1.2E+10	1.0E+10	3.5E+10	1.3E+10	5.4E+8
Ba-140	6.3E-7	2.0E+6	2.3E+7	3.3E+7	6.0E+6	1.2E+8	1.6E+7

Table 3-5d

DOSE RATE PARAMETERS--IMPLEMENTATION OF 10 CFR 50, AIRBORNE RELEASES

Age Group: Adult

		Dose Parameters (Maximum Organ)					
		Inhalation	Ground	Milk (Cow)	Milk (Goat)	Vegetables	Meat
		R_i^I	R_i^G	R_i^C	R_i^C	R_i^V	R_i^M
Nuclide	sec^{-1}	mrem/yr (per ($\mu Ci/m^3$))	m^2 x mrem/yr (per (μCi/sec)	m^2 x mrem/yr (per (μCi/sec)	m^2 x mrem/yr (per (μCi/sec)	m^2 x mrem/yr (per (μCi/sec)	m^2 x mrem/yr (per (μCi/sec)
H-3	1.8E-9	1.3E+3	--	1.1E+3	2.2E+3	3.0E+3	4.7E+2
I-131	1.0E-6	1.2E+7	1.0E+7	3.2E+10	5.7E+10	8.2E+9	1.2E+9
I-133	9.2E-6	2.2E+6	1.5E+6	2.3E+8	4.1E+8	1.1E+8	2.2E+1
Cr-51	2.9E-7	1.4E+4	5.5E+6	3.1E+6	5.5E+5	8.7E+6	7.7E+5
Fe-55	8.5E-9	7.2E+4	--	1.3E+7	2.0E+6	1.8E+8	1.5E+8
Fe-59	1.8E-7	1.0E+6	3.2E+8	1.0E+8	1.9E+7	8.0E+8	9.2E+8
Mn-54	2.6E-8	1.4E+6	1.6E+9	1.3E+7	1.9E+6	8.5E+8	1.4E+7
Co-58	1.1E-7	9.3E+5	4.4E+8	4.4E+7	7.1E+6	5.3E+8	1.7E+8
Co-60	4.2E-9	6.0E+6	2.5E+10	1.7E+8	2.4E+7	2.9E+9	7.6E+8
Sr-89	1.5E-7	1.4E+6	2.5E+4	6.5E+8	1.9E+9	8.2E+9	1.3E+8
Sr-90	7.9E-10	9.9E+7	--	2.7E+10	6.7E+10	6.2E+11	7.2E+9
Cs-134	1.1E-8	8.5E+5	8.0E+9	7.0E+9	2.5E+10	9.9E+9	8.2E+8
Cs-136	5.9E-7	1.5E+5	1.7E+8	4.6E+8	2.1E+9	9.0E+7	2.1E+7
Cs-137	7.3E-10	6.2E+5	1.2E+10	5.6E+9	1.5E+10	8.3E+9	6.7E+8
Ba-140	6.3E-7	1.3E+6	2.3E+7	2.5E+7	4.4E+6	1.4E+8	2.6E+7

Table 3-6

INPUT PARAMETERS FOR CALCULATING R_i^C

Parameter	Value	Table*
r (dimensionless)	1.0 for radioiodine	E-15
	0.2 for particulates	E-15
F_m (days/liter)	Each stable element	E-1
U_{ap} (liters/yr)--Infant	330	E-5
--Child	330	E-5
--Teen	400	E-5
--Adult	310	E-5
$(DFL_i)_a$ (mrem/pCi)	Each radionuclide	E-11 to E-14
Y_p (kg/m^2)	0.7	E-15
Y_s (kg/m^2)	2.0	E-15
t_f (seconds)	1.73×10^5 (2 days)	E-15
t_h (seconds)	7.78×10^6 (90 days)	E-15
Q_F (kg/day)	50	E-3
fs (dimensionless)	1.0	NUREG-0133
fp (dimensionless)	0.5 for cow	Site specific
	0.75 for goat	Site specific

*Of Regulatory Guide 1.109 unless stated otherwise.

Table 3-7

INPUT PARAMETERS FOR CALCULATING R_i^M

Parameter	Value	Table*
r (dimensionless)	1.0 for radioiodine	E-15
	0.2 for particulates	E-15
F_f (days/kg)	Each stable element	E-1
U_{ap} (kg/yr)--Infant	0	E-5
--Child	41	E-5
--Teen	65	E-5
--Adult	110	E-5
$(DFL_i)_a$ (mrem/pCi)	Each radionuclide	E-11 to E-14
Y_p (kg/m^2)	0.7	E-15
Y_s (kg/m^2)	2.0	E-15
t_f (seconds)	1.73×10^6 (20 days)	E-15
t_h (seconds)	7.78×10^6 (90 days)	E-15
Q_F (kg/day)	50	E-3

*Of Regulatory Guide 1.109.

Table 3-8

INPUT PARAMETERS FOR CALCULATING R_i^V

Parameter	Value	Table*
r (dimensionless)	1.0 for radioiodine	E-1
	0.2 for particulates	E-1
$(DFL_i)_a$ (mrem/pCi)	Each radionuclide	E-11 to E-14
U_a^L (kg/yr)--Infant	0	E-5
--Child	26	E-5
--Teen	42	E-5
--Adult	64	E-5
U_a^S (kg/yr)--Infant	0	E-5
--Child	520	E-5
--Teen	630	E-5
--Adult	520	E-5
f_L (dimensionless)	Site specific (default = 1.0)	E-5
f_g (dimensionless)	Site specific (default = 0.76)	RG 1.109, p 28
t_L (seconds)	8.6×10^4 (1 day)	E-15
t_h (seconds)	5.18×10^6 (60 days)	E-15
Y_v (kg/m^2)	2.0	E-15

*Of Regulatory Guide 1.109.

Table 3-9

INPUT PARAMETERS NEEDED FOR CALCULATING DOSE
TO THE MAXIMUM INDIVIDUAL FROM WNP-2 GASEOUS EFFLUENT

Input Parameter	Value	Reference
Distance to Maine (miles)	3000	Ref 1
Fraction of year leafy vegetables are grown	0.42	May 15-Oct 15
Fraction of year cows are on pasture	0.5	Ref 2
Fraction of crop from garden	0.76	Ref 3
Fraction of daily intake of cows derived from pasture while on pasture	1.0	Ref 3
Annual average relative humidity (%)	53.8	Ref 4
Annual average temperature (Fo)	53.0	Ref 5
Fraction of year goats are on pasture	0.75	Site Specific
Fraction of daily intake of goats derived from pasture while on pasture	1.0	Ref 2
Fraction of year beef cattle are on pasture	0.5	Ref 2
Fraction of daily intake of beef cattle derived from pasture while on pasture	1.0	Ref 2
Population within 50 miles of plant and the year that the population is used	336,115 (year 2000)	Ref 6
Annual 50-mile milk production (liters/yr)	9.91E+06	Refs 7 & 9
Annual 50-mile meat production (kg/yr)	3.54E+06	Refs 6, 7, & 9
Annual 50-mile vegetable production (kg/yr)	2.0E+07	Refs 6, 7, & 9
Source terms		GALE-Gaseous & Ref 8

Table 3-9 (contd.)

Input Parameter	Value	Reference
X/Q values by sector for each distance (recirculation, no decay) (sec/m^3)	See Tables 3-11 through 3-12	Ref 10
X/Q values by sector for each distance (recirculation, 2.26 days decay, undepleted) (sec/m^3)	See Tables 3-11 through 3-12	Ref 10
X/Q values by sector for each distance (recirculation, 8,0 days decay, depleted) (sec/m^3)	See Table 3-11 through 3-12	Ref 10
D/Q values by sector for each distance (1/m^2)	See Table 3-11 through 3-12	Ref 10
Number of special locations*	4	Ref 11

*Refer to Tables 3-3 and 3-4 for location name, distance from WNP-2, and X/Q and D/Q values.

Table 3-10
REACTOR BUILDING STACK X/Q AND D/Q VALUES*

a) No Decay, Undepleted

CHI/Q (sec/meter cubed) for each segment

Direction From Site	Segment Boundaries in Miles from the Site									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	1.103E-06	3.229E-07	1.153E-07	6.291E-08	4.151E-08	2.056E-08	6.109E-08	4.956E-08	3.370E-08	2.530E-08
SSW	8.824E-07	2.569E-07	9.106E-08	4.941E-08	3.243E-08	1.607E-08	5.267E-08	4.304E-08	2.930E-08	2.201E-08
SW	7.484E-07	2.220E-07	8.257E-08	4.646E-08	3.098E-08	4.101E-08	6.486E-08	4.274E-08	2.917E-08	2.195E-08
WSW	5.687E-07	1.717E-07	6.362E-08	3.543E-08	2.341E-08	2.882E-08	4.367E-08	2.851E-08	1.940E-08	1.457E-08
W	2.201E-07	7.362E-08	2.829E-08	1.604E-08	1.065E-08	5.201E-09	2.986E-08	2.489E-08	1.695E-08	1.274E-08
WNW	3.037E-07	1.024E-07	3.926E-08	2.208E-08	1.459E-08	7.801E-09	2.680E-08	2.168E-08	1.471E-08	1.104E-08
NW	9.434E-07	2.769E-07	9.967E-08	5.427E-08	3.563E-08	1.789E-08	3.036E-08	2.344E-08	1.582E-08	1.183E-08
NNW	3.010E-06	8.542E-07	3.077E-07	1.684E-07	1.121E-07	5.498E-08	5.529E-08	4.004E-08	2.706E-08	2.023E-08
N	3.675E-06	1.034E-06	3.712E-07	2.037E-07	1.343E-07	1.060E-07	8.208E-08	4.484E-08	3.033E-08	2.269E-08
NNE	2.430E-06	6.639E-07	2.313E-07	1.237E-07	8.113E-08	9.852E-08	5.491E-08	2.952E-08	1.980E-08	1.473E-08
NE	1.308E-06	3.571E-07	1.242E-07	6.798E-08	7.999E-08	9.512E-08	4.486E-08	2.428E-08	1.634E-08	1.219E-08
ENE	1.086E-06	3.381E-07	2.229E-07	2.754E-07	2.056E-07	9.895E-08	4.020E-08	2.168E-08	1.455E-08	1.082E-08
E	1.218E-06	3.665E-07	2.195E-07	2.582E-07	1.926E-07	9.269E-08	3.768E-08	2.036E-08	1.369E-08	1.020E-08
ESE	2.409E-06	7.211E-07	4.124E-07	4.440E-07	3.242E-07	1.423E-07	5.594E-08	3.335E-08	2.231E-08	1.656E-08
SE	3.043E-06	8.555E-07	3.108E-07	2.844E-07	3.417E-07	1.677E-07	8.760E-08	5.311E-08	3.586E-08	2.680E-08
SSE	1.842E-06	5.373E-07	1.943E-07	1.064E-07	7.011E-08	3.471E-08	7.245E-08	5.737E-08	3.891E-08	2.917E-08

*Desert Sigmas, Building wake effect. All stability classes A through G.

Table 3-10 (contd.)

b) 2.26-Day Decay, Undepleted

CHI/Q (sec/meter cubed) for each segment

Direction From Site	Segment Boundaries in Miles from the Site									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	1.101E-06	3.218E-07	1.146E-07	6.238E-08	4.106E-08	2.202E-08	5.876E-08	4.683E-08	3.113E-08	2.285E-08
SSW	8.810E-07	2.561E-07	9.054E-08	4.900E-08	3.208E-08	1.580E-08	5.064E-08	4.064E-08	2.704E-08	1.985E-08
SW	7.471E-07	2.212E-07	8.208E-08	4.608E-08	3.065E-08	4.023E-08	6.259E-08	4.036E-08	2.692E-08	1.980E-08
WSW	5.678E-07	1.711E-07	6.326E-08	3.515E-08	2.317E-08	2.827E-08	4.213E-08	2.691E-08	1.789E-08	1.313E-08
W	2.197E-07	7.334E-08	2.810E-08	1.589E-08	1.053E-08	5.107E-09	2.859E-08	2.338E-08	1.553E-08	1.138E-08
WNW	3.031E-07	1.020E-07	3.899E-08	2.187E-08	1.442E-08	7.652E-09	2.570E-08	2.039E-08	1.350E-08	9.877E-09
NW	9.419E-07	2.760E-07	9.911E-08	5.383E-08	3.527E-08	1.760E-08	2.929E-08	2.223E-08	1.469E-08	1.074E-08
NNW	3.006E-06	8.520E-07	3.063E-07	1.673E-07	1.111E-07	5.422E-08	5.369E-08	3.830E-08	2.542E-08	1.867E-08
N	3.671E-06	1.031E-06	3.696E-07	2.024E-07	1.332E-07	1.044E-07	7.996E-08	4.291E-08	2.852E-08	2.096E-08
NNE	2.427E-06	6.624E-07	2.303E-07	1.230E-07	8.050E-08	9.700E-08	5.336E-08	2.812E-08	1.850E-08	1.350E-08
NE	1.307E-06	3.562E-07	1.236E-07	6.753E-08	7.927E-08	9.359E-08	4.343E-08	2.300E-08	1.514E-08	1.104E-08
ENE	1.085E-06	3.371E-07	2.217E-07	2.733E-07	2.036E-07	9.737E-08	3.890E-08	2.051E-08	1.346E-08	9.792E-09
E	1.216E-06	3.655E-07	2.185E-07	2.563E-07	1.907E-07	9.125E-08	3.649E-08	1.928E-08	1.268E-08	9.243E-09
ESE	2.406E-06	7.193E-07	4.104E-07	4.408E-07	3.212E-07	1.403E-07	5.420E-08	3.164E-08	2.072E-08	1.506E-08
SE	3.039E-06	8.532E-07	3.093E-07	2.825E-07	3.389E-07	1.655E-07	8.498E-08	5.050E-08	3.341E-08	2.446E-08
SSE	1.839E-06	5.356E-07	1.932E-07	1.055E-07	6.939E-08	3.414E-08	6.903E-08	5.436E-08	3.608E-08	2.646E-08

Table 3-10 (contd.)

c) 8.0-Day Decay, Depleted

CHI/Q (sec/meter cubed) for each segment

Direction From Site	Segment Boundaries in Miles from the Site									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	1.006E-06	2.858E-07	9.773E-08	5.164E-08	3.323E-08	1.572E-08	5.545E-08	4.289E-08	2.735E-08	1.946E-08
SSW	8.039E-07	2.269E-07	7.694E-08	4.035E-08	2.578E-08	1.221E-08	4.794E-08	3.733E-08	2.383E-08	1.697E-08
SW	6.775E-07	1.942E-07	6.924E-08	3,784E-08	2.462E-08	3.644E-08	5.757E-08	3.520E-08	2.246E-08	1.597E-08
WSW	5.169E-07	1.515E-07	5.398E-08	2.923E-08	1.886E-08	2.562E-08	3.875E-08	2.347E-08	1.493E-08	1.060E-08
W	2.038E-07	6.726E-08	2.521E-08	1.407E-08	9.223E-09	4.395E-09	2.772E-08	2.189E-08	1.399E-08	9.964E-09
WNW	2.813E-07	9.369E-08	3.505E-08	1.938E-08	1.263E-08	6.663E-09	2.393E-08	1.828E-08	1.161E-08	8.239E-09
NW	8.584E-07	2.450E-07	8.465E-08	4.468E-08	2.865E-08	1.391E-08	2.688E-08	1.987E-08	1.257E-08	8.893E-09
NNW	2.714E-06	7.416E-07	2.547E-07	1.345E-07	8.724E-08	4.071E-08	4.583E-08	3.202E-08	2.021E-08	1.427E-08
N	3.312E-06	8.954E-07	3.060E-07	1.619E-07	1.037E-07	8.674E-08	6.796E-08	3.375E-08	2.123E-08	1.495E-08
NNE	2.196E-06	5.789E-07	1.924E-07	9.939E-08	6.360E-08	8.587E-08	4.544E-08	2.222E-08	1.387E-08	9.713E-09
NE	1.186E-06	3.134E-07	1.045E-07	5.570E-08	7.080E-08	8.611E-08	3.736E-08	1.841E-08	1.153E-08	8.096E-09
ENE	9.883E-07	3.011E-07	1.866E-07	2.147E-07	1.554E-07	7.012E-08	2.504E-08	1.187E-08	7.208E-09	4.925E-09
E	1.107E-06	3.252E-07	1.832E-07	2.013E-07	1.456E-07	6.569E-08	2.347E-08	1.115E-08	6.784E-09	4.643E-09
ESE	2.182E-06	6.364E-07	3.437E-07	3.464E-07	2.451E-07	1.014E-07	3.460E-08	1.827E-08	1.107E-08	7.548E-09
SE	2.747E-06	7.450E-07	2.593E-07	2.509E-07	3.134E-07	1.463E-07	6.976E-08	3.884E-08	2.434E-08	1.709E-08
SSE	1.671E-06	4.722E-07	1.634E-07	8.657E-08	5.559E-08	2.633E-08	5.975E-08	4.484E-08	2.835E-08	2.003E-08

Table 3-10 (contd.)

d) Reactor Building Stack Relative Deposition Rate, (D/Q), Per Unit Area ($meter^{-2}$)

Direction From Site	Segment Boundaries in Miles from the Site									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	7.256E-09	1.756E-09	5.194E-10	2.494E-10	1.466E-10	5.865E-11	3.375E-11	1.798E-11	9.603E-12	5.944E-12
SSW	5.752E-09	1.380E-09	4.082E-10	1.959E-10	1.150E-10	4.626E-11	2.608E-11	1.395E-11	7.448E-12	4.610E-12
SW	3.176E-09	7.513E-10	2.191E-10	1.035E-10	6.028E-11	3.817E-11	2.414E-11	9.646E-12	5.151E-12	3.188E-12
WSW	2.757E-09	6.889E-10	2.061E-10	9.796E-11	5.718E-11	3.358E-11	1.980E-11	7.927E-12	4.233E-12	2.620E-12
W	1.601E-09	4.334E-10	1.358E-10	6.565E-11	3.861E-11	1.524E-11	1.094E-11	6.220E-12	3.321E-12	2.056E-12
WNW	2.215E-09	5.797E-10	1.816E-10	8.829E-11	5.204E-11	2.856E-11	1.697E-11	7.175E-12	3.031E-12	2.372E-12
NW	4.901E-09	1.218E-09	3.728E-10	1.813E-10	1.068E-10	4.328E-11	2.419E-11	1.286E-11	6.869E-12	4.252E-12
NNW	1.235E-08	2.845E-09	8.198E-10	3.873E-10	2.303E-10	9.105E-11	4.558E-11	2.363E-11	1.262E-11	7.811E-12
N	1.914E-08	4.304E-09	1.213E-09	5.660E-10	3.273E-10	1.707E-10	7.090E-11	2.810E-11	1.501E-11	9.288E-12
NNE	2.034E-08	4.577E-09	1.284E-09	5.961E-10	3.471E-10	1.810E-10	6.374E-11	2.526E-11	1.349E-11	8.350E-12
NE	1.338E-08	2.986E-09	8.341E-10	3.918E-10	2.819E-10	1.483E-10	4.323E-11	1.713E-11	9.150E-12	5.663E-12
ENE	9.298E-09	2.169E-09	7.730E-10	4.579E-10	2.604E-10	1.001E-10	2.897E-11	1.148E-11	6.132E-12	3.795E-12
E	1.017E-08	2.355E-09	8.239E-10	4.749E-10	2.699E-10	1.038E-10	3.003E-11	1.190E-11	6.355E-12	3.934E-12
ESE	1.832E-08	4.190E-09	1.440E-09	8.177E-10	4.647E-10	1.780E-10	5.136E-11	2.049E-11	1.094E-11	6.773E-12
SE	2.006E-08	4.525E-09	1.262E-09	7.531E-10	6.421E-10	2.467E-10	7.197E-11	2.872E-11	1.534E-11	9.492E-12
SSE	9.321E-09	2.265E-09	6.764E-09	3.250E-10	1.905E-10	7.633E-11	4.186E-11	2.224E-11	1.187E-11	7.350E-12

Table 3-11
TURBINE BUILDING X/Q AND D/Q VALUES*

a) No Decay, Undepleted

CHI/Q (sec/meter cubed) for each segment

Direction From Site	Segment Boundaries in Miles from the Site									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	1.791E-05	5.032E-06	1.836E-06	1.019E-06	6.765E-07	3.337E-07	1.405E-07	7.800E-08	5.333E-08	4.018E-08
SSW	1.513E-05	4.282E-06	1.560E-06	8.729E-07	5.803E-07	2.781E-07	1.214E-07	6.758E-08	4.627E-08	3.489E-08
SW	1.419E-05	4.080E-06	1.513E-06	8.468E-07	5.651E-07	2.811E-07	1.198E-07	6.690E-08	4.584E-08	3.457E-08
WSW	1.004E-05	2.847E-06	1.044E-06	5.811E-07	3.862E-07	1.909E-07	8.059E-08	4.481E-08	3.066E-08	2.311E-08
W	8.834E-06	2.512E-06	9.240E-07	5.149E-07	3.426E-07	1.695E-07	7.171E-08	3.988E-08	2.728E-08	2.056E-08
WNW	8.324E-06	2.320E-06	8.416E-07	4.654E-07	3.080E-07	1.511E-07	6.317E-08	3.489E-08	2.380E-08	1.791E-08
NW	9.578E-06	2.620E-06	9.367E-07	5.135E-07	3.377E-07	1.639E-07	6.739E-08	3.687E-08	2.506E-08	1.881E-08
NNW	1.520E-05	4.196E-06	1.494E-06	8.198E-07	5.393E-07	2.620E-07	1.078E-07	5.905E-08	4.107E-08	3.015E-08
N	1.661E-05	4.558E-06	1.636E-06	8.987E-07	6.918E-07	2.881E-07	1.189E-07	6.518E-08	4.435E-08	3.329E-08
NNE	1.259E-05	3.378E-06	1.189E-06	6.456E-07	4.217E-07	2.025E-07	8.191E-08	4.445E-08	3.015E-08	2.260E-08
NE	1.019E-05	2.764E-06	9.837E-07	5.377E-07	3.528E-07	1.707E-07	6.978E-08	3.804E-08	2.581E-08	1.935E-08
ENE	9.328E-06	2.528E-06	8.989E-07	4.907E-07	3.215E-07	1.550E-07	6.302E-08	3.426E-08	2.322E-08	1.739E-08
E	8.659E-06	2.344E-06	8.336E-07	4.553E-07	2.985E-07	1.441E-07	5.868E-08	3.191E-08	2.162E-08	1.619E-08
ESE	1.452E-05	3.919E-06	1.391E-06	7.573E-07	4.950E-07	2.375E-07	9.577E-08	5.173E-08	3.494E-08	2.611E-08
SE	2.052E-05	5.657E-06	2.038E-06	1.121E-06	7.387E-07	3.595E-07	1.482E-07	8.123E-08	5.519E-08	4.141E-08
SSE	2.128E-05	5.940E-06	2.156E-06	1.193E-06	7.895E-07	3.875E-07	1.619E-07	8.949E-08	6.108E-08	4.596E-08

*Ground level release, Desert Sigmas. All stability classes A through G

Table 3-11 (Contd)

b) 2.26-Day Decay, Undepleted

CHI/Q (sec/meter cubed) for each segment

Direction From Site	Segment Boundaries in Miles from the Site									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	1.783E-05	4.991E-06	1.009E-06	9.984E-07	6.586E-07	3.195E-07	1.287E-07	6.725E-08	4.334E-08	3.079E-08
SSW	1.506E-05	4.246E-06	1.545E-06	8.547E-07	5.647E-07	2.746E-07	1.110E-07	5.810E-08	3.745E-08	2.660E-08
SW	1.413E-05	4.046E-06	1.490E-06	8.292E-07	5.500E-07	2.689E-07	1.095E-07	5.754E-08	3.712E-08	2.637E-08
WSW	9.992E-06	2.823E-06	1.029E-06	5.689E-07	3.750E-07	1.825E-07	7.359E-08	3.846E-08	2.475E-08	1.756E-08
W	8.792E-06	2.489E-06	9.089E-07	5.030E-07	3.324E-07	1.614E-07	6.487E-08	3.368E-08	2.152E-08	1.515E-08
WNW	8.286E-06	2.300E-06	8.282E-07	4.549E-07	2.990E-07	1.441E-07	5.731E-08	2.961E-08	1.891E-08	1.332E-08
NW	9.550E-06	2.600E-06	9.244E-07	5.040E-07	3.295E-07	1.576E-07	6.218E-08	3.220E-08	2.073E-08	1.475E-08
NNW	1.515E-05	4.145E-06	1.479E-06	8.080E-07	5.293E-07	2.541E-07	1.013E-07	5.321E-08	3.473E-08	2.503E-08
N	1.656E-05	4.532E-06	1.619E-06	8.858E-07	5.808E-07	2.794E-07	1.117E-07	5.878E-08	3.839E-08	2.769E-08
NNE	1.255E-05	3.356E-06	1.175E-06	6.350E-07	4.128E-07	1.956E-07	7.628E-08	3.941E-08	2.548E-08	1.821E-08
NE	1.015E-05	2.743E-06	9.705E-07	5.274E-07	3.441E-07	1.638E-07	6.419E-08	3.303E-08	2.117E-08	1.500E-08
ENE	9.291E-06	2.508E-06	8.865E-07	4.810E-07	3.133E-07	1.487E-07	5.788E-08	2.966E-08	1.897E-08	1.342E-08
E	8.626E-06	2.326E-06	8.225E-07	4.467E-07	2.912E-07	1.384E-07	5.403E-08	2.774E-08	1.777E-08	1.259E-08
ESE	1.446E-05	3.891E-06	1.373E-06	7.435E-07	4.834E-07	2.285E-07	8.846E-08	4.521E-08	2.893E-08	2.049E-08
SE	2.045E-05	5.618E-06	2.013E-06	1.102E-06	7.222E-07	3.446E-07	1.376E-07	7.159E-08	4.625E-08	3.301E-08
SSE	2.120E-05	5.895E-06	2.127E-06	1.170E-06	7.700E-07	3.721E-07	1.491E-07	7.790E-08	5.030E-08	3.583E-08

Table 3-11 (Contd)

c) 8.0-Day Decay, Depleted

CHI/Q (sec/meter cubed) for each segment

Direction From Site	Segment Boundaries in Miles from the Site									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	1.602E-05	4.299E-06	1.468E-06	7.920E-07	5.081E-07	2.342E-07	8.603E-08	4.155E-08	2.544E-08	1.742E-08
SSW	1.353E-05	3.657E-06	1.269E-06	6.782E-07	4.358E-07	2.014E-07	7.428E-08	3.596E-08	2.205E-08	1.510E-08
SW	1.269E-05	3.485E-06	1.224E-06	6.579E-07	4.244E-07	1.972E-07	7.328E-08	3.561E-08	2.184E-08	1.497E-08
WSW	8.976E-06	2.432E-06	8.448E-07	4.515E-07	2.901E-07	1.339E-07	4.930E-08	2.384E-08	1.460E-08	9.995E-09
W	7.901E-06	2.145E-06	7.473E-07	3.998E-07	2.571E-07	1.188E-07	4.375E-08	2.112E-08	1.291E-08	8.819E-09
WNW	7.446E-06	1.982E-06	6.808E-07	3.614E-07	2.312E-07	1.060E-07	3.858E-08	1.850E-08	1.129E-08	7.701E-09
NW	8.579E-06	2.239E-06	7.584E-07	3.993E-07	2.538E-07	1.152E-07	4.137E-08	1.971E-08	1.201E-08	8.205E-09
NNW	1.360E-05	3.564E-06	1.211E-06	6.382E-07	4.061E-07	1.847E-07	6.652E-08	3.185E-08	1.950E-08	1.337E-08
N	1.487E-05	3.897E-06	1.326E-06	6.996E-07	4.456E-07	2.030E-07	7.334E-08	3.516E-08	2.153E-08	1.477E-08
NNE	1.127E-05	2.888E-06	9.630E-07	5.023E-07	3.173E-07	1.426E-07	5.042E-08	2.386E-08	1.454E-08	9.933E-09
NE	9.117E-06	2.362E-06	7.964E-07	4.180E-07	2.651E-07	1.199E-07	4.280E-08	2.030E-08	1.235E-08	8.415E-09
ENE	8.348E-06	2.160E-06	7.277E-07	3.814E-07	2.416E-07	1.089E-07	3.864E-08	1.827E-08	1.109E-08	7.752E-09
E	7.750E-06	2.003E-06	6.749E-07	3.539E-07	2.243E-07	1.013E-07	3.601E-08	1.704E-08	1.035E-08	7.046E-09
ESE	1.299E-05	3.349E-06	1.126E-06	5.889E-07	3.722E-07	1.671E-07	5.883E-08	2.766E-08	1.676E-08	1.139E-08
SE	1.836E-05	4.834E-06	1.650E-06	8.720E-07	5.555E-07	2.529E-07	9.116E-08	4.353E-08	2.656E-08	1.815E-08
SSE	1.904E-05	5.075E-06	1.745E-06	9.273E-07	5.933E-07	2.723E-07	9.932E-08	4.779E-08	2.925E-08	2.002E-08

Table 3-11 (contd.)

d) Turbine Building Relative Deposition Rate, (D/Q), Per Unit Area (meter^{-2})

Direction From Site	Segment Boundaries in Miles from the Site									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	2.244E-08	4.597E-09	1.200E-09	5.390E-10	3.049E-10	1.173E-10	3.392E-11	1.344E-11	7.180E-12	4.444E-12
SSW	1.749E-08	3.583E-09	9.353E-10	4.201E-10	2.376E-10	9.138E-11	3.644E-11	1.048E-11	5.595E-12	3.463E-12
SW	1.218E-08	2.496E-09	6.515E-10	2.926E-10	1.655E-10	6.366E-11	1.842E-11	7.299E-12	3.898E-12	2.413E-12
WSW	1.010E-08	2.069E-09	5.402E-10	2.426E-10	1.372E-10	5.178E-11	1.527E-11	6.051E-12	3.231E-12	2.000E-12
W	7.468E-09	1.530E-09	3.993E-10	1.794E-10	1.015E-10	3.902E-11	1.129E-11	4.474E-12	2.389E-12	1.479E-12
WNW	8.961E-09	1.836E-09	4.792E-10	2.152E-10	1.218E-10	4.682E-11	1.355E-11	5.368E-12	2.867E-12	1.774E-12
NW	1.615E-08	3.309E-09	8.638E-10	3.880E-10	2.195E-10	8.440E-11	2.442E-11	9.677E-12	5.168E-12	3.199E-12
NNW	3.066E-08	6.280E-09	1.639E-09	7.363E-10	4.165E-10	1.602E-10	4.634E-11	1.837E-11	9.808E-12	6.070E-12
N	3.891E-08	7.970E-09	2.081E-09	9.345E-10	5.287E-10	2.033E-10	5.881E-11	2.331E-11	1.245E-11	7.705E-11
NNE	3.647E-08	7.471E-09	1.950E-09	8.760E-10	4.956E-10	1.906E-10	5.513E-11	2.185E-11	1.167E-11	7.222E-12
NE	2.492E-08	5.104E-09	1.333E-09	5.985E-10	3.386E-10	1.302E-10	3.766E-11	1.493E-11	7.972E-12	4.934E-12
ENE	1.906E-08	3.905E-09	1.019E-09	4.578E-10	2.590E-10	9.960E-11	2.881E-11	1.142E-11	6.098E-12	3.775E-12
E	1.977E-08	4.050E-09	1.057E-09	4.748E-10	2.686E-10	1.033E-10	2.988E-10	1.184E-11	6.325E-12	3.915E-12
ESE	3.404E-08	6.972E-09	1.820E-09	8.175E-10	4.624E-10	1.778E-10	5.145E-11	2.039E-11	1.089E-11	6.740E-12
SE	4.158E-08	8.518E-09	2.224E-09	9.907E-10	5.650E-10	2.173E-10	6.285E-11	2.491E-11	1.330E-11	8.234E-12
SSE	2.983E-08	6.111E-09	1.595E-09	7.165E-10	4.053E-10	1.559E-10	4.509E-11	1.787E-11	9.543E-12	5.907E-12

Table 3-12
RADWASTE BUILDING X/Q AND D/Q VALUES*

a) No Decay, Undepleted

CHI/Q (sec/meter cubed) for each segment

Direction From Site	Segment Boundaries in Miles from the Site									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	1.791E-05	5.032E-06	1.836E-06	1.019E-06	6.765E-07	3.337E-07	1.405E-07	7.800E-08	5.333E-08	4.018E-08
SSW	2.513E-05	4.282E-06	1.568E-06	8.729E-07	5.765E-07	2.871E-07	1.214E-07	6.758E-08	4.627E-08	3.489E-08
SW	1.419E-05	4.080E-06	1.513E-06	8.468E-07	5.651E-07	2.811E-07	1.198E-07	6.690E-08	4.584E-08	3.457E-08
WSW	1.004E-05	2.847E-06	1.044E-06	5.811E-07	3.862E-07	1.909E-07	8.059E-08	4.481E-08	3.066E-08	2.311E-08
W	8.834E-06	2.512E-06	9.240E-07	5.149E-07	3.426E-07	1.695E-07	7.171E-08	3.988E-08	2.728E-08	2.056E-08
WNW	8.324E-06	2.320E-06	8.416E-07	4.654E-07	3.080E-07	1.511E-07	6.317E-08	3.489E-08	2.380E-08	1.791E-08
NW	9.587E-06	2.620E-06	9.367E-07	5.135E-07	3.377E-07	1.639E-07	6.739E-08	3.687E-08	2.506E-08	1.881E-08
NNW	1.520E-05	4.169E-06	1.494E-06	8.198E-07	5.393E-07	2.620E-07	1.078E-07	5.905E-08	4.017E-08	3.015E-08
N	1.661E-05	4.558E-06	1.636E-06	8.987E-07	5.918E-07	2.881E-07	1.198E-07	6.518E-08	4.435E-08	3.329E-08
NNE	1.259E-05	3.378E-06	1.189E-06	6.456E-07	4.217E-07	2.025E-07	8.191E-08	4.445E-08	3.015E-08	2.260E-08
NE	1.019E-05	2.764E-06	9.837E-07	5.377E-07	3.528E-07	1.707E-07	6.978E-08	3.804E-08	2.581E-08	1.935E-08
ENE	9.328E-06	2.528E-06	8.989E-07	4.907E-07	3.215E-07	1.550E-07	6.302E-08	3.426E-08	2.322E-08	1.739E-08
E	8.659E-06	2.344E-06	8.336E-07	4.553E-07	2.985E-07	1.441E-07	5.868E-08	3.191E-08	2.162E-08	1.619E-08
ESE	1.452E-05	3.919E-06	1.391E-06	7.573E-07	4.950E-07	2.375E-07	9.577E-08	5.173E-08	3.494E-08	2.611E-08
SE	2.052E-05	5.657E-06	2.038E-06	1.121E-06	7.387E-07	3.595E-07	1.483E-07	8.123E-08	5.519E-08	4.141E-08
SSE	2.128E-05	5.940E-06	2.156E-06	1.193E-06	7.895E-07	3.875E-07	1.619E-07	8.949E-08	6.108E-08	4.596E-08

*Ground Level release. Desert sigmas. All stability classes A through G.

Table 3-12 (Cont'd)

b) 2.26-Day Decay, Undepleted

CHI/Q (sec/meter cubed) for each segment

Direction From Site	Segment Boundaries in Miles from the Site .5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	1.783E-05	4.991E-06	1.809E-06	9.984E-07	6.586E-07	3.195E-07	1.287E-07	6.725E-08	4.334E-08	3.079E-08
SSW	1.506E-05	4.246E-06	1.545E-06	8.547E-07	5.647E-07	2.746E-07	1.110E-07	5.810E-08	3.745E-08	2.660E-08
SW	1.413E-05	4.056E-06	1.490E-06	8.292E-07	5.500E-07	2.689E-07	1.095E-07	5.754E-08	3.712E-08	2.637E-08
WSW	9.992E-06	2.823E-06	1.029E-06	5.689E-07	3.758E-07	1.825E-07	7.359E-08	3.846E-08	2.475E-08	1.756E-08
W	8.792E-06	2.489E-06	9.089E-07	5.030E-07	3.324E-07	1.614E-07	6.487E-08	3.368E-08	2.152E-08	1.515E-08
WNW	8.286E-06	2.300E-06	8.282E-07	4.549E-07	2.990E-07	1.441E-07	5.731E-07	2.961E-08	1.891E-08	1.332E-08
NW	9.550E-06	2.600E-06	9.244E-07	5.040E-07	3.295E-07	1.576E-07	6.218E-08	3.220E-08	2.073E-08	1.475E-08
NNW	1.515E-05	4.145E-06	1.479E-06	8.080E-07	5.293E-07	2.541E-07	1.013E-07	5.321E-08	3.473E-08	2.503E-08
N	1.656E-05	4.532E-06	1.619E-06	8.858E-07	5.808E-07	2.794E-07	1.117E-07	5.878E-08	3.839E-08	2.769E-08
NNE	1.255E-05	3.356E-06	1.175E-06	6.350E-07	4.128E-07	1.956E-07	7.628E-08	3.941E-08	2.548E-08	1.821E-08
NE	1.015E-05	2.743E-06	9.705E-07	5.274E-07	3.441E-07	1.638E-07	6.419E-08	3.303E-08	2.117E-08	1.500E-08
ENE	9.291E-06	2.508E-06	8.865E-07	4.810E-07	3.133E-07	1.487E-07	5.788E-08	2.966E-08	1.897E-08	1.342E-08
E	8.626E-06	2.326E-06	8.225E-07	4.467E-07	2.912E-07	1.384E-07	5.403E-08	2.774E-08	1.777E-08	1.259E-08
ESE	1.446E-05	3.891E-06	1.383E-06	7.435E-07	4.834E-07	2.285E-07	8.846E-08	4.521E-08	2.893E-08	2.049E-08
SE	2.045E-05	5.618E-06	2.013E-06	1.103E-06	7.222E-07	3.466E-07	1.376E-07	7.159E-08	4.625E-08	3.301E-08
SSE	2.120E-05	5.895E-06	2.127E-06	1.170E-06	7.700E-07	3.721E-07	1.491E-07	7.790E-08	5.030E-80	3.583E-08

Table 3-12 (Cont'd)

c) <u>8.0 Day Decay, Depleted</u> (Corrected for Open Terrain Recirculation)

CHI/Q (sec/meter cubed) for each segment

Direction From Site	Segment Boundaries in Miles from the Site									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	1.602E-05	4.299E-06	1.486E-06	7.920E-07	5.081E-07	2.342E-07	8.603E-08	4.155E-08	2.544E-08	1.742E-08
SSW	1.353E-05	3.657E-06	1.269E-06	6.782E-07	4.358E-07	2.014E-07	7.428E-08	3.596E-08	2.205E-08	1.510E-08
SW	1.269E-05	3.485E-06	1.224E-06	6.579E-07	4.244E-07	1.972E-07	7.328E-08	3.561E-08	1.460E-08	1.497E-08
WSW	8.976E-06	2.432E-06	8.448E-07	4.515E-07	2.901E-07	1.339E-07	4.930E-08	2.384E-08	1.460E-08	9.995E-09
W	7.901E-06	2.145E-06	7.473E-07	3.998E-07	2.571E-07	1.188E-07	4.375E-08	2.112E-08	1.291E-08	8.819E-09
WNW	7.446E-06	1.982E-06	6.808E-07	3.614E-07	2.312E-07	1.060E-07	3.858E-08	1.850E-08	1.129E-08	7.701E-09
NW	8.579E-06	2.239E-06	7.584E-07	3.993E-07	2.538E-07	1.152E-07	4.137E-08	1.971E-08	1.201E-08	8.205E-09
NNW	1.360E-05	3.564E-06	1.211E-06	6.382E-07	4.061E-07	1.847E-07	6.652E-08	3.185E-08	1.950E-08	1.337E-08
N	1.487E-05	3.897E-06	1.326E-06	6.996E-07	4.456E-07	2.030E-07	7.334E-08	3.516E-08	2.153E-08	1.477E-08
NNE	1.127E-05	2.888E-06	9.630E-07	5.023E-07	3.173E-07	1.426E-07	5.042E-08	2.386E-08	1.454E-08	9.933E-09
NE	9.117E-06	2.362E-06	7.964E-07	4.180E-07	2.651E-07	1.199E-07	4.280E-08	2.030E-08	1.235E-08	8.415E-09
ENE	8.348E-06	2.160E-06	7.277E-07	3.814E-07	2.416E-07	1.089E-07	3.864E-08	1.827E-08	1.109E-08	7.552E-09
E	7.750E-06	2.003E-06	6.749E-07	3.539E-07	2.243E-07	1.013E-07	3.601E-08	1.704E-08	1.035E-08	7.046E-09
ESE	1.299E-05	3.349E-06	1.126E-06	5.889E-07	3.722E-07	1.671E-07	5.883E-08	2.766E-08	1.676E-08	1.139E-08
SE	1.836E-05	4.834E-06	1.650E-06	8.720E-07	5.555E-07	2.529E-07	9.116E-08	4.353E-08	2.656E-08	1.815E-08
SSE	1.904E-05	5.075E-06	1.745E-06	9.273E-07	5.933E-07	2.723E-07	9.932E-08	4.779E-08	2.925E-08	2.002E-08

Table 3-12 (Cont'd)

d) Radwaste Building Relative Deposition Rate, (D/Q), Per Unit Area ($Meter^{-2}$)

Direction From Site	Segment Boundaries in Miles from the Site									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	2.244E-08	4.597E-09	1.200E-09	5.390E-10	3.049E-10	1.173E-10	3.392E-11	1.344E-11	7.180E-12	4.444E-12
SSW	1.749E-08	3.583E-09	9.353E-10	4.201E-10	2.376E-10	9.138E-11	2.644E-11	1.048E-11	5.595E-12	3.463E-12
SW	1.218E-08	2.496E-09	6.515E-10	2.926E-10	1.655E-10	6.366E-11	1.842E-11	7.299E-12	3.898E-12	2.413E-12
WSW	1.010E-08	2.069E-09	5.402E-10	2.426E-10	1.372E-10	5.278E-11	1.527E-11	6.051E-12	3.231E-12	2.000E-12
W	7.468E-09	1.530E-09	3.993E-10	1.794E-10	1.015E-10	3.902E-11	1.129E-11	4.474E-12	2.389E-12	1.479E-12
WNW	8.961E-09	1.836E-09	4.792E-10	2.152E-10	1.218E-10	4.682E-11	1.355E-11	5.368E-12	2.867E-12	1.774E-12
NW	1.615E-08	3.309E-09	8.638E-10	3.880E-10	2.195E-10	8.440E-11	2.442E-11	9.677E-12	5.168E-12	3.199E-12
NNW	3.066E-08	6.280E-09	1.639E-09	7.363E-10	4.165E-10	1.602E-10	4.634E-11	1.837E-11	9.808E-12	6.070E-12
N	3.891E-08	7.970E-09	2.081E-09	9.345E-10	5.287E-10	2.033E-10	5.881E-11	2.331E-11	1.245E-11	7.705E-12
NNE	3.647E-08	7.471E-09	1.950E-09	8.760E-10	4.956E-10	1.906E-10	5.513E-11	2.185E-11	1.167E-11	7.222E-12
NE	2.492E-08	5.104E-09	1.333E-09	5.985E-10	3.386E-10	1.302E-10	3.766E-11	1.493E-11	7.972E-12	4.934E-12
ENE	1.906E-08	3.905E-09	1.019E-09	4.578E-10	2.590E-10	9.960E-11	2.881E-11	1.142E-11	6.098E-12	3.775E-12
E	1.977E-08	4.050E-09	1.057E-09	4.748E-10	2.686E-10	1.033E-10	2.988E-11	1.184E-11	6.325E-12	3.915E-12
ESE	3.404E-08	6.972E-09	1.820E-09	8.175E-10	4.624E-10	1.778E-10	5.145E-11	2.039E-11	1.089E-11	6.740E-12
SE	4.158E-08	8.518E-09	2.224E-09	9.987E-10	5.650E-10	2.173E-10	6.285E-11	2.491E-11	1.330E-11	8.234E-12
SSE	2.983E-08	6.111E-09	1.595E-09	7.165E-10	4.053E-10	1.559E-10	4.509E-11	1.787E-11	9.543E-12	5.907E-12

Table 3-13

CHARACTERISTICS OF WNP-2 GASEOUS EFFLUENT RELEASE POINTS

	Reactor Building	Radwaste Building	Turbine Building
Height of release point above ground level (m)	70.6m	31.1	27.7
Annual average rate of air flow from release point (m^3/sec)	44.8	38.7	125.6
Annual average heat flow from release point (cal/sec)	1.06×10^6	2.9×10^6	9.1×10^5
Type and size of release point (m)	Duct 1.14 x 3.05	3 Louver houses 1.4 x 2.4 x 0.8 Each	4 Exhaust fans 1.45 x 2.01 Each
Effective vent area (m^2)	3.48	2 x 2.7	3 x 2.91
Vent velocity (m/sec)*	12.9	2 x 525 cfm**	14.4
Effective diameter (m) (πr^2 = area)	1.1	--	1.0
Building height (m)	70.1	70.1	70.1

*Reactor Building exhaust in vertical direction. Radwaste and Turbine Building exhaust in horizontal plane.

**FSAR Drawing 6-41, 525 cfm x 2 out of 3, will run at any one time.

Table 3-14

REFERENCES FOR VALUES LISTED IN TABLE 3-9

Reference 1	U.S. Map
Reference 2	GASPAREDIT Input Instruction, page 10
Reference 3	Regulatory Guide 1.109, Table E-15
Reference 4	Section 2.3, WNP-2 FSAR, Table 2.3-20
Reference 5	Section 2.3, WNP-2 FSAR, page 2.3-3
Reference 6	Keith E. Yandon, October 1980, "Projections and Distributions of Population Within a 50-Mile Radius of Washington Public Power Supply System Nuclear Projects Nos. 1, 2, and 4 by Compass Direction and Radii Intervals," 1970-2030
Reference 7	WNP-2 ER, Table 5.2-12
Reference 8	WNP-2 FSAR, Table 11.3-7
Reference 9	Radiological Programs Calculation Log No. 83-1
Reference 10	WNP-2 XOQDOQ Computer Run
Reference 11	Regulatory Guide 1.145, Section C.1.2

Table 3-15

DESIGN BASE PERCENT NOBLE GAS (30-MINUTE DECAY)*

Isotope	Percent of Total Activity
Kr-83M	2.9
Kr-85M	5.6
Kr-85	0
Kr-87	15
Kr-88	18
Kr-89	0.2
Xe-131M	0.02
Xe-133M	0.3
Xe-133	8.2
Xe-135M	6.9
Xe-135	22
Xe-137	0.7
Xe-138	21

*From Table 11.3-1 WNP-2 FSAR

TABLE 3-16 ANNUAL DOSES AT SPECIAL LOCATIONS WITHIN WNP-2 SITE BOUNDARY

Source: WNP-2 Gaseous Effluent

Location	Distance (Miles)	Occupancy (hrs/yr)	Whole Body Dose (mrem/yr)	Thyroid Dose (mrem/yr)
BPA Ashe Substation	0.5 N	2080	2.3E-0	3.4E-0
DOE Train	0.5 SE*	78	9.2E-02	1.5E-01
Wye Burial Site	0.5 WNW	8	4.0E-03	6.1E-03
WNP-1	1.2 ESE	2080	6.1E-01	9.6E-01
WNP-4	1.0 ENE	2080	3.8E-01	6.0E-01
WNP-2 Visitor Center	0.5 ENE	8	9.1E-03	1.6E-02
Taylor Flats**	4.2 SE	8760	1.2E-0	7.9E-0
Site Boundary***	1.2 SE	8760	4.3E+01	2.4E+0

*The sector with the highest X/Q values (within 0-0.5 mile radius) was used.

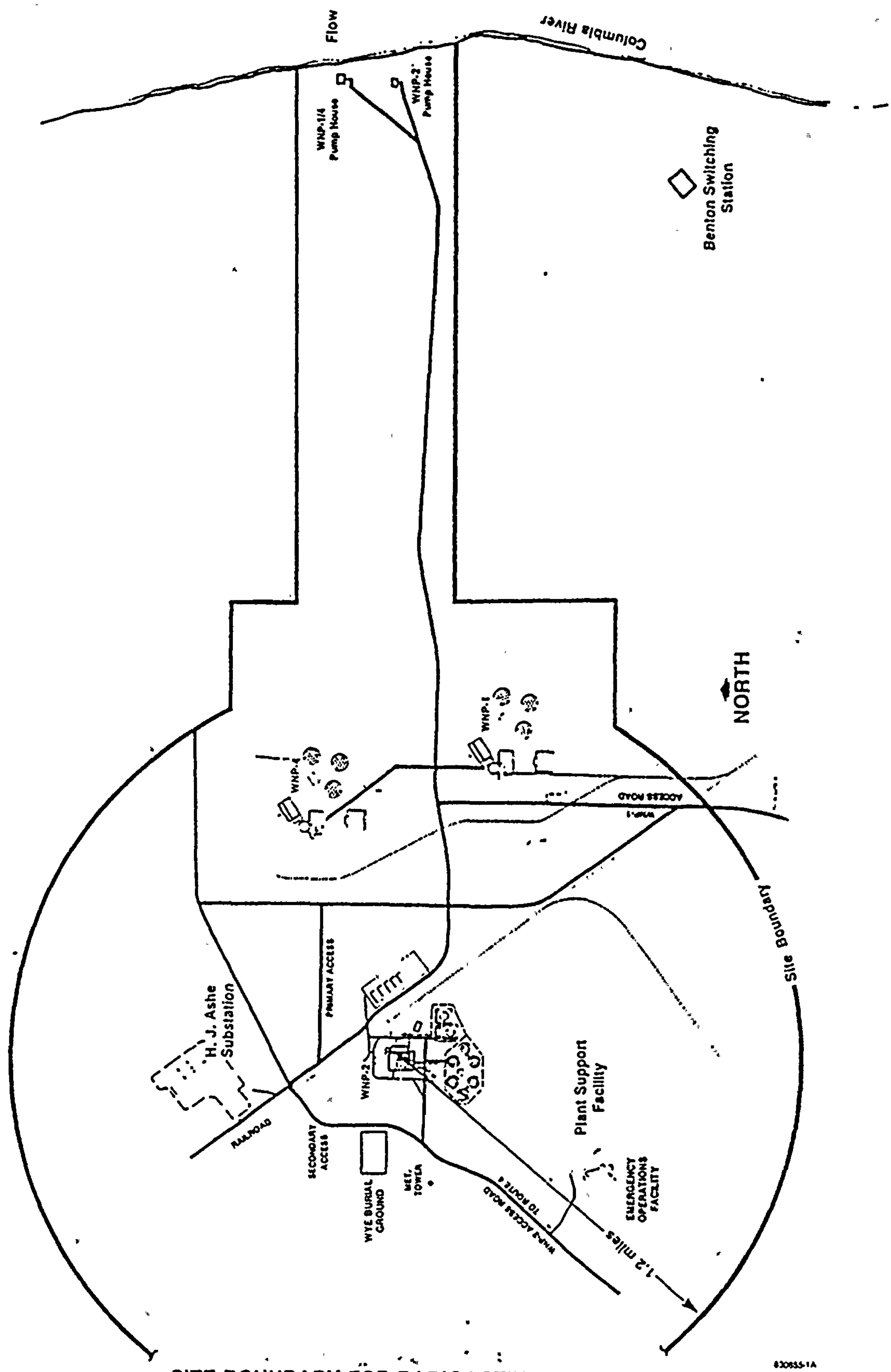
**Not within site boundary. Closest residental area representative of maximum individual dose from plume, ground, goat milk, and inhalation exposure pathways. Included for comparison.

***Assumed continuously occupied. Actual occupancy is very low. Doses from Inhalation and Ground Exposure pathways. No food crops.

TABLE 3-17 ANNUAL OCCUPIED AIR DOSE AT SPECIAL LOCATIONS WITHIN WNP-2 SITE BOUNDARY

Location	Annual Beta Air dose (mrad)	Annual Gamma Air Dose (mrad)
BPA Ashe Substation	2.1E-0	3.2E-0
DOE Train	9.2E-02	1.5E-01
Wye Burial Site	3.6E-03	6.0E-03
WNP-1	5.5E-01	8.6E-01
WNP-4	3.6E-01	2.2E-0
WNP-2 Visitor Center	9.4E-03	1.5E-02
Taylor Flats*	1.5E-0	1.8E-0
Site Boundary	2.9E-01	5.4E+0

*Not within site boundary. Closest residential area. Included for comparison.



SITE BOUNDARY FOR RADIOACTIVE GASEOUS AND LIQUID EFFLUENTS
Figure 3-1

4.0 COMPLIANCE WITH 40 CFR 190

Standard Technical Specification 3.11.4 specifies that when the calculated doses associated with the effluent releases exceed twice the limits of any one of the Specifications 3.11.1.2, 3.11.2.2, or 3.11.2.3, a Special Report to the Commission shall be prepared and submitted, and subsequent releases will be limited such that the dose or dose commitment to a real individual from all uranium fuel cycle sources is limited to _ 25 mrem to the total body or any organ (except the thyroid, which is limited to _ 75 mrem) over 12 consecutive months. The Report shall include an analysis which demonstrates that radiation exposures to all real individuals from all uranium fuel cycle sources (including all liquid and gaseous effluent pathways and direct radiation) are less than the standards in 40 CFR Part 190, Environmental Radiation Protection Standards for Nuclear Power Operations. If analysis indicates that releases resulting in doses that exceed the 40 CFR 190 standard could occur, a variance from the Commission to permit such releases will be requested. The Special Report shall include the following:

1. Determination of which uranium fuel cycle facilites or operations, in addition to WNP-2, contribute to the annual dose to the maximum exposed member of the public.

2. Identification and explanation of the location of the maximum individual.

3. Determination of the total annual dose to the maximum individual from all pathways and sources of radioactivity and radiation, including direct radiation from N-16, the plant, and storage facilities. The direct radiation dose may be either calculated or measured. Pathway doses shall be calculated using the methodologies described in NUREG-0597 (GASPAR), NUREG GR-1276 (LADTAP). The external measurements or calculations of direct radiation will be documented in the report.

5.0 RADIOLOGICAL ENVIRONMENTAL MONITORING

Radiological environmental monitoring is intended to supplement radiological effluent monitoring by verifying that measurable concentrations of radioactive materials and levels of radiation in the environment are not greater than expected based on effluent measurement and dose modeling of environmental exposure pathways. The Radiological Environmental Monitoring Program (REMP) for WNP-2 provides for measurements of radiation and radioactive materials in those exposure pathways and for those radionuclides for which the highest potential dose commitment to a member of the public would result due to plant operations.

The WNP-2 REMP is designed to conform to regulatory guidence provided by Regulatory Guide 4.1, 4.8 and the Radiological Assessment Branch Technical Position, taking into consideration certain site specific characteristics. The unique nature of the WNP-2 site on Federally owned and administered land (Hanford Reservation) dedicated to energy facilities, research, waste management and as a natural reserve, forms the basis for many of the site specific parameters. Amongst the many site specific parameters considered is demographic data such as:

1) No significant clusters of population including schools, hospitals, business facilities or primary public transportation routes are located within 8 km (5 mile) radius of the plant.

2) No private residences are located on the Hanford Reservation.

3) The closest resident is east of the Columbia River at a distance of approximately 4 miles.

Additional site information is available in the WNP-2 Environmental Report, Operating License Stage.

The Radiological Environmental Monitoring Program is conducted as specified in the Plant Technical Specifications, 3/4.12 and detailed in the following sections.

5.1 Radiological Environmental Monitoring Program (REMP)

Environmental samples for the REMP are collected in accordance with Table 5-1. This table provides a detailed outline of the sampling program by sample type, sample location code, sampling and collection frequency, and type and frequency of analysis of samples collected within exposure pathway. Deviations from the sampling frequency detailed in Table 5-1 may occur due to circumstances such as hazardous conditions, malfunction of automatic sampling equipment, seasonal unavailability, or other legitimate reasons. When sample media is unobtainable due to equipment malfunction, special actions per program instruction shall be taken to ensure that corrective action is implemented prior to the end of the next sampling period. In some cases, alternate sample collection may be substituted for the missing speciman. All deviations from the sampling program detailed in Table 5-1 shall be documented and reported in the Annual Radiological Environmental Operating Report in accordance with Plant Technical Specifications.

In the event that it becomes impossible or impractical to continue sampling a media of choice at currently established location(s) or time, an evaluation shall be made to determine-a-suitable alternative media and/or location to provide appropriate exposure pathway evaluations. The evaluation and any substitution made shall be implemented in the sampling program within 30 days of identification of the problem. All changes implemented in the sampling program due to unavailability of samples shall be fully documented in the next Semiannual Radioactive Effluent Release Report and ODCM, including revised table(s) and figure(s) reflecting the new locations and/or media.

WNP-2 sampling stations are described in Table 5-2. Each station is identified by an assigned number or alphanumeric designation, meteorological sector (16 different, 22-1/2° compass sections) in which the station is located, and radial distance from WNP-2 containment as estimated from map positions. Also included in Table 5-2 is information identifing the type(s) of samples collected at each station.

5.2 Land Use Census

A land use census shall be conducted in accordance with Plant Technical Specifications at least once per calendar year during the growing season being completed no later than September 30 each year. The information obtained is to be used to identify demographic changes in the unrestricted areas to permit modifications in monitoring programs for evaluation of doses to individuals through critical pathway analysis and estimation of dose to the total population within a 50-mile (80 km) radius. Local demographic data shall include information on growing season, irrigation practices, cattle feed sources, land productivity, and fish and game consumption within a 50-mile radius. More specific data within each of the 16 meteorological sectors, such as distance to nearest resident, nearest milk animal, and nearest garden greater than $50 m^2$ ($500 ft^2$) in size producing broad leaf vegetation shall be identified to support recalculation of maximum individual dose estimates. Site-specific considerations such as the Department of Energy's Hanford Reservation Site Boundary, within which WNP-2 is located, may require that specific information be collected beyond a 5-mile (8 km) radius in certain meteorological sectors to adequately identify pertinent data.

The results of the land use census will be reported within 30 days of completion of all field work and no later than October 31 of each year to the person(s) responsible for calculation of individual and population doses. All changes, such as a location yielding a greater estimated dose or different location with a 20 percent greater estimated dose than a currently sampled location, shall be reported in the next Semiannual Radiological Effluent Report per Plant Technical Specifications and the monitoring program changed to reflect the new data as appropriate.

The best available information, whether obtained by aerial survey, door-to-door survey, or consultation with local authorities, shall be used to complete the Land Use Survey and the results reported in the Annual Radiological Environmental Operating Report per Plant Technical Specifications.

5.3 Laboratory Intercomparison Program

Analysis of REMP samples is contracted to a provider of radiological analytical services. By contract, this analytical service vendor is required to conduct all activities in accordance with Regulatory Guides 4.1, 4.8, and 4.15 and to include in each monthly report actions pertinent to their participation in the Environmental Protection Agency's (EPA) Environmental Radioactivity Laboratory Intercomparison Studies (Crosscheck) Program. A precontract award survey and annual audit at the contractor's facility ensure that the contractor is participating in the Crosscheck Program.

The results of the contractor's analysis of Crosscheck samples shall be included in the Annual Radiological Environmental Operating Report in accordance with the Plant Technical Specifications.

Besides the vendor's required participation in the EPA's Crosscheck Program, the Department of Social and Health Services (DSHS) of the State of Washington oversees an analytical program for the Energy Facility Site Evaluation Council (EFSEC) to provide an independent test of WNP-2 REMP sample analyses. The WNP-2/DSHS split samples are analyzed by Washington State's Office of Public Health Laboratories and Epidemiology, Environmental Radiation Laboratory (ERL). The State's ERL participates in the EPA Crosscheck Program, as well as other federal participatory analytical quality assurance programs. The results of the ERL, EPA Crosscheck data are included in an annual report, "Environmental Radiation Program, Environmental Health Surveillance, State of Washington" which is available for comparison with the WNP-2 data.

5.4 Reporting Requirements

WNP-2 radiological environmental surveillance program activities are presented annually in the Annual Radiological Environmental Operating Report (AREOR). This report is submitted to the Director of the NRC Regional Office, with copies to the Director, Office of Nuclear Reactor Regulation, and the State of Washington Energy Facility Site Evaluation Council (EFSEC) by May 1 of each

year for all program activities conducted the previous calendar year. The period of the first operational report begins with the date of initial criticality. A preoperational report is due to EFSEC within 90 days of initial criticality.

The annual report is to include the following types of information: a tabulated summary; interpretations and analyses of trends for results of radiological environmental surveillance activities for the report period, including comparisons with operational controls, preoperational studies, and previous environmental surveillance reports as appropriate; an assessment of the observed impacts of plant operation on the environment; a brief description of the radiological environmental monitoring program; maps representing sampling station locations, keyed to tables of distance and direction from reactor containment; results of the land use census; and the results of analytical laboratory participation in the EPA's Crosscheck Program. The tabulated summary shall be presented in a format represented in Table 5-3. A supplementary report is required if all analytical results are not available for inclusion in the annual report within the specified time frame. The missing data shall be submitted as soon as possible upon receipt of the results. Along with the missing data, the supplementary report shall include an explanation as to the cause for the delay in completion of the analysis within the report period.

A nonroutine radiological environmental operating report is required to be submitted within 30 days from the end of any quarter in which a confirmed measured radionuclide concentration in an environmental sample averaged over the quarter sampling period exceeds a reporting level. Table 5-4 specifies the reporting level (RL) for most radionuclides of environmental importance due to potential impact from plant operations. When more than one of the nuclides listed in Table 5-4 is detected in a sample, the reporting level is considered to be exceeded and a nonroutine report required if the following conditions are satisfied:

$$\frac{\text{Concentration (1)}}{\text{Reporting Level (1)}} + \frac{\text{Concentration (2)}}{\text{Reporting Level (2)}} + \text{- - - - - - - -} \geq 1$$

For radionuclides other than those listed in Table 5-4, the reporting level is considered to have been exceeded if the potential annual dose to an individual is greater than or equal to the design objective doses of Appendix I, 10 CFR 50. When a nonroutine report on an unlisted (Table 5-4) radionuclide must be issued, it shall include an evaluation of any release conditions, environmental factors, or other aspects necessary to explain the anomalous sample results.

When it can be demonstrated that the anomolous sample result(s) exceeding reporting levels is not the result of plant effluents, a nonroutine report does not have to be submitted. A full discussion of the sample result and subsequent evaluation or investigation of the anomolous result will be included in the Annual Radiological Environmental Operational Report.

TABLE 5-1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

	Sample Type	Sample Location Code*1	Sampling and Collection Frequency[1]	Type and Frequency of Analysis[1]
1.	AIRBORNE			
	a. Particulates and radioiodine	1, 4-9, 21, 23, 40, and 48	Continuous sampling Weekly collection	Particulate: Gross beta[2], weekly; gamma isotopic[3], quarterly composite (by location) Radioiodine: I-131 analysis, weekly
	b. Soil[11]	9, 1, 7, 21, and 23	Annually	Gamma isotopic[3]
2.	DIRECT RADIATION			
	a. TLD[4]	1-9, 10-25, 40-47, 49-51, 53-56, 1S-16S	Quarterly, annually	Gamma, quarterly data review
	b. PIC[12]	1, 21, and 23	Continuous recording, monthly tape exchange	Gamma, monthly data review
3.	WATERBORNE			
	a. Surface[13]	26 and 28	Composite aliquots[5], monthly	Gamma isotopic[3], tritium quarterly composite
	b. Drinking water[6]	26, 28 and 29	Composite aliquots[5], monthly	Gamma isotopic[3], Gross Beta, tritium quarterly composite
	c. Ground water[7]	31, 32, and 52	Quarterly	Gamma isotopic[3] and tritium, quarterly

TABLE 5-1 (contd.)

Sample Type	Sample Location Code*[1]	Sampling and Collection Frequency[1]	Type and Frequency of Analysis[1]
WATERBORNE (contd.)			
d. Sediment from shoreline	33 and 34	Semiannually	Gamma isotopic[3]
4. INGESTION			
a. Milk[8]	9, 35, 36, and 40	Semimonthly during grazing season, monthly at other times	Gamma isotopic[3] Iodine-131
b. Fish[9]	30, 38, and 39	Seasonal or Semiannually	Gamma isotopic[3]
c. Garden produce[10]	37 and 9	Monthly during growing season in the Riverview area of Pasco and a control near Grandview	Gamma isotopic[3]

*Sample locations are graphically depicted in Figures 5-1 and 5-2.

[1]Deviations are permitted if samples are unobtainable due to hazardous conditions, seasonal availability, malfunction of automatic sampling equipment, or other legitimate reasons. All deviations will be documented in the Annual Radiological Environmental Monitoring Report.

[2]Particulate sample filters will be analyzed for gross beta after at least 24-hour decay. If gross beta activity is greater than 10 times the mean of the control sample, gamma isotopic analysis should be performed on the individual sample.

[3]Gamma isotopic means identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents of the facility.

[12]Pressurized Ion Chambers (PICs) are instruments for measuring and recording dose rate continuously. The three PICs are a part of a special two-phase, two-year monitoring program for the Energy Facility Site Evaluation Council.

[13]Station 28, 300 Area drinking water (untreated at sampling point) is a river (surface) water sample from beyond the mixing zone of the WNP-2 discharge, safisfying the BTP criteria for a discharge sample. Station 27 is sampled from the WNP-2 discharge effluent to allow for quantification of discharges to the river from each operating plant.

[14]Drinking and groundwater samples will be analyzed and reported in accordance with the requirements of 40 CFR Part 141 for tritium, because of the presence of a tritium plume in the unconfined aquifer in the vicinity of WNP-2. This groundwater containment is the result of Hanford Site operations since 1944 (PNL-4659, Groundwater Surveillance at the Hanford Site for CY 1982).

[4]TLD refers to thermoluminescent dosimeter. For purposes of WNP-2 REMP, a TLD is a phosphor card (32mm x 45mm x 0.5mm) with eight individual read-out areas (four main dosimeter areas and four back-up dosimeter areas) in each badge case. TLDs used in REMP meet the requirements of Regulatory Guide 4.13 (ANSI N545-1975), except for specified energy-dependence response. Correction factors are available for energy ranges with response outside of the specified tolerances. TLD stations IS-16S are special interest stations and are not included amongst the 34 routine TLD stations required by Plant Technical Specification, Table 3.12-1.

[5]Composite samples will be collected with equipment which is capable of collecting an aliquot at time intervals which are short relative to the compositing period.

[6]Station 26, WNP-2 makeup water intake from the Columbia River, is considered the control for drinking water samples. Drinking water samples are not routinely analysed for I-131 from two week composit. I-131 analysis calculated for the consumption of water is greater than 1 mrem per year.

[7]Additional groundwater sampling is conducted by plant chemistry personnel to demonstrate compliance with EPA drinking water standards. Results of WNP-2 well #3 pumphouse sample from plant sampling program will be included in REMP Annual Radiological Environmental Monitoring Report (Station 52).

[8]Milk samples will be obtained from farms or individual milk animals which are located in sectors with high calculated annual average ground-level D/Qs and high dose potential. Milk sample locations are7greater than 5 km distance recommended in the Branch Technical Position due to the restricted area of the Hanford Reservation on which WNP-2 is located. Nearest resident is approximately 6 km and nearest milk animal is approximately 10 km distant from WNP-2. If Cesium-134 or Cesium-137 is measured in an individual milk sample in excess of 30 pCi/l, then Strontium-90 analysis should be performed.

[9]There are no commercially important species in the Hanford reach of the Columbia River. Most recreationally important species in the area are anadromous, primarily salminoids. Four specimen will normally be collected by electroshock technique in the vicinity of the plant discharge. If electroshocking produces insufficient samples, anadromous species may be obtained from a catch pond at the Ringold Fish Hatchery (Station 39).

[10]Garden produce will routinely be obtained from farms or gardens using Columbia River water for irrigation. One sample of a root crop, leafy vegetable, and a fruit should be collected each sample period if available. The variety of the produce sample will be dependent on seasonal availability.

[11]Soil samples are collected to satisfy the requirements of the Site Certification Agreement (SCA), WNP-2.

TABLE 5

WNP-2 REMP LOCATIONS

Station	Sector	Radial Miles[a]											
1S	N	0.3	X										
2S	NNE	0.4	X										
3S	NE	0.5	X										
4S	ENE	0.4	X										
5S	E	0.4	X										
6S	ESE	0.4	X										
7S	SE	0.5	X										
8S	SSE	0.7	X										
9S	S	0.7	X										
10S	SSW	0.8	X										
11S	SW	0.7	X										
12S	WSW	0.5	X										
13S	W	0.5	X										
14S	WNW	0.5	X										
15S	NW	0.5	X										
16S	NNW	0.4	X										

TABLE 5-2 (contd.)

Station	Sector	Radial Miles[a]											
1	S	1.3	X	X								X	X
2	NNE	1.8	X										
3	SE	2.0	X										
4	SSE	9.3	X	X									
5	ESE	7.7	X	X									
6	S	7.7	X	X									
7	WNW	2.7	X	X									X
8	ESE	4.7	X	X									
9A*	WSW	30.0	X	X									
9B*	WSW	35.0									X		
9C*	WSW	33.0							X				X
10	E	3.1	X										
11	ENE	3.1	X										
12	NNW	6.1	X										
13	SW	1.4	X										
14	WSW	1.4	X										
15	W	1.4	X										
16	WNW	1.4	X										
17	NNW	1.2	X										

TABLE 5-2

Station	Sector	Radial Miles[a]											
18	N	1.1	X										
19	NE	1.8	X										
20	ENE	1.9	X										
21	ENE	1.5	X	X								X	X
22	E	2.1	X										
23	ESE	3.0	X	X								X	X
24	SE	1.9	X										
25	SSE	1.6	X										
26*	E	3.2			X	X							
27	E	3.2			X								
28	SSE	7.4				X							
29	SSE	11.0				X							
30	E	3.5								X			
31	E	1.1					X						
32	E	1.2					X						
33*	ENE	3.3						X					
34	ESE	3.3						X					
35	ENE	10.5							X				
36	ESE	7.2							X				
37A	SSE	17.0									X		
37B	SSE	17.0									X		
38*	E	9.3								X			

TABLE 5-2 (contd.)

Station	Sector	Radial Miles[a]											
39	NE	4.3								X			
40	SE	6.4	X	X					X				
41	SE	5.8	X										
42	ESE	5.6	X										
43	E	5.7	X										
44	ENE	5.7	X										
45	ENE	4.2	X										
46	NE	4.7	X										
47	N	0.5	X										
48	NE	4.3		X									
49	NW	1.2	X										
50	SSW	1.2	X										
51	ESE	2.1	X										
52	N	0.1				X	X						
53	N	7.5	X										
54	NNE	6.5	X										
55	SSE	7.0	X										
57	SSW	7.0	X										

*Control location.

[a]Estimated from center of WNP-2 Containment from map positions.

[b]Included in sampling program to satisfy requirements for Site Certification Agreement with the State of Washington.

[c]WNP-2 drinking water sampled and analyzed through plant chemistry program.

TABLE 5-3

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM ANNUAL SUMMARY[a]

Name of Facility ____________________ Docket No. ____________

Location of Facility ____________________ Reporting Period ____________
(County, State)

Medium or Pathway Sampled (Unit of Measurement)	Type and Total Number of Analyses Performed	Lower Limit of Detection (LLD)	All Indicator Locations Mean (f)[c] Range	Location with Highest Annual Mean: Name Distance and Direction	Location with Highest Annual Mean: Mean (f)[c] Range	Control Locations Mean (f)[c] Range	Number of Nonroutine Reported Measurements
Air particulates (pCi/m^3)	Gross 416	0.01	0.08 (200/312) (0.05-2.0)	Middletown 5 mi. 340°	0.10 (5/52) (0.08-2.0)	0.08 (8/104) (1.05-1.40)	1
	-Spec 32						
	^{137}Cs	0.01	0.05 (4/24) (0.03-0.13)	Smithville 2.5 mi. 160°	0.08 (2/4) (0.03-2.0)	LLD	4
	^{131}I	0.07	0.12 (2/24) (0.09-0.18)	Podunk 4.0 mi. 270°	0.20 (2/4) (0.10-0.31)	0.02 (2/4)	1
Fish (pCi/kg) (wet weight)	-Spec. 8						
	^{137}Cs	130	LLD		LLD	90 (1/4)	0
	^{134}Cs	130	LLD		LLD	LLD	0
	^{60}Co	130	180 (3/4) (150-225)	River Mile 35	See Column 4	LLD	0

[a]Summary Table is taken from the NRC's Branch Technical Position, Rev. 1, Nov. 1979, and provided for illustrative purposes only.

[c]Mean and range based upon detectable measurements only. Fraction of detectable measurements at specified locations is indicated in parentheses (f).

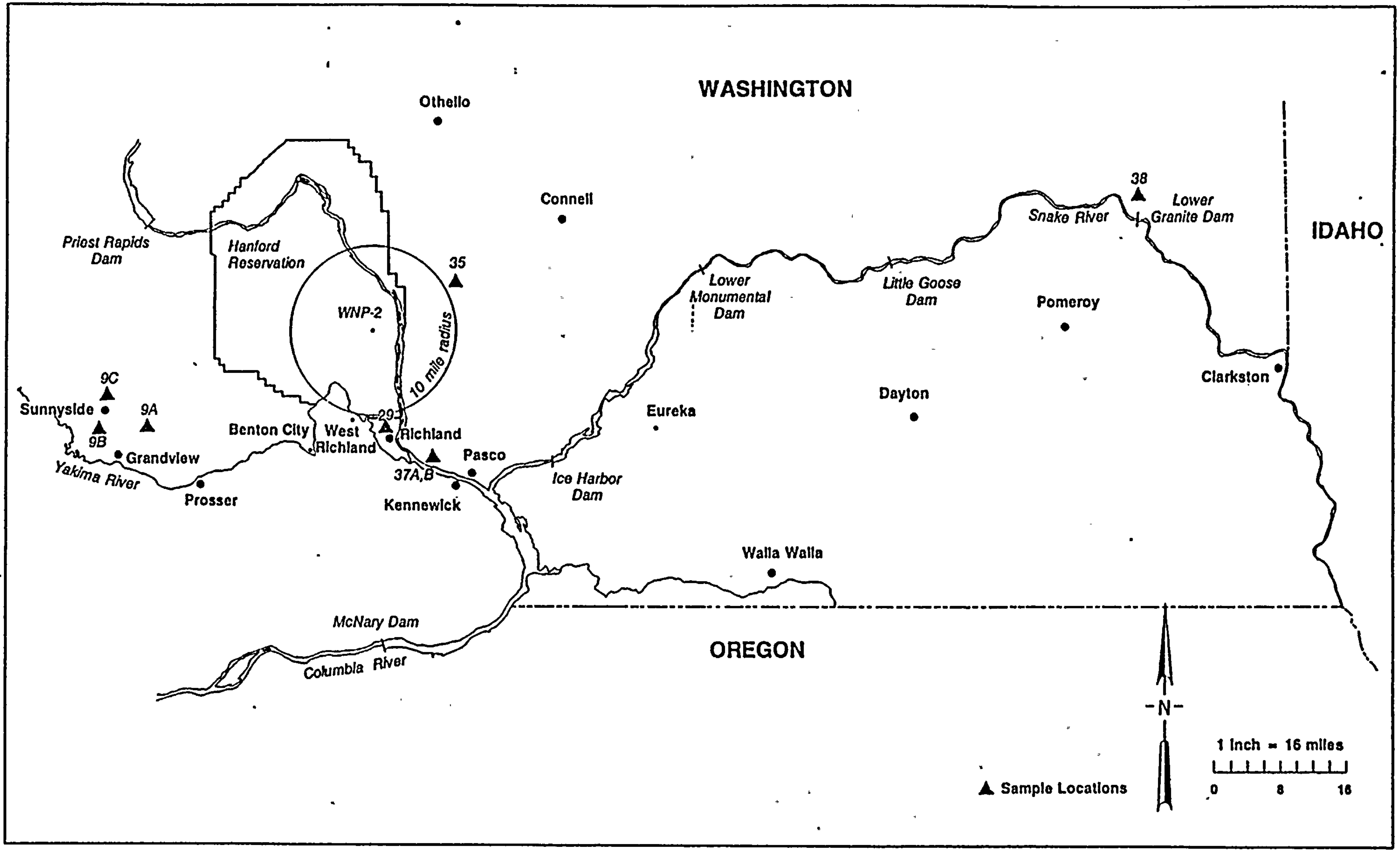


FIGURE 5-1. Radiological Environmental Monitoring Sample Locations Outside of 10-Mile Radius

822171

TABLE 5-4

REPORTING LEVELS FOR NONROUTINE OPERATING REPORTS
Reporting Level (RL)

Analysis	Water (pCi/l)	Airborne Particulate or Gases (pCi/m^3)	Fish (pCi/kg, wet)	Milk (pCi/l)	Broad Leaf Vegetation (pCi/Kg, wet)
H-3	2×10^4*				
Mn-54	1×10^3		3×10^4		
Fe-59	4×10^2		1×10^4		
Co-58	1×10^3		3×10^4		
Co-60	3×10^2		1×10^4		
Zn-65	3×10^2		2×10^4		
Zr-Nb-95	4×10^2				
I-131	2	0.9		3	1×10^2
Cs-134	30	10	1×10^3	60	1×10^3
Cs-137	50	20	2×10^3	70	2×10^3
Ba-La-140	2×10^2			3×10^2	

*For drinking water samples. This is 40 CFR Part 141 value.

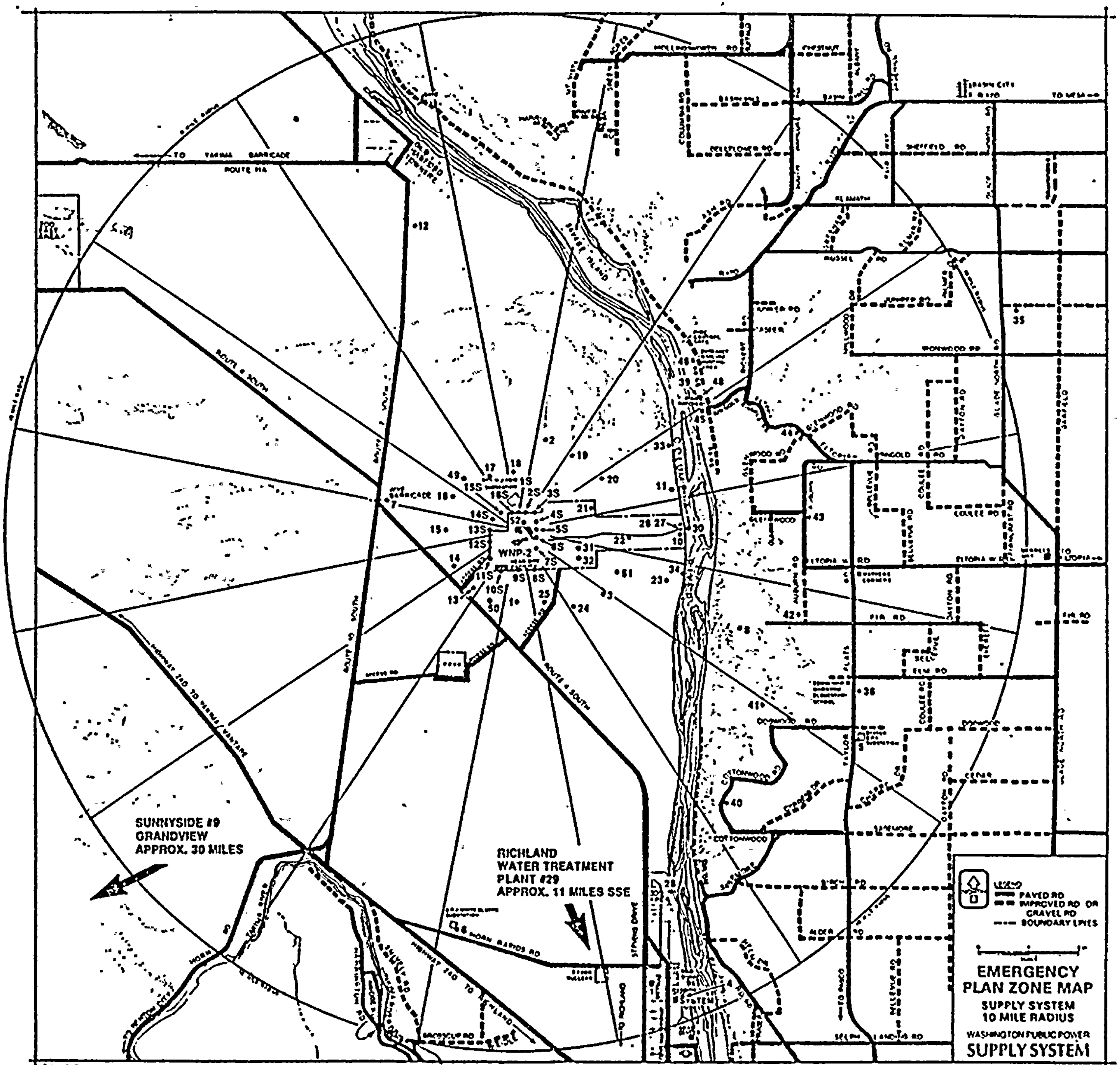


FIGURE 5-2.
RADIOLOGICAL ENVIRONMENTAL MONITORING SAMPLE LOCATIONS INSIDE OF 10 MILE RADIUS

ANSI 13.10 COMPARISON OFF GAS SYSTEM

OG-RIS-609A and B

#8407100290

5.4.1 Detection Capabilities

The monitors in this report are off-line units which can continuously sample from selected sample points on the off gas system e.g. inlet to charcoal beds, outlet of the first charcoal bed, inlet to after filters. The monitors are sensitive to both gamma and beta radiation. There are three GM tubes in each of the two chambers. The sampled gases are first drawn through a particulate filter then a charcoal cartridge and then into the counting chamber to insure noble gases are analyzed and the chambers remain clear of particulates and radioiodines. The sampled radioactive gas is then returned to the inlet side of the gas chillers.

5.4.1.1 The monitors, mounted in 13.1 liter chambers are designed to be sensitive to radiation in a range that will relate to Technical Specification limits directed to the off site dose. The following tables will summarize the parameters. See Tables 1 and 2.

5.4.1.2 Not Applicable

5.4.2 Range

The requirement of 10^4 MDA's is exceeded.

5.4.3 Sensitivity

The detector unit is purposefully insensitive to assure the adequate range to cover the Technical Specification limits of activity at the off gas pretreatment monitor, T.S. 3.11.2.7. See Table 1 Column 7 and Table 2.

TABLE 1

Detector	Isotope	Background Installed (cpm) (1) Sb (2)	Calibration Factor [1] CF cpm/uCi/cc	Detection Limits in Cr/cc: Tech Specs LLD $\frac{4.66\ Sb}{CF}$	Normal MDA = $\frac{1.96\ Sb}{CF}$	ANSI 13.:10 MDA = $\frac{1.96\ Ns}{CF}$	ANSI 13:10 Design MDA
OG-601A	$^{133}X_e$	66.6 8.16	1.15E + 5	3.31E-4	1.39E-4	8.41E-5	(2)
OG-601B	$^{133}X_e$	96.2 9.81	1.04E + 5	4.39E-4	1.05E-4	6.62E-4	(2)

(1) The calibration factor is evaluated at 2 x 10^4 cpm, estimated set point for an alarm.

(2) Design MDA does not apply for this monitor as other plant factors must be necessary before a cpm/dose relationship is established.

TABLE 1

Detector	Isotope	Background Installed (cpm) (1) Sb (2)	Calibration Factor [1] CF cpm/uCi/cc	Detection Limits in Cr/cc Tech Specs LLD $\frac{4.66\ Sb}{CF}$	Normal MDA = $\frac{1.96\ Sb}{CF}$	ANSI 13.:10 MDA = $\frac{1.96\ Ns}{CF}$	ANSI 13:10 Design MDA
OG-601A	$^{133}X_e$	66.6 8.16	1.15E + 5	3.31E-4	1.39E-4	8.41E-5	(2)
OG-601B	$^{133}X_e$	96.2 9.81	1.04E + 5	4.39E-4	1.05E-4	6.62E-4	(2)

(1) The calibration factor is evaluated at 2 x 10^4 cpm, estimated set point for an alarm.

(2) Design MDA does not apply for this monitor as other plant factors must be necessary before a cpm/dose relationship is established.

5.4.4 Accuracy

The system described in this report was calibrated with ^{133}Xe gas, 100 cc grab samples were taken and analyzed on the ND6620 gamma analyzer system.

In the same calibration transfer and linearity sources were placed on the system. A modification by GE was made on the system after gas calibrations which allowed the voltage reduction to the GM tubes. This also causes a reduction in sensitivity, which is included in these calculations. As this recalibration, was performed to develop the ratios for the gas calibration to the current transfer source calibration, no applicable values for the error, $(R_s - R_t)*100/R_t$, is available. Over all primary calibration error calculations are included on the Table.

General Electric states the follow accuracies:

Recorder Output	No accuracy in cpm stated but Vmax to be set at 1 ± 0.002 volt.
Rate Meter Reading	No accuracy in cpm stated in the particular GE manual.

Information from Startup at the time of primary calibration was that the accuracy required is ± 20% of scale.

TABLE 2

Monitor	Range	Sensitivity	Accuracy (1)	Precision
	(1) Meter Scale (2) $^{133}X_e$ in uCi/cc	$N_s = 1.96\ (N_b/2\ RC)^{1/2}$ MDL range $^{137}C_s$ in uCi/cc MDL to MDL * 10^4 after bkg subtract	$\frac{(R_r - R_t)}{R_t}$ 100% Primary Cal (err of cal est.) (Incl. ratio after GE mod)	$\bar{X}_n$ n = number of determinations $\pm$ error at 1σ
OG-601A	(1) 10 - 10^6 (2) 8.37E-5 to 8.76	N_s = 9.66 cpm 8.03E-5 to 8.08E-1 within meter range	11.7% 1σ	$\bar{X}_3$ $\pm$ 0.22%
OG-601B	(1) 10 - 10^6 (2) 6.49E-5 to 10.6	N_s = 11.62 cpm 7.59E-5 to 7.59E-1 within meter range	9.2% 1σ	$\bar{X}_3$ $\pm$ 0.63%

(1) This calibration will be confirmed periodically with gas grab samples.

5.4.5 Precision

The precision for this monitor set is taken from multiple measurements on the WNP-2-83 linearity transfer source. The results demonstrate repositioning of the source and are listed on Table 2.

5.4.6 Response Time

The off gas system upon a Hi Hi Hi radiation alarm closes OG-V-60, the stroke time for this valve is 4.0 seconds as measured in the system line up test. This time is well within the response time of the rate meter module. The following Table 3 list the response time parameters for these modules.

Table 3 Response Time of GE Log Count Rate Meter*

Decade	RC Time Constant Down Scale Seconds	Response Time Seconds (2.2 RC)
10	82.17	180.8
100	82.17	180.8
1000	24.9	54.8
10^4	9.71	21.4
10^5	2.49	5.5
10^6	0.2	0.44

* This module is a GE Model 145C3284AA G1-G3

5.4.7.1 Temperature

The rate meter and power supplies are located in the main control room which is designed to be habitable under normal conditions; see Technical Specificaion 3/4.7.2, an 85°F (29.4°C) limit. The FSAR limit is 104°F (40°C). For this temperature range, calibration drift would be very small and is typically ignored.

Detectors	-40° to 75°C
Preamplifier	similar to pulse preamplifier 0° to 60°C
RIS Module	40°F to 120°F, 4.4°C to 48.8°C
Ratemeter	4° to 49°C

5.4.7.2 Pressure

The counting chamber, 13.1 liters, pressure limits was not stated, however, the chamber while undergoing calibration was operated from -15 inches mercury to + 6 psi with no apparent leaks.

5.4.7.3 Humidity

The RIS module had a humidity range from 0% to 90% relative. All other components had no statement specifying limits.

Recorder operating limit not specified.

5.4.7.4 Corrosive Atmosphere

No specification and no corrosive atmosphere expected. Chamber is stainless steel. GM tube holders are aluminum. GM tubes have stainless steel walls.

5.4.7.5 Power Requirements

The detector and preamplifier derive their power from the rate meter module.

The rate meter module requires 120V of 50 or 60 Hz power. No statement about the range of power input was made.

The recorder is a Bailey instrument which requires 115 volts, -10% to + 5% limitation before DC supplies are affected.

5.4.7.6 Electrical Effects

This unit has no shielding around the component boards and is exceedingly sensitive to RFI when opened for calibration work. When the module was calibrated an administrative ban on radios was in effect in the control room.

The detectors and preamplifiers are RFI shielded.

Recorder when panel mounted was not affected.

5.4.7.7 Mechanical Effects (Seismic Testing)

Sesmic Class II, design verification only.

5.4.8 Radiation Alarms

There are two radiation alarms in the rate meter module and one taken from the recorder:

1. Hi Ratemeter — Provides for closure of the charcoal bed bypass valve, OG-V-45.

2. Hi Hi Recorder — Alerts operators of impending off gas system closure.

3. Hi Hi Hi Ratemeter — Isolates the reactor off gas system, closes OG-V-60.

All alarms indicate on the annunciator panel P-604 and initiate a buzzer to sound. The alarm circutry will latch nessitating a manual reset to restore non-trip conditions. Indicator lights for the Hi and Hi Hi Hi are on the RIS module. There is no reset or light on the recorder for the Hi Hi alarm.

5.4.7.9 Failure Indicator

A downscale or HV failure light (INOP) is on the RIS module and will illuminate when tripped, it will also illuminate a light and cause a buzzer to sound on P602-A5. The downscale/INOP will automatically reset when conditions return to normal.

5.4.7.10 Calibration

A. A primary calibration using ^{133}Xe was made by introducing three concentrations of ^{133}Xe gas into the chamber. The gas was circulated until no activity changes were noted, then two 100 cc gas vial grab samples were taken. The vials were sealed and counted on a HPGe detector and ND6620 analyzer system. The system has been calibrated using gas sources from an NBS Traceable Laboratory, Analytics Inc., and cross calibrated with vials filled with liquids which were directly compared to NBS sources. The range of these calibrations was 5.2% at ^{133}Xe peak of 81 Kev. All samples were multi-counted and each count was at least 50,000 counts to assure counting statistics was not an important factor. The error noted in this report was primarily due to solid source placement early on in the calibration. As the precision indicates, this problem appears to be resolved. See Item C below.

When sufficient activity is present grab samples will be taken periodically and analyzed on the HPGe system, these samples will further confirm the primary calibrations.

B. Transfer sources are high activity ^{137}Cs sources having calibrations traceable to NBS either by outside laboratory or WNP-2 laboratory analysis. These sources must be placed at some distance from the detectors due to system physical limitations.

C. The detectors are mounted inside a stainless steel cylinder and are not removable for calibrations. The transfer sources are positioned over the check source opening and can be repositioned to within a $\pm$ 0.3% error.

D. The flow rate is measured by a ratemeter capable of measuring from 0.3 cfm to 10 cfm. The system flow is 0.5 cfm. The rate meter is repeatable to within 20% of any reading.

E. Check sources, ^{137}Cs, are mounted on top the detector shield these sources are activated by a switch on the RIS module. The detector units also have ^{137}Cs bug (keepalive) sources mounted between the preamplifier and the detectors. These keep alive sources provide the high background activity of the system and prevented the downscale trips.

F. Electronic calibration signals are provided for in each rate meter module by:

1. Depressing the alarm button and reading its current setting.

2. Switch to the trip test and observe alarm trips as meter moves upscale.

3. Switch to cal test and observe meter positioning to the calibrate marker.

ANSI 13.10 COMPARISON
TGB SUMP MONITORING SYSTEMS

T-1, FD-RIS-1
T-2, FD-RIS-2
T-3, FD-RIS-3

5.4.1 Detection Capability

Turbine Generator Building (TGB) Sump Monitoring Systems utilize NaI gamma scintillation detectors mounted in pipe wells immersed in the sump water to detect a liquid system failure resulting in excessive fission or activation products reaching any of the three non-radioactive TGB sumps. The sump discharges which are normally routed to an evaporative basin via a storm drain system are automatically diverted to the radwaste system for processing upon receipt of an upscale high-high trip. The high-high trip alarm point is set at 50% of the Cs-137 MPC to allow up to a 20% error in calibration and to be consistant with the alarm setpoint methodology for liquid effluents. The response to the other principle nuclide of interest (Co-60) MPC value will present no problem because of the 2 gammas per disintegration aspect of Co-60. Calculated efficiencies are based on Cs-137 since we are looking for fission or activation products which have leaked into the sumps. Strontium-90 is monitored in the reactor coolant. Off line samples from a composite sampler to be installed at each sump will be used to verify the adequacy of the calibrations and the in place detector response.

5.4.1.1 Not applicable

5.4.1.2 Detection in Liquid Streams

The TBG Sump Monitors are shielded to lower the background countrate from cement structures, etc. in order to achieve a low LLD. The LLD was calculated by using the Technical Specification definition, by using the method typically used in industry and by using the ANSI 13.10 method featuring the RC time constant. All represent the 95% confidence level.

Detector	Installed Bkg	Calibration Factor	Tech. S[illegible] LLD = 4.66 [illegible]kg / Cal. Factor	Normal MDA = 2 √Bkg / Cal. Factor	ANSI MDA = 1.96 √Bkg/2RC / Cal. Factor
T-1	650 cpm	3.084E8 cpm/uCi/cc	3.85E-7 uCi/cc	1.65E-7 uCi/cc	4.74E-7 uCi/cc
T-2	653 cpm	3.234E8 cpm/uCi/cc	3.68E-7 uCi/cc	1.58E-7 uCi/cc	4.53E-7 uCi/cc
T-3	689 cpm	3.219E8 cpm/uCi/cc	3.80E-7 uCi/cc	1.63E-7 uCi/cc	4.68E-7 uCi/cc

And the corresponding MDL or cpm for the above minimum detectable activity concentrations:

Detector	Tech. Spec. MDL = 4.66 √Bkg	Normal MDL = 2 √Bkg	ANSI MDL = 1.96 √Bkg/2RC
T-1	119 cpm	50.9 cpm	146 cpm
T-2	119 cpm	51.1 cpm	147 cpm
T-3	122 cpm	52.5 cpm	151 cpm

5.4.2 Range

The range which should be 10^4 MDL's is calculated by multiplying each MDL in Section 5.4.1.2 by 10^4. The resulting values should be within the detector range of 10 to 10^7 cpm.

	Range Requirement MDL Basis X 10^4		
Detector	Tech. Spec. MDL	Normal MDL	ANSI MDL
T-1	1.19E+6	5.09E+5	1.46E+6
T-2	1.19E+6	5.11E+5	1.47E+6
T-3	1.22E+6	5.25E+5	1.51E+6

All values are within the detector capabilities.

5.4.3 Sensitivity

The sensitivities of the TGB sumps are calculated according to the ANSI definition featuring the RC time constant as shown in Section 5.4.1.2 in the tables. The time constant used was 3.5 sec. since this is the time constant for the decade of the background level.

5.4.4 Accuracy

The accuracy of the 3 TGB sumps was determined in primary liquid calibrations utilizing a sump mock-up barrel. The resulting total error at the 95% confidence level and the detector response to the transfer calibration source against which future calibrations will be compared are shown below.

	Primary Calibration Error	Transfer Cal. Response
T-1	$\pm$ 4.15%	1.499E5 cpm/uCi
T-2	$\pm$ 4.50%	1.5929E5 cpm/uCi
T-3	$\pm$ 5.30%	1.490E5 cpm/uCi

The above values are based upon the output of a scaler which takes a signal equivalent (in count rate) to the signal which drives the alarm function.

The KAMAN manual specifies the following ratemeter and recorder accuracies:

Recorder: $\pm$ 0.5% of span
Ratemeter: $\mp$ 5%
Meter Reading Accuracy: 1/2 smallest scale division

5.4.5 Precision

The precision was determined using all available positioning/counting data points taken from the Cs-137 transfer source counts taken during the primary calibration. The data and results follow.

	T-1			T-2			T-3		
	Gross	Bkg	Net	Gross	Bkg	Net	Gross	Bkg	Net
1	79282	156	79126	84151	89	84062	80096	213	79883
2	79402	156	79246	83907	89	83818	77589	94	77495
3	78958	111	78847	84252	117	84135	77176	156	77020
4	79515	111	79404	84522	117	84405	79982	259	79723
		Σ=	316623		Σ=	336420		Σ=	314121
		mean =	79156		mean =	84105		mean =	78530
		std. dev. =	203.71		std. dev. =	209.24		std. dev. =	1285.03
		% error =	0.26%		% error =	0.25%		% error =	1.64%

All three precision errors are within ± 10%

5.4.6 Response Time

The response time is adequate to achieve the required accuracy as demonstrated in other sections of this report where the RC time constant was used. Since no delay circuits or devices are encorporated into our electronic circuits after the log ratemeter the nominal value of 2.2 time constants is easily met.

From the KAMAN manual, the response time for given signal changes and the 2.2 time constants values are shown below.

Signal Change	RC Time Constant	Response Time (2.2) (RC)
$10 - 10^2$	12 sec.	26.4 sec.
$10 - 10^3$	3.5 sec.	7.7 sec.
$10 - 10^4$	1.0 sec.	2.2 sec.
$10 - 10^5$	0.1 sec.	0.22 sec.
$10 - 10^6$	0.1 sec.	0.22 sec.
$10 - 10^7$	0.1 sec.	0.22 sec.

5.4.7.1 Temperature

The recorder, power supply and ratemeter are located in the Radwaste Control Room which is designed for human habitability under normal and analyzed abnormal conditions and which will never exceed 140°F (60°C). The ambient temperature at the detectors which are located in pipe wells with air space between the pipe walls and the detector would be very unlikely to exceed 140°F. The following information was taken from the KANAM manual:

Equipment	Operating Limits	Temperature Effect Based on 80°F Midpoint
Mo. 7723 Recorder	0° to 140°F	± 0.2% Span for ± 40°F
Bailey 7000 AC/DC Power Supply	0° to 140°F	± 0.5% DC for ± 40°F ± 1.0% AC for ± 40°F
Log Count Ratemeter	0 to 60°C	± 5% over range (total error all effects)
Gamma Scintillation Detector	32°F to 140°F	Cal. drift would be very small and is typically ignored, energy cal. would change but does not effect function.

5.4.7.2 Pressure

The TGB sump radiation monitoring components are open to building atmosphere; therefore pressure response is not applicable.

5.4.7.3 Humidity

The components of the TGB sump radiation monitoring system are subject to environmental conditions dictated by the TGB HVAC system and so humidity should not significantly effect their operation, however, the KAMAN manual provides some information which follows:

Log Count Ratemeter

Operating limits 0 - 95% relative humidity

Gamma Scintillation Detector

No operating limits given, but these are assumed to be the same as the storage limits given by Kaman Instrumentation, of 0 - 95% relative humidity.

5.4.7.4 Other Environmental Effects

Not applicable and none expected.

5.4.7.5 Power Requirements

The detector, including preamp, ratemeter and recorder are powered from instrument buses in the Radwaste Control Room. The power supply is stabilized and variations of 15% will not be seen.

Model 7723 Recorder

DC Voltage Effect: ± 0.2% of span for ∓ 2 volt change from 24V DC

Bailey 7000 AC/DC Power Supply

Voltage variation of -10%, +5% results in output variation of ± 0.5% DC voltage and -12%, +6% AC voltage at 50% load

Frequency variation of ± 1 Hz results in ± 0.2% output frequency variation. The input voltage is 120V AC & 230V AC at 50/60 Hz. The operating voltage is -15% & +10% of input. The operating frequency limit is ± 2% of input. (Normal frequency range inputs are ± 1 Hz)

Log Count Ratemeter

Operating Voltage Range 90 to 130V AC at 50 to 60 Hz

Gamma Scintillation Detector

Operating Limits: +12V ± 0.5V DC @ 1ma
-12V ∓ 0.5V DC @ 1 ma
600 to 1100V DC @ 1 ma

5.4.7.6 Electrical Effects, i.e. RF and Microwave Interference

This has been a problem especially when instrument racks are pulled out. The use of radios is being controlled administratively to avoid the problem.

5.4.7.7 Mechanical Effects

The TGB sump monitoring system is not seismic I qualified, however, the system would divert any flows to radwaste for processing in case of system failure. Therefore its function is maintained although not required by exception.

5.4.8 The ratemeter is equipped with two upscale alarms (Hi and Hi Hi) which can be set at any point over the range of the instrument. These alarms are latching type and must be manually reset. The alarms illuminate a light (Hi amber, Hi Hi red) at the ratemeter and open a solenoid which causes a trouble light on an annunciator panel to illuminate and a buzzer to sound.

The Hi & Hi Hi alarm setpoints can be adjusted externally without removing the instrument from service.

5.4.9 Failure Alarm

The ratemeter provides a latching alarm in case of power failure, HV below the HV INOP setpoint, or counting rate below the setpoint value.

5.4.10 Calibration

a. Primary calibrations were performed on the TGB sump radiation monitoring systems using a 55 gal. barrel mock-up of the sump geometry. A detector well in the barrel corresponds to the pipe well in the sumps. An NBS traceable liquid solution of Cs-137 was continually circulated through the mock-up during the calibration and a "stand pipe" apparatus was used to insure that no air was trapped within the system.

b. Transfer standards (Cs-137) were counted during the primary calibrations to establish a baseline for use in subsequent periodic calibrations.

c. Source to detector geometry for the transfer standards is maintained by by the use of, and insertion in, a standard KAMAN calibrator.

d. The transfer source is 1 inch in diameter and is positioned directly below the 1-1/2" x 1" NaI detector.

e. A remotely actuated check source is provided (Cs-137).

f. Calibrated electrical signals are provided and can be externally inputted prior to ratemeter amplifier and discriminator circuits.

11.5.1.2.2 Systems Required for Plant Operation

a. Provide continuous indication of radiation levels in the Main Control Room.

Yes, but in Radwaste Control Room

b. Provide warning of increasing radiation levels indicative of abnormal conditions by alarm annunciation.

Yes

c. Insofar as practical, provide self-monitoring of components to the extent that power failure or component malfunction causes annunciation and, for systems initiating protective action, channel trip.

Yes - failure alarm for low count rate, low HV and loss of power

d. Monitor a sample representative of the bulk stream or volume.

Yes, monitor TGB sump liquids

e. Have provisions for calibration, function and instrumentation checks.

Yes - 3 cal. check buttons for ratemeter
- an external signal can be put into the ratemeter
- Cs-137 check source

f. Have sensitivities and ranges compatible with anticipated radiation levels and technical specification limits.

Yes

g. Register full scale output if radiation detection exceeds full scale.

Probably not, but alarm latches

- change FSAR

13. Operable under expected normal & abnormal conditions?

Yes

60. (1) Control radioactive effluent?

(2) Is adequate hold up volume provided?

(1) Yes, by closing release path if abnormal rad levels detected.

(2) Yes, the sump volume serves as a hold up volume. The hold up volume is not really needed since the release path is isolated on High High Alarm.

64. Monitoring Rad. Releases

The TGB sump radiation monitoring system monitors the potential release path of the TGB non-rad. floor drains and automatically diverts flow to the radwaste systems on High High Alarm. It whould operate under accident conditions but is not required since the release pathway can be manually diverted.

Attachment 3

ANSI 13.10 COMPARISON

Liquid Effluent Monitoring Systems

Residual Heat Exchange	RHR Loop A
Residual Heat Exchange	RHR Loop B
Reactor Closed Cooling	RCC
Radwaste Liquid Effluent	FDR

5.4.1 Detection Capabilities

The liquid monitors in this report are off line units which continuously sample, or sample when fluid is in the line, a portion of the liquid stream for gamma emitting isotopes. The liquids are pumped into a marinelli type stainless steel chamber, which is four pi shielded with lead, having a 2" x 2" NaI(tl) detector for a gamma sensor; the liquid is then returned to the original stream.

5.4.1.1 Not applicable

5.4.1.2 Detection in Liquid Streams

The monitor's ability to detect small quantities of radiation is dependent upon the detector size, liquid chamber size and adequate shielding. The following table summarizes the minimum detection parameters. See Table 1

5.4.2 Range

The requirement is exceeded, see Table 2.

5.4.3 Sensitivity

The sensitivity is noted as uCi/ml in Column 7, Table 1; also in Table 2.

5.4.4 Accuracy

The systems described in this report were calibrated with liquid solutions. The liquid solution results and the transfer and linearity sources were compared and tabulated to form the primary calibration package. Only one monitor required additional work after the primary calibration, this was the RHR Loop A, SW-RE-4 detector. Upon completion of the task the unit was recalibrated with the NBS traceable transfer and a set of linearity sources. The result was +2.32% using the following relationship

$$\frac{R_r - R_t}{R_t} \times 100 \text{ percent}$$

ANSI 13.10 Comparison: Table 1

Detector	Isotope	Background (Installed) cps	Calibration factor[1], CF cps/uCi/ml	Detection Limits in uCi/ml: Tech. Spec. LLD= $\frac{4.66\ Sb}{Cf}$ [2]	Normal MDA= $\frac{1.96\ Sb}{Cf}$	ANSI 13.10 MDA= $\frac{1.96\ Ns}{Cf}$	ANSI 13.10 Design MDA
RHR Loop A SW-RE-4	^{137}Cs	1.6	2.98 E+6	1.2 E-7	5.1 E-8	6.0 E-8	4. E-7
	^{60}Co (3)		4.97 E+6	7.2 E-8	3.1 E-8	3.6 E-8	3. E-7
RHR Loop B SW-RE-5	^{137}Cs	1.9	3.09 E+6	1.2 E-7	5.0 E-8	6.6 E-8	4. E-7
	^{60}Co		5.16 E+6	7.2 E-8	3.0 E-8	4.0 E-8	3. E-7
RCC-RE-7	^{137}Cs	3.8	3.69 E+6	1.6 E-7	6.7 E-8	8.6 E-8	4. E-7
	^{60}Co		6.16 E+6	9.6 E-8	4.0 E-8	5.2 E-8	3. E-7
FDR-RE-6	^{137}Cs	5.6	2.92 E+6	2.5 E-7	1.0 E-8	1.4 E-7	4. E-7
	^{60}Co		4.28 E+6	1.5 E-8	6.2 E-8	8.4 E-8	3. E-7

Notes:
1. Calibration factor is calculated at the count rate of the transfer source.
2. Sb is calculated at the 95% confidence level of attaining the meter reading, i.e. $Sb = (Bckgnd/3\ RC)^{1/2}$
3. The Colbalt 60 results are a constant factor of 1.67 for a 2 x 2 NaI(tL) detector versus Ceasium 137. Information via Harshaw Inc. additional information indicates the factor could be 1.88, Kaman Sciences Corporation, the more conservative factor of 1.67 was used.

5.4.4 Accuracy (Continued)

The transfer source at the time of manufacture was 0.092 uCi $\pm$ 5% at the 95% confidence level.

The accuracies of the ratemeters and recorders output as specified by General Electric as as follows:

Recorder Output	$\pm$ 2% of Equivalent linear full scale
Ratemeter	$\pm$ 5% in the bottom decade

5.4.5 Precision

The precision for this monitor is stated on Table 2 from results of the primary calibration. The precision of these units is within the $\pm$ 3% as required by the approved calibration procedures. The indication is that a $\pm$ 10% precision error can be met or exceeded by these liquid monitors.

5.4.6 Response Time

The FDR-RE-6 monitor provides signals for valve closure, the others in this report provide trip signals to the alarm annunciators. The FDR-RE-6 controlled valves will complete their stroke from open to fully closed in 4.2 seconds, as measured in the system lineup test. This time is well within the response time of the ratemeter modules. The following table, Table 3, lists the response time parameters for these modules.

ANSI 13.10 Comparison: Table 2

Monitor	Range	Sensitivity	Accuracy	Precision
	(1) Meter Scale (2) ^{137}Cs in uCi/ml (3) ^{60} Co in uCi/ml	$N_5 = 1.96\ (N_b/2\ RC)^{1/2}$ MDL range ^{137}Cs from MDL to MDL 10^4	$\frac{R_R - R_T}{R_T} \times 100\%$ Primary Cal = N/A	$\overline{X}_n$ n = number of determinations $\pm$ % error at 1σ
RHR Loop A SW-RE-4	(1) 10^{-1} to 10^6 cps (2) 3.10E-8 to 3.53E-1 (3) 1.86E-8 to 2.11E-1	$N_5 = 0.198$ cps 6.02E-8 to 6.02E-4 uCi/ml within meter range	$\frac{1.315 - 1.285}{1.285} \times 100\%$ = 2.3%	$\overline{X}_4 \pm 1.02\%$
RHR Loop B SW-RE-5	(1) 10^{-1} to 10^6 cps (2) 2.67E-8 to 3.65E-1 (3) 1.60E-8 to 2.18E-1	$N_5 = 0.217$ cps 6.64E-8 to 6.64E-4 uCi/ml within meter range	N/A	$\overline{X}_3 \pm 0.53\%$
RCC-RE-7	(1) 10^{-1} to 10^6 cps (2) 2.83E-8 to 3.64E-1 (3) 1.69E-8 to 1.58E-1	$N_5 = 0.306$ cps 8.62E-8 to 8.62E-4 uCi/ml within meter range	N/A	$\overline{X}_3 \pm 0.85\%$
RCC-RE-6	(1) 10^{-1} to 10^6 cps (2) 3.83E-8 to 3.18E-1 (3) 2.30E-8 to 1.91E-1	$N_5 = 0.372$ cps 1.41E-7 to 1.41E-3 uCi/ml within meter range	N/A	$\overline{X}_3 \pm 0.41\%$

Table 3: Response Time of GE Process Radiation Monitor*

Decade (cps)	RC Time Constant (seconds) Upscale	Downscale	Response Time (seconds) 2.2 x RC
10^{-1}	18.8	78	172
10^{0}	2.3	78	172
10^{1}	0.24	78	172
10^{2}	0.02	78	172
10^{3}	0.02	3.0	6.6
10^{4}	0.02	0.3	0.66
10^{5}	0.02	0.03	0.066
2.6×10^{5}	0.02	0.001	0.0025

*Note: This ratemeter module is common to the monitors in this report, it is a GE model 368X103AAG1 & G2.

5.4.7.1 Temperature

The ratemeters and power supplies are located in the Main Control Room which is designed to be habitable under normal conditions; see Technical Specification 3/4.7.2, an 85°F (29.4°C) limit. The FSAR limit is 104°F (40°C). For this temperature range, temperature calibration drift would be very small and is typically ignored.

Detectors and Pre-Amplifiers

a. The NaI(tl) scintallator will undergo no change in sensitivity from 0° to 60°C.

b. The photomultiplier tube, P.M., can operate from -30°C to 50°C (122°F) normally, but can operate from -30°C to 80°C (176°F) for short periods.

c. The preamplifier, mounted near detector and skid, has temperature rating limits of 0° to 60°C. The ideal opertion is at 25°C. The temperature drift factor is 0.3%/°C and a ± 1% per 100 hours of operation can occur.

The ratemeter and power supply are in the same drawer, the temperature range of the combined unit is from 5 to 50°C (122°F).

5.4.7.2 Pressure

All the liquid monitors are mounted in a Marinelli type stainless steel chamber. The 2.4 liter chamber used for RHR SW-RE-4 and 5 is rated at 35 psi while the 3 liter chamber used for the RCC-RE-7 and FDR-RE-6 is rated at 225 psig. All other components are designed to operate at ambient atmospheric pressures.

5.4.7.3 Humidity

The detector assembly can operate from 0 to 95% humidity. The ratemeter module can operate from 20 to 90% relative humidity. It operates best at 50% relative humidity. The preamplifier operates from 20 to 90% relative humidity.

5.4.7.4 Corrosive Atmosphere

No specification and no corrosive atmospheric or liquid conditions expected. The liquid chamber is stainless steel.

5.4.7.5 Power Requirements

The detector and preamplifier derive their power from the ratemeter module.

The ratemeter module requires 26.5 volts D.C. and can operate without degradation of readings and alarms with an input variation from 19 to 29.5 volts D.C.

5.4.7.6 Electrical Effects

The ratemeter drawer assembly has each of its component boards mounted inside a metal shield. No RFI was noted during the preoperational test which involved keying a hand held 4 watt transmitter near the ratemeter drawer.

5.4.7.7 Mechanical Effects (Seismic Testing)

Not required on this equipment as it is Class II.

5.4.7.8 Radiation Alarms

The ratemeter is equipped with two upscale alarms Hi and Hi-Hi which can be set at any point over the range of the instruments. The circuitry latches the alarm even though the detector input may have returned to normal; the alarms must be manually reset. Indicator lights alarm at the ratemeter and causes a light on the annunciator panel to turn on along with a buzzer to sound, P602-A5.

5.4.9 Failure Indicators

A downscale or H.V. failure light (INOP) is on each ratemeter and will illuminate when tripped. A corresponding light will indicate on a panel on the control console and a buzzer will sound. This circuit will self reset when the voltages return to normal.

5.4.10 Calibration

a. Primary Solutions

The primary solutions, ^{137}Cs, were made from uncalibrated source material. Aliquots of the solution were taken and compared directly with NBS reference standards, ^{137}Cs, after assuring the geometrics of the samples were identical. During the calibration the solutions were pumped and circulated continuously in a closed system; three liquid samples were withdrawn into glass ampoules and then flame sealed. The liquid samples were counted along with identical liquid samples, in flame sealed vials also, that were directly traceable to NBS. The calibration error ranged from 5.9% downward with the bulk of the errors about 4%; this error was at the 95% confidence level.

b. The transfer calibration sources are ^{137}Cs sources supplied by Kaman Sciences Corporation. They are disk sources designed to fit into a portable calibrator. The ^{137}Cs sources were calibrated by ICN Inc. on an instrument calibrated with NBS traceable sources. Their calibration error was stated to be $\pm$ 5% at 2σ.

Linearity sources are ^{133}Ba, provided by Kaman Instrumentation.

c. Constant Geometry

The detector rests against the bottom of the well and can be repositioned within the detection of the counting statistics, i.e. better than 0.3%.

The portable shielded calibrator with source drawer assembly has demonstrated repeatability of better than 0.3%.

d. The flow rate device is a rotometer capable of measuring from 0.2 to 6 gpm on the RHR SW-RE-5 and 5 with an error of $\pm$ 20% at any reading. The flowmeters on the RCC-RE-7 and FDR-RE-6 measure from 0.5 to 5 gpm with an error of $\pm$ 10% on an individual reading.

e. Check sources, ^{137}Cs, are mounted only on RCC-RE-7 and FDR-RE-6 and are solenoid activated devices. The RHR SW-RE-4 and 5 are manually activated by sliding a ^{137}Cs source mounted in a rod in a port on the detector shield.

f. Electronic calibration signals are provided for in each ratemeter module. Two specific pulse rates are generated 10 and 10^5 pulses per second for a ratemeter check. Also the oscillator sweeps the range of the instrument for alarm trip test.

Attachment 4

ANSI 13.10 REVIEW

MAIN CONTROL ROOM FRESH AIR INTAKE MONITORS (WOA's)

EPN's:

SAMPLE RACK	DETECTOR	RATEMETER	RECORDER
WOA-SR-18A	WOA-RE-31A	WOA-RIS-31A	WOA-RR-31
WOA-SR-18B	WOA-RE-31B	WOA-RIS-31B	WOA-RR-32
WOA-SR-19A	WOA-RE-32A	WOA-RIS-32A	WOA-RR-31
WOA-SR-19B	WOA-RE-32B	WOA-RIS-32B	WOA-RR-32

General System Description

The "Main Control Room Fresh Air Intake Monitors" (also called remote air intake monitors or WOA's) are four identical off line air monitoring systems. These instruments monitor the concentration of radioactivity in the air supplied to the Control Room in accident conditions. The major contributions to the activity is expected to be Xe-133 and Kr-85.

Normally, the Control Room obtains intake air (1000 cfm) from a local intake and 21,000 cfm is recirculated. In addition to the local intake there are two remote air intakes that normally do not supply air to the Control Room. One of these intakes is located 518 feet NW of the Reactor Building vent and the other is 404 feet SE. A purge flow of 150 cfm is maintained in each remote air supply duct. The purge is exhausted by the WEA system.

Upon receipt of a F, A or Z signal, the dampers in the local intake close and the dampers in both remote air supply ducts open. A total of 1000 cfm is then drawn from either or both remote air intakes. The air from each intake is monitored for radioactivity by redundant air monitoring systems (WOA's). After being monitored, each stream passes through separate HEPA and charcoal filtering system. After the filtration system the air becomes the make-up air for the Control Room.

Upon receipt of a Hi Hi radiation alarm from the associated WOA monitor, the dampers in the affected remote air supply duct close. However, the dampers are interlocked so that one remote air supply remains open even in the highly unlikely event that a Hi Hi alarm is received on both channels.

The sample for each monitor (2 per supply duct) is obtained via a 1/2 inch diameter probe centered in and pointed upstream in the 12 inch supply duct. The sample probe is upstream of the purge exhaust which in turn is upstream of the dampers. The sample passes through a chamber containing a beta detector. The sample chamber, which contains 2.2 liters of sample, and detector are shielded with 3 inches of lead. The sample then passes through a 0 to 6 SCFM ratemeter which has low flow detection/alarm capabilities, a vacuum pump and back to the duct. The sample flow is typically 2 to 3 cfm.

The detector is a 2 inch dia. by 30 mil thick NE 102 scintillator optically coupled to a photo-multiplier tube and followed by a preamplifier. This detector is immersed in the gaseous sample. The signal is sent to a 6 decade (10 to 10^7 cpm) log ratemeter and recorder which are located in the Main Control Room. The ratemeter provides power to the detector, displays the counting rate, and provides alarm functions. The ratemeter has three internal calibration points and provisions to input a calibrated signal. An alarm test function is also provided. A 1 uCi Cl-36 check source is provided at the detector to check overall system response. The check source is controlled from the ratemeter.

The WOA monitors are seismic I, Quality Class I qualified and are powered by Class 1E power. Operability requirements are given in Technical Specification 3.3.7.1.

Comparison of the Remote Air Intake Monitors (WOA's) to ANSI 13.10 "Standards of Performance"

5.4.1 Detection Capabilities

The WOA Monitoring System is composed of 4 identical off line air monitoring systems wich two divisionally separated monitors on each of the two remote air intake supply ducts. This system monitors the concentration of radioactivity in the air supplied to the Control Room in accident conditions. The major contributions to the radioactivity are expected to be Xe-133 and Kr-85 which are beta emitters.

The sample for each of the monitors is obtained via a 1/2 inch diameter probe and sample line. The sample probe is located on the center line of the 12 inch remote air supply duct served by that monitor and faces upstream. The sample probe is located upstream of the redundant isolation dampers. Typically the sample flow is 2 to 3 cfm.

The detector consists of a 2 inch by 30 mil thick NE102 plastic scintillator optically coupled to a PM tube and followed by a preamp. The detector is immersed in a shielded chamber containing 2.2 liters of sample gas. Three inches of lead shielding are provided to decrease the background from the ambient radiation in accident conditions. This type and thickness of phosphor maximizes the response to beta radiation while minimizing the response to gamma radiation, providing optimum detection capabilities in the analyzed accident environment.

5.4.1.1 Detection in Gaseious Streams

Detection of Xe-133 and/or Kr-85 at a concentration of 1-3 E-6 uCi/ml, per letter to the NRC, will provide adequate protection to Control Room personnel because the particulates and other radio nuclides with more restrictive limits will be filtered out of the air stream.

The primary calibration was made by the vendor, Kaman Instrumentation. For Xe-133 the counting efficiency ranged from 4.29E7 cpm/uCi/cc to 5.20E7 cpm/uCi/cc as the activity of the sample varied from 7.511E-2 to 1.085E-5 uCi/cc. The slope using these points (average of 2 measurements) is 0.998. At the time of the primary calibration, the counting efficiency for the transfer standard source was established as 9.83E5 cpm/uCi. of Sr-90. The calibration made in Jan. - Feb. 1984 reestablished the counting efficiency of the transfer standard source for these 4 monitors as 9.44E5 cpm/uCi $\pm$ 3%. The calibration curve for these monitors was adjusted by the ratio of the transfer source counting efficiency - 0.960. The slope of the counting rate v.s. activity agreed well with the slope obtained on the primary calibration. Therefore, this factor is applicable across the range of calibration. The same factor would apply to the primary Kr-85 calibration data.

The LLDs at the 95% confidence level have been calculated using the Technical Specification method, the method typically used in industry and the method given in ANSI 13.10. The results are tabulated in both cpm and uCi/ml Xe-133 below. The background is based on a 10 minute count for each monitor. The efficiency factor used is average factor obtained during the primary calibration at the lowest counting rate adjusted by the factor obtained during the recalibration i.e. (5.068E7) (0.960) = 4.87E7 cpm/uCi/cc.

Monitor	Installed Bkg (cpm)	Calibration Factor (cpm/uCi/cc)	Tech. Spec. LLD = 4.66 $\sqrt{Bkg}$	Typical MDA = 1.96 $\sqrt{Bkg}$	ANSI 13.10 $1.96\sqrt{\frac{Bkg}{2RC}}$
31A	15	4.87E7	18.0 cpm 3.7E-7 uCi/cc	7.6 cpm 1.5E-7 uCi/cc	12.0 cpm 2.5E-7 uCi/cc
31B	21	4.87E7	24.5 cpm 5.0E-7 uCi/cc	9.0 cpm 1.8E-7 uCi/cc	14.2 cpm 2.9E-7 uCi/cc
32A	8	4.87E7	13.2 cpm 2.7E-7 uCi/cc	5.5 cpm 1.1E-7 uCi/cc	8.8 cpm 1.8E-7 uCi/cc
32B	16	4.87E7	18.64 cpm 3.8E-7 uCi/cc	7.8 cpm 1.6E-7 uCi/cc	12.4 cpm 2.5E-7 uCi/cc

5.4.1.2 Detection in Liquid Streams

Not applicable

5.4.2 Range

The range which should be 10^4 MDLs is calculated by multiplying each MDL in section 5.4.1.1 by 10^4. The resulting values should be within the instrument range of 10 to 1E7 cpm.

The maximum MLD in section 5.4.1.1 is 25 cpm or 5.0E-6 uCi/cc. The counting rate for 10^4 MDLs can be approximated by:

(5.0E-7 uCi/cc)(E4)(5.20E7 cpm/uCi/cc) + BKg - 2.6E5 cpm

This is within the range of the instrument.

5.4.3 Sensitivity

The sensitivity as given by $NS = 1.96 \sqrt{\frac{BKg}{2RC}}$ was calculated and tabulated in Section 5.4.1.1. A time constant of 12 seconds was used for sensitivity calculations.

5.4.4 Accuracy

The accuracy of the 4 WOA monitors is tabulated below using the formula $\% \text{ error} = \frac{Rt - Rr}{Rt} (100)$

R_t = Counting rate of the transfer standard established by vendor at the time primary calibration = 9.83E5 cpm/uCi.

R_r = Counting rate of the transfer standard when field calibrated. R_r is the average of the two counts, except for WOA-32A which is the average of 3 counts, taken on a calibrated scaler.

Monitor	R_r	% Error
31A	9.35E5	4.9
31B	9.44E5	4.0
32A	9.70E5	1.3
32B	9.23E5	6.1
	$\bar{X}$=9.43E5	$\bar{X}$=4.1
	σ =1.99E4	σ =2.0

5.4.5 Precision

The precision was determined using the net counting rate of the transfer standard as neasured by the scaler. In most cases only two counts were available.

31A

81921
81656

$\bar{X}$=8.18E4
σ= 132
1.96σ= 259

$$\frac{1.96\sigma}{\bar{X}} = 0.3\%$$

31B

8.2408E4
8.2734E4

$\bar{X}$=8.26E4
σ= 163
1.96σ= 319

$$\frac{1.96\sigma}{\bar{X}} = 0.4\%$$

32A

8.45E4 cpm
8.53E4 cpm
8.48E4 cpm

$\bar{X}$=8.49E4
σ=3.30E2
1.96σ=6.60E2

$$\frac{1.96\sigma}{\bar{X}} = 0.8\%$$

32B

80555 cpm
80999 cpm

$\bar{X}$=8.08E4
σ=3.84E2
1.96σ=5.57E2

$$\frac{1.96\sigma}{\bar{X}} = 0.7\%$$

The precision is within ± 10% at the 95% confidence level.

5.4.6 Response Time

With a time constant of 12 seconds for the first decade and a MDA of less than 2E-7 uCi/ml, the monitors will easily see required detection level of 4.0E-6 uCi/cc.

5.4.7.1 Temperature

The ratemeter, recorder, and power supply are located in the Main Control Room. The Control Room is designed for human habitability under normal and analyzed abnormal conditions. The temperature in the Control Room will not exceed 104°F.

Ratemeter

Per vendor specification, ± 5% change over a temperature range of 0-60°C (0-140°F).

Recorder

Per vendor specification, the normal operating range is 4-49°C (40-120°F). The operating limit is -18-60°C (0-140°F). The temperatures effect is 0.2% of span for 40°F to 120°F.

Power Supply (for recorder)

Per vendor specifications operating range and limits are the same as for the recorder. The temperature effects are DC ± 0.5% and AC ± 1% for a ± 40°F based on 80°F midpoint operating range.

Detector

Per vender specifications the normal operating temperature is 0-60°C (32-140°F). The effect on the calibration is not defined.

Under normal conditions, the ambient temperature at the sample rack is maintained for human comfort. Under extreme accident conditions the temperatures might increase to the upper limit of human occupancy (120°F). Experience indicates that calibration drift (counting efficiency) over this range is probably negligible.

The temperature of the air stream being monitored could conceivably reach the same extremes as the outside air (-27°F to 115°F). The upper temperature is within the specification. The lower temperature is outside the specification but is expected to have essentially no effect on the system.

Blower/Motor/Rotameter

The range of temperatures will have minimal effect if any. The rotameter calibration changes with the density of air.

5.4.7.2 Pressure

Except for the vacuum head created by drawing the sample, the range of pressure variation will be the same as outside air.

5.4.7.3 Humidity

The environmental conditions at the sample rack are dictated by the Radwaste Building Ventilation System. The humidity even in accident conditions should not be extreme. The environmental conditions in the Control Room where the ratemeter and recorder are located is controlled to within a narrow range. Kaman provides the following information.

Detector (scintillator/preamp) - Vendor gives no operating specifications. Since storage in a humidity range of 0-95% is approved by vendor, operation in this range of humidities should be permissible. The calibration and accuracy will not be affected.

Other components at skid - The motor, blower, flow meter etc. should not be affected by humidity.

Ratemeter/Recorder - No effect expected because of the controlled atmosphere in the Control Room.

5.4.7.4 Other Environmental Effects

There are no anticipated environmental conditions, other than those previously discussed, that will effect these monitors.

5.4.7.5 Power Requirements, i.e., Voltage and frequency variations of ± 15% should not result in readout variations in excess of ± 5%.

The detector, including preamp, ratemeter and recorder are powered from instrument power buses in the Control Room. This power supply is stabilized and variations of 15% will not be seen.

Per Kaman specs: for the ratemeter 90 - 130 VAC, 50-60 Hz is acceptable. Kaman Spec for the recorder power supply and recorder indicate that the recorder would easily meet a -10% +5% variation in power supply.

Motor/pump - no significant effect.

5.4.7.6 Electrical Effects

This has been a problem. Kaman Instrumentation specs indicate that the power supply for the recorder is sensitive to RF. Experience indicates that the system is sensitive to RF generated at either the sample rack or the ratemeter locations. Use of radios is being controlled administratively to eliminate this problem.

5.4.7.7 Mechanical Effects

The WOAs are qualified to seismic I standards. The detectors presently installed are not seismic I qualified.

5.4.8 Radiation Alarms

The ratemeter is equipped with two upscale alarms (Hi and Hi Hi) which can be set at any point over the range of the instrument. These alarms are latching type and must be manually reset. The alarms illuminate a light at the ratemeter and open a relay which causes a trouble light on an annunciator panel to illuminate and a buzzer to sound. Opening of the relay on Hi Hi alarm causes the Control Room Ventilation System to switch to the emergency mode of operation and also causes the dampers in the associated remote air intake duct to close.

The downscale, Hi and Hi Hi alarms are reset and the setpoint can be checked from the face of the ratemeter.

The Hi and Hi Hi alarm points can be adjusted at the meter face. The low high voltage alarm and the downscale alarm setpoints are adjusted internally but the instrument does not have to be removed from service to adjust them.

5.4.9 Failure Alarm

The ratemeter provides a latching alarm in case of power failure, HV below the HVINOP setpoint, or counting rate below a setpoint value.

5.4.10 Calibration

A. The primary calibration of the 4 WOA monitors was made by the vendor, Kaman Instrumentation. The primary calibration using Xe-133 and Kr-85 gas was related to Kaman's secondard standard source and WNP's "transfer standard" source and 3 "linearity" sources. Kaman's secondary standard and the transfer standard are solid Sr-90 sources about 1 inch in diameter and at the time of calibration about 0.09 uCi. The linearity sources are identical to Kaman's secondary standard and the transfer standard and had activities of about 0.5, and 0.005 uCi of Sr-90. The sources were precisely positioned under the detector using a "calibrator" (shielded calibration jig). The calibrator was also furnished to WNP-2 to assure reproducible geometry when making transfer calibrations. All sources, including Xe-133 and Kr-85 gas, are NBS traceable.

The primary calibration consisted of exposing a detector to three different concentrations of Xe-133 and Kr-85 in the geometry actually used. Kaman's secondary standard, the transfer standard and the linearity sources were counted in the calibrator. The counting efficiency for each isotope of noble gas was established over the range of concentrations used. This counting efficiency is related to the counting rate obtained on the secondary standard and transfer standard sources. The remainder of the detectors are cross calibrated to the transfer standard and Kaman's secondary standard sources.

FSAR Table 11.5-1 requires these monitors to be calibrated to Xe-133. The primary calibration covered the expected range of activity.

B. The primary calibration source is related to a transfer standard and linearity sources which are NBS traceable. The linearity sources are used to assure that instrument responds properly over the range of activity of interest.

C. The transfer standard and the linearity sources are small (about 1 inch diameter) compared to the detector (about 2 inches diameter). However, the source to detector geometry is precisely maintained by using the calibrator. Using the calibrator, the error due to source positioning is negligible. An exception to the requirement for the transfer standard to the same surface area as the detector was requested.

D. Since this is a noble gas monitor, the loss in the sample line is nonexistent.

E. The flow rate measuring device (rotameter) was calibrated in September 1983.

F. A remotely actuated 1 uCi Cl-36 check source is provided to check the overall response of the monitor.

G. Calibrated electrical pulses are provided by the ratemeter and externally generated signals can be inputted at the ratemeter. In both cases, the signals are inputted downstream of the gain and discriminator circuits in the ratemeter.

Comparison of WOAs to FSAR 11.5.1.2.1
(Systems Required for Safety)

a. Withstand the effect of natural phenomena (e.g., earthquakes) without loss of capability to perform their functions.

- WOA systems were designed to Seismic I and QC I requirements.
- Presently, the detectors have not been qualified as Seismic I. New detectors are on order.

b. Perform its intended safety function in the environment resulting from normal and postulated accident conditions.

The WOAs are normally in an environment controlled for human comfort and is therefore no problem.

During postulated accident conditions the pressure, temperature and humidity may increase slightly but should not exceed the upper range of human comfort.

Although there will be no significant sources of radiation in the hallway where the sample racks are located, the radiation level in the Reactor Building will contribute to the background of the instruments. Based on data given in the Shielding Evaluation Report (SER), the major contributors to the dose rate in the Reactor Building are:

- Airborne concentration which contributes 1E3 R/hr max or 2E5 cumulative integrated dose (CIND).
- The RHR pumps located about 15 feet from the wall on the 422' level.
- A horizontal run of 6" RCIC piping located about 10' from the wall.
- A vertical run of 6" RCIC piping about 2 feet from the wall. This 6" vertical pipe is near WOA-SR-18B.

The maximum dose to vital equipment on the 441' level of the Reactor Building is 1.7E6 Rad CIND. Apparently this maximum does is at and from the 6" vertical RCIC line.

Using the method given in Appendix C of the SER the maximum does rate at WOA-SR-18B can be approximated as follows. The dose rate at the other WOA sample racks will be lower. For ease of calculation, the total dose and dose rates will be remodeled as the standard 8" pipes.

Total dose from std pipe = 1E5 Rads CIND. Maximum dose rate at 8 feet from standard pipe is 3E3 Rads/hr.

$$\frac{1.7E6}{1.E5} = 17 \text{ pipes}$$

From SER Figure C-13 dose rate from 17 pipes through Reactor Building wall (40" concrete) is

$$(17)(0.28 \text{ R/hr}) = 5 \text{ R/hr}$$

Attenuation through 3" (7.67 cm) of Pb is 0.0003, there- fore dose rate in shield is (5E3 mR/hr)(0.0003) = 1.5 mR/hr gamma plus some auger electrons.

This detector (30 mil thick NE 102) has a minimal (0.4% to 100 Kev X-rays) response to gamma radiation. On a typical GM type detector the counting rate in a 1.5 mR/hr field would be about 3E3 cpm. The counting rate on this detector would be lower by at least a factor of 3.

c. Meet the reliability, testability, independence and failure mode requirements of engineered safety features.

Reliability:

- o Redundant monitors on each air supply.

Testability:

- o Any one unit can be completely isolated for testing, calibration and/or maintenance.

Independence:

- o Any one unit can be isolated.
- o Loss of two units places the Control Room Ventilation System in safe mode.
- o Powered by divisionally separated class 1E power.
- o There are no shared components in any of the monitoring systems.

Failure Mode:

- o Alarms & annunciates on downscale reading, loss of power, or HV below a specified setpoint.

d. Provide continuous output on Control Room panels.

- o Dial, recorder and annunciation in the Main Control Room.
- o WOAs input into TDAS.

e. Permit checking of the operational availability of each channel during reactor operation with provision for calibration function and instrument check.

- Can isolate any one unit.

- Has "Ext. Calib." for input of calibrated pulses at the count rate meters.

- Has check source to check the overall system response.

- Has alarm test; alarm setpoint; Low, Mid, Hi, cal. point; and HV pushbuttons to check these parameters. These parameters can be tested without activating the control functions.

f. Assure an extremely high probability of accomplishing its safety function in the event of anticipated operational occurrences.

The WOA monitors are Seismic I qualified (except for the presently used detector), Quality Class I, redundant, and are driven by Class IE power. This provides an extremely high probability of operation during any anticipated operational conditions.

g. Initiate prompt protective action prior to exceeding plant technical specification limits.

The systems monitor the concentration of radioactive material in the remote air intake ducts. Upon a Hi Hi alarm, the damper in the affected inlet is closed and the Control Room ventilation system is switched to the emergency mode.

h. Provide waring of increasing radiation levels indicative of abnormal conditions by alarm annunciation.

Yes - Have a failure alarm (see i below), Hi alarm, and Hi Hi alarm. The failure alarm and Hi Hi alarm activate an annunciator and buzzer. The Hi Hi alarm also closes dampers in the affected air duct.

i. Insofar as practical, provide self-monitoring of components to the extent that power failure or component malfunction causes annunciation and channel trip.

Yes - The failure alarm trips and causes annunciation in case of loss of power, HV below a setpoint and downscale meter reading.

j. Register full scale output if radiation detection exceeds full scale.

No, if PM tube driven to current mode, the alarm stays latched and the meter drops to zero.

k. Have sensitivities and ranges compatible with anticipated radiation levels.

Yes - see comparison to ANSI 13.10 Sections 5.4.1, 5.4.2, and 5.4.3.

Comparison of WOAs to the Applicable General Design Criteria
10CFR50 Appendix A

1. Quality Standards and Records

The remote air intake monitoring system is designed to Quality Class I, Seismic Class I criteria. Appropriate records have been maintained.

2. Design Bases for Protection Against Natural Phenomena

The design basis is given in the FSAR and does consider appropriate natural phenomena.

3. Fire Protection

Fire protection that is consistent with the design basis is provided, i.e., Halon System in the Control Room, administrative control of combustible etc.

4. Environmental and Missile Design Basis

The design basis is given in the FSAR and does consider environmental effects and protection from missiles.

13. Instrumentation & Controls

The remote air intake monitor is designed to assure that it will perform its expected function over the anticipated range of all normal and accident conditions.

19. Control Room

A Control Room is provided that is safe under normal or accident conditions.

20. Protection System Functions

The remote air intake monitors will sense radioactivity in the intake air and automatically close dampers to terminate the intake of contaminated air.

21. Protection Reliability and Testability

Each remote air intake has redundant monitors. Any single unit can be taken out of service for maintenance, calibration, etc.

22. Protection System Independence

System is designed to Quality Class I, Seismic Class I criteria and has Class IE power. This assures that the equipment will operate in all normal and expected accident conditions.

23. Protection from System Failure

Failure upscale of anyone of these monitors places the Control Room in a safe condition. Failure downscale requires manual action and is administratively controlled.

24. Separation of Protection and Control Systems

The protection system that closes is isolated from the monitoring system. Any one unit of the monitoring system can be removed from service.

29. Protection against anticipated operational occurrences.

N/A

60. Control of releases to the environment.

N/A

64. Monitoring radioactive releases.

N/A

[illegible]

Attachment 5

ANSI 13.10 COMPARISON

LOW RANGE GASEOUS EFFLUENT MONITORING SYSTEM

Reactor Building - REA-RIS-19
Radwaste Building - WEA-RIS-14
Turbine Generator Building - TEA-RIS-13

5.4.1 Detection Capabilities

The Low Range Gaseous Effluent Monitoring Systems, REA-RIS-19, WEA-RIS-14 and TEA-RIS-13, all utilize plastic (polyvinyl-toluene) beta scintillators supplied by Kaman Instrumentaiton. The detectors are mounted in a 2.2 liter stainless steel sample chamber surrounded by a three inch 4π lead shield. A continuous gas sample is pulled through the sample chamber after the sample stream has passed through a charcoal cartridge and particulate filter.

These monitors provide continuous indication of the radioactive gas concentration for the three plant effluent pathways. The sample system for the REA and TEA employs isokinetic samplers which assures representative sampling. The WEA system utilizes isokinetic probes with a fixed flow rate expected to be isokinetic over the normal ventilation operating range.

These monitors provide downscale, Hi and Hi Hi alarms in the main control room. The Hi Hi alarm point corresponds to reaching 80% of an MPC based on Xe-133 equivalent setting for the percent of total allowable effluent discharge as listed in the WNP-2 ODCM. These monitors were calibrated by Kaman Instrumentation using NBS traceable quantaties of Xe-133 and Kr-85. These gas calibrations are used as the primary calibration, with transfer calibration performed to within ±20% accuracy on the monitor as installed in their sampling configurations at WNP-2.

The principle nuclides these detector systems are required to measure are Xe-133 and Kr-85. The response as determined by the primary and secondary (transfer) calibration indicate that the ANSI 13.10 MDA's are within the capabilities of the installed instrumentation. As these systems employ beta scintillators that are relatively insensitive to gamma photons, the detectors are expected to be able to see low levels of beta activity from noble gases in appreciable external gamma fields.

5.4.1.1 Detection In Gaseous Systems

The Reactor Building, Radwaste Building and Turbine Building gaseous effluent monitors are shielded from gamma radiation and monitor air

streams that are preconditioned by passing through particulate filters and charcoal cartridges. This design reduces the system background and helps achieve a low system MDA or LLD. The LLD was calculated using the technical specification method. The MDA's were calculated using the method typically used in the industry and by using the ANSI 13.10 method incorporating the RC time constant.

The listed LLD and MDA's represent the 95% confidence level.

Detector	Nuclide	Installed Background	Calibration Factor[1]	Tech Spec $LLD = \frac{4.66\sqrt{Bkg}}{Cal.\ Factor}$	Normal $MDA = \frac{2\sqrt{Bkg}}{Cal.\ Factor}$	ANSI 13.10 $MDA = \frac{1.96\sqrt{Bkg/2RC}}{Cal.\ Factor}$	ANSI 13.10 Design MDA
REA	Xe-133	24.4 cpm	4.55E+7 cpm/uCi/cc	5.06E-07 uCi/cc	2.13E-07 uCi/cc	3.36E-07 uCi/cc	5.0E-7 uCi/cc
WEA	Xe-133	20.1 cpm	4.80E+7 cpm/uCi/cc	4.35E-07 uCi/cc	1.83E-07 uCi/cc	2.89E-07 uCi/cc	5.0E-7 uCi/cc
TEA	Xe-133	27.3 cpm	4.82E+7 cpm/uCi/cc	5.05E-07 uCi/cc	2.12E-07 uCi/cc	3.36E-07 uCi/cc	5.0E-7 uCi/cc
REA	Kr-85	24.4 cpm	7.32E+7 cpm/uCi/cc	3.14E-07 uCi/cc	1.32E-07 uCi/cc	2.09E-07 uCi/cc	3.0E-7 uCi/cc
WEA	Kr-85	20.1 cpm	7.71E+7 cpm/uCi/cc	2.71E-07 uCi/cc	1.14E-07 uCi/cc	1.80E-07 uCi/cc	3.0E-7 uCi/cc
TEA	Kr-85	27.3 cpm	7.74E+7 cpm/uCi/cc	3.15E-07 uCi/cc	1.32E-07 uCi/cc	2.09E-07 uCi/cc	3.0E-7 uCi/cc

[1] The calibration factor is evaluated at 8.625 E+4 cpm, the transfer standard count in year = 84.00000.

The LLD and MDA's from the three methods used compare closely with the MDA listed in Table 1 of ANSI 13.19. The normal and ANSI 13.10 MDA's both meet or exceed the design specification levels suggested in Table 1 for Xe-133 and Kr-85.

5.4.1.2 Detection In Liquid Streams

The range of these three instruments meets the criteria of at least 10^4 minimum detectable levels. The range of the detectors is 10 to 10^7 cpm. The table below gives the specifics.

Range	REA	WEA	TEA
Meter Scale	10 to 10^7cpm	10 to 10^7cpm	10 to 10^7cpm
Xe-133 uCi/cc	2.2E-7 to 0.22	2.1E-7 to 0.21	2.0E-7 to 0.21
Kr-85 uCi/cc	1.4E-7 to 0.14	1.3E-8 to 0.13	1.2E-7 to 0.13
MDL cpm	15.3	13.9	16.19
MDL x 10^4cpm	1.53 x 10^5	1.39 x 10^5	1.62 x 10^5

5.4.3 Sensitivity

The sensitivities of the REA, TEA and WEA monitoring systems were calculated according to ANSI 13.10 definition based on the RC time constant for the instrument. The RC time constant used was 12 seconds as this is the time constant for the decade of the background level. Following is a tabulation of the sensitivities.

Instrument	REA	WEA	TEA
Sensitivity $Ns=1.96\ Nb/2RC$	$Ns=1.96\sqrt{\frac{24.4}{\frac{2 \times 12}{60}}}$ = 15.3 cpm	$Ns=1.96\sqrt{\frac{20.1}{\frac{2 \times 12}{60}}}$ = 13.9 cpm	$Ns=1.96\sqrt{\frac{27.3}{\frac{2 \times 12}{60}}}$ = 16.19 cpm

5.4.4 Accuracy

The accuracy of the REA, WEA and TEA systems was determined based on the count rate of the WNP-1 standard Sr-90 transfer calibration source activity as was determined at the time of the primary calibration. The transfer source is NBS traceable and nominal count rate at time of manufacture is cpm/uCi = $9.83 \times 10^5 \pm 5.02\%$ at the 95% confidence level.

The REA, WEA and TEA monitors were calibrated using the transfer source and the count rate off from a scaler system hooked into the output of the detector module to determine the accuracy. During the calibration performed on the installed configuration, the detectors were all determined to be within the ±10% accuracy meeting the ±20% in ANSI 13.10.

The formula used to determine error was percent error $= \frac{(Rt-Rr) \times 100}{Rt}$ where Rr was the scaler output and Rt the NBS traceable transfer source activity. The following table lists the accuracies for each unit.

	REA	WEA	TEA
Accuracy	-4.11%	+1.06%	-1.49%

The accuracies of the ratemeters and recorder are specified by the Kaman Instrumentation manual as follows:

Recorder: ±0.5% of span

Ratemeter: ±5%

Meter reading accuracy: ½ smallest scale division

5.4.5 Precision

The precision was determined for the REA, WEA and TEA systems during the transfer source calibration with the data being taken from Sr-90 source counts. The precision for these units was determined to all be within ±3%. This was a requirement of the approved calibration procedures used during the calibration.

The indication for other counts on similar beta scintillation indicates that ±10% precision error can be met or exceeded for the REA, WEA and TEA low range effluent monitoring systems.

5.4.6 Response Time

The response time is adequate to achieve the required accuracy as demonstrated in the other sections of this report where the RC time constant was used. Since no delay circuits or devices are incorporated into our electronic circuits after the log ratemeter the nominal value of 2.2 time constants is easily met.

From the Kaman manual, the response time for given signal changes and the 2.2 time constants values are shown below.

Signal Change	RC Time Constant	Response Time (2.2) (RC)
$10-10^2$	12 sec.	26.4 sec.
$10-10^3$	3.5 sec.	7.7 sec.
$10-10^4$	1.0 sec.	2.2 sec.
$10-10^5$	0.1 sec.	0.22 sec.
$10-10^6$	0.1 sec.	0.22 sec.
$10-10^7$	0.1 sec.	0.22 sec.

5.4.7.1 Temperature

The ratemeters, recorders and power supplies are located in the main control room which is designed to be habitable under normal and analyzed abnormal conditions and will never exceed 140°F (60°C). At this temperature calibration drift would be very small and is typically ignored.

Detectors - Kaman states normal operating temperature to be 32-140°F (0-60°C).

a. The beta scintillator is a polyvinyltoluene based plastic. The plastic will undergo no change in sensitivity from -60°C to 20°C, but will decrease to 95% of the 20°C response at 60°C (140°F). The beta scintillator will have about 0.34% response to 100KeV gamma rays.

b. P.M. tube is a 10 dynode stage unit, which is intended to operate from -30°C to 50°C (122°F) normally but can operate from -30°C to 80°C (176°F) for short periods.

c. Preamplifier, contained in the beta scintillator housing can operate to a temperature limit of 60°C. The lower limit was not specified but would definitely be below 0°C.

Ratemeter Module

The module is rated to operate between the temperature limits of 0°C to 60°C, maintaining the accuracy stated of one-half the smallest scale division, 0.39% ELFS. No statement is made concerning the 4-20 MA output with respect to accuracy vs. temperature.

Recorder Module

The recorder is designed to operate normally from 4° to 49°C (40° to 120°F) for a normal operational limit. Maximum limits are stated to be from -18° to 60°C (0 to 140°F). Its power supply operates from 18° to 60° normally.

Power Supply

The operating range of the power supply is the same as the recorder. The temperature effect as stated by Kaman Instrumentation is ±0.5%DC and ±1.0%AC for ±40°F based on an operating range mid point of 80°F.

5.4.7.2 Pressure

The detector chamber and detector are the devices that could be pressure sensitive. "O" rings are used to seal the detector into its housing, and the housing into the chamber. When grab samples have been taken with indicated systems pressure at 5 inches of mercury (approximately 630 torr), no apparent changes in background radiation levels have been noticed (130 torr = 5 inches mercury = 2.5 psi). No specific statements relating to pressure/vacuum were found in the operating manual.

5.4.7.3 Humidity

Detector assembly - Vendor suggested storage can be from 0 to 95% humidity. Operation should be over the same range.

Ratemeter module has an operating limit from 0 to 95% relative humidity.

Recorder operating limit, not specified.

5.4.7.4 Corrosive Atmosphere

No specification and no corrosive atmospheric conditions expected, but detector housing and chamber is stainless steel. The alumized Mylar windows could be sensitive to organics as Acetone, etc., but none should be used in close proximity.

5.4.7.5 Power Requirements

Detector - Derives its power from the RIS module.

RIS Module - Can operate with power ranging from 90 to 130 volts and over a frequency range from 50 to 60 Hz.

The recorder obtains its power from a rack mounted power supply. The input variation of -10% to +5% or from 103.5 to 121 volts will cause a change of 0.5% in the DC voltage. Beyond that range the changes in the supply output is not specified. A frequency of ±1 Hz will cause a 0.3% change in the DC supply.

5.4.7.6 Electrical Effects

This has been a problem. Kaman Instrumentation specs indicate that the power supply for the recorder is sensitive to RF. Experience indicates that the system is sensitive to RF generated at either the sample rack or the ratemeter/recorder locations. During the pre-operational testing, a hand-held transmitter was keyed (this was prior to the ban of such items in the control room). If an effect was noticed, it was entered in the pre-op test summary. The following summarizes the test:

> With the module mounted in its rack, key a walkie talkie in the vicinity and note the effects. The test was repeated at the monitor skid location.

The walkie talkies output approximately 4 watts into the antenna. Assume a function of $1/r^2$ at first approximation for energy at the module face. At approximately 6 feet the power would be about 12 μ watts. The result was the rack mounted module alarmed (all alarms). All Kaman Instrumentation modules responded in a similar fashion, yet when the same test was applied to the corresponding skid, no effect was observed. Use of radios is being controlled administratively to eliminate this problem with the Kaman instruments.

5.4.7.7 Seismic Testing

Not required on this equipment as it is Class II; however, the equipment in the control room i.e., ratemeter recorder, etc., is in a seismically qualified rack and is identical in design and manufacture to other seismically qualified units such as the remote air intake monitors (WOA's). This requirement is probably fully met but it is not documented and is not critical to the monitor functions.

5.4.8 Radiation Alarms

The ratemeter is equipped with two upscale alarms (Hi and Hi Hi) which can be set at any point over the range of the instrument. These alarms are latching type and must be manually reset. The alarms illuminate a light (Hi amber; Hi Hi red) at the ratemeter and open a solenoid which causes a trouble light on an annunciator panel to illuminate and a buzzer to sound, Board "S" ANN panel P851-S1.

The Hi and Hi Hi alarm setpoints can be adjusted externally without removing the instrument from service.

5.4.9 Failure Indicators

A down scale or H.V. failure indicator (green) is on each module and will illuminate when tripped. A corresponding trouble alarm will indicate on Board S, ANN Panel P851. The alarms are the latching type that have to be manually reset.

5.4.10 Calibration

a. NBS Traceable - Three each of ^{133}Xe and ^{85}Kr NBS certified gases were used in the primary calibrations. The gases were introduced into the known volume standard Kaman gas chambers. The detectors used were "generic" Kaman beta scintillator units. The counting and analysis, carried out on the WNP-1 digital system, was completed and entered onto calibration report sheets. This report was forwarded to WNP-2 as part of the equipment package. The total calibration errors, including NBS gas calibration errors, ranged from 9.7%, a low activity sample, to 1.6%, a high activity sample at the 95% confidence level.

b. Transfer Calibration Sources - Disk sources of ^{90}Sr were used at the same time as the above mentioned gas calibration. A response factor was developed relating ^{90}Sr to ^{133}Xe. A further study of 25 different detectors response to the primary and secondary ^{90}Sr transfer sources indicated the true "generic" quality of the detectors. A mean error of 2.6% and 4.3% respectively at the 95% confidence level indicates a very good group. Further, the response to Kaman's standard and WNP-1's secondary transfer sources were within 0.6% at 95% C.L. These secondary sources were and are periodically analyzed on beta detectors which are calibrated with NBS and NBS traceable sources.

c. Constant Geometry - The vendor, Kaman, has a shielded portable constant geometry rack (field calibrator). Demonstrated reproduceability of source placement is within ±0.3%.

d. DOP Testing - There is no anticipated problem of noble gas and sample lines. DOP testing not required and an exception was taken to the ANSI 13.10 criteria in the December 8, 1983, memo.

e. Flow Rate Devices - Each sample skid has a rotometer that ranges from 0 to 10 cfm, a measureable range of 0.5 to 9.5 is repeatable to within 20% at any reading. Furthermore, the WEA skid has a flow totalizer which is periodically calibrated and is accurate to ±10% of its reading.

Coupled to flow rate measurement is the pressure measurement on each monitor skid. Each skid is provided with a vacuum gauge that reads from 0 to 30 inches at ±2% of reading according to the vendor.

f. Check Source - Each unit has a solenoid activated check source composed of ^{36}Cl. These solenoids are activated at the RIS module in the control room.

g. Electronic Calibration Signals - Each RIS module has 1) an internal oscillator which allows a sweep across the output range for alarm test and 2) a calibration signal input (pulse) for accurately establishing the setpoints.

11.5.1.2.2 Responses

a. Yes - see M893.
TEA-RIS-13, TEA-RR-13 on BD-RAD-24
WEA-RIS-14, WEA-RR-14 on BD-RAD-24
REA-RIS-19, REA-RR-19 on BD-RAD-24

b. Yes. See 5.4.8.

c. Yes. See 5.4.9.

d. Representative Sample:

   1. REA and TEA utilize air monitor sampling systems which assure isokenetic and representative sampling. Air flow changes are monitored and inlet flows are adjusted accordingly.

   2. WEA utilizes isokenetic probes and a fixed sample flow rate. The fixed flow rate will be isokenetic over the expected operational range.

e. Each RIS module allows for:

Check Source
Alarm Test
H.V.
Calibration Signal Input
Alarm Reset

f. See monitor summary sheet, RANGE.

g. These monitors have a holding circuit for the alarm when it is tripped. It requires manual reset. The meter will record the signal status on the detector.

Design Criteria Appendix A

13. Met as far as range of instrument intends.

60. Measures release to the environment. Does not control release as per system design. Administrative controls are imposed upon alarm trips to initiate action to assure the safety of the public is assured.

64. Monitors measure rad gas actively in reactor unit gas release pathways.

ANSI 13.10 REVIEW

Turbine Service Water Monitor
(Plant Service Water)

EPN:

Sample Rack	TSW-SR-34
Detector	TSW-RE-5
Flow Meter	TSW-FIS-1
Recorder	None

General Description of System

The Turbine Service Water Monitor measures the activity in Plant Service Water return header. The Plant Service Water draws water from the circulating water intake structure and provides cooling water for about 25 pieces or groups of equipment. About half of this equipment has no potential for contaminating the service water and these streams enter the discharge header downstream of the monitor. The remainder have only a small potential for contaminating the service water however, the TSW monitor draws its sample downstream of the latter group of equipment which have the low potential for contamination.

The Sample probe is a 3/4" SS line inserted through the side of the 18" header. The sample line extends 2 1/2 inches into the 18" header and is cut on a 45° angle. The sample is passed through sample chamber, a rotameter, a pump, and back to the header.

The sample chamber is a 2.4 liter stainless steel marinelli beaker with the detector position to the chamber in an essentially a 2π configuration. A 7 inch thick 4π shield is provided for the sample chamber and detector. From the sample chamber, the sample stream flows through a rotameter with a range of 0.2 to 6 gpm. The rotameter has low flow detection/alarm capabilities and is typically set to alarm at 2.0 gpm. The sample flow is maintained by a centrifugal pump which returns the sample flow to the service water header.

The detector consists of a 1 x 1-1/2 inch NaI (Tl) crystal optically coupled to a photomultiplier tube and followed by a preamplifier. The signal is sent to a 6 decade (10 to 10^7 cpm) ratemeter which is in the main control room. The ratemeter has three internal calibration points and provisions for inputting an external calibration signal. An alarm test function is also provided. A 8 uCi Cs-137 (11/14/78) check source is provided at the detector. The check source is controlled from the ratemeter. The TSW monitor does not have a recorder. The TSW monitor is Quality Class II, seismic II and covered by Technical Specification, Section 3.3.7.11.

The release rate via the plant service water is expected to be zero to very low. This monitor provides no automatic control function.

Comparison to ANSI 13.10, 5.4 "Standards of Performance"

5.4.1 Detection Capability

The TSW monitor detects gamma radiation using a 1" x 1-1/2" NaI (tl) cyrstal. This type and size of crystal provides a good counting efficiency for radiation emitted from the expected radio nuclides which are Cs-137 and Co-60. The monitor was calibrated with an NBS traceable Cs-137 solution and was set to measure gamma radiation with energies greater than 80 kev. The alarm set point is set at 80% of the MPC for Cs-137 and allows for a 20% error in calibration. The MDA from Section 5.4.1.2 (below) of 3.65 E-7 uCi/ml meets the MDA criteria of ANSI 13.10. The other nuclide of interest, Co-60 detection at MPC will be no problem as two gamma per disintegration are emitted.

Periodic samples from the service water system will be taken to verify that the monitor calibration remains representative.

5.4.1.1 Detection in Gaseous Streams

Not applicable.

5.4.1.2 Detection in Liquid Streams

The TSW monitor employes a shielded detector system as described in the General Discription of System section. The shielded off line monitor provides a fairly stable background level resulting in low MDA. The LLD for this monitor was calculated by using the Technical Specification definition. The MDA's were determined by using the method typically used in the industry and by the ANSI 13.10 method using the R.C. Time Constant. The LLD and MDA's are expressed at the 95% confidence level based on a Cs-137 primary calibration.

Detector	ANSI 13.10 Criteria	Back-ground	Calibration Factor	Tech. Spec. LLD= $\frac{4.66\sqrt{Bkg}}{Cal. Fac.}$	Normal MDA=$\frac{1.96\sqrt{Bkg}}{Cal. Fac.}$	ANSI MDA=$\frac{1.96\sqrt{Bkg/2RC}}{Cal. Factor}$
TSW	4.E-7uCi/ml	155	6.68 E7Cpm/uCi/ml	8.69E-7 uCi/ml	3.65E-7uCi/ml	1.07E-6uCi/ml

The RC time constant for the second decade or decade of background is 3.5 sec and was used in the ANSI 13.10 calculation.

TSW Primary Calibration Data

Liquid Sources

Source	CPM	BKg	Net Ct	$(X - \bar{X})^2$	$\frac{cpm}{uCi/ml}$ Cs-137
1	5037		4895	169	
7.60E-5uCi/ml	5033		4891	81	6.424E7
+ 7.0%	5009	142	4867	225	
@ 2	5016		4874	64	
			$\bar{X}$ = 4882	Σ539	

$$\sigma = \sqrt{\frac{(X - \bar{X})^2}{N - 1}}$$

$$\sigma = \sqrt{\frac{539}{3}} = 13$$

Source	CPM	BKg	Net Ct	$(X - \bar{X})^2$	$\frac{cpm}{uCi/ml}$ Cs-137
2	70279		70117	9	
1.025E-3uCi/ml	70496		70334	48,406	6.84E7
+ 2.47%	69823	162	70661	299,209	
@ 2	69507		69345	591,361	
			$\bar{X}$ = 70114	Σ938,979	

$$\sigma = \sqrt{\frac{938,979}{3}} = 560$$

Source	CPM	BKg	Net Ct	$(X - \bar{X})^2$	$\frac{cpm}{uCi/ml}$ Cs-137
3	790,639		790,479	498,436	
1.168E-2uCi/ml	791,208		791,148	1,369	6.77E7
+ 1.61%	791,310	160	791,150	1,225	
@ 2	792,121		791,961	602,176	
			$\bar{X}$ = 791,185	Σ654,606	

σ = 467

Calibration Factors

Cpm/ uCi/cc	$(X - \bar{X})^2$	% From $\bar{X}$
64.24 E6	6.45	4%
68.4 E6	6.26	2%
67.7 E6	0.85	1%
$\bar{X}$ = 66.78 E6	Σ= 13.56 E12	

6.68 E7 cpm/uCi/ml σ = 2.13 E6

Bkgrd Counts

Bkg cpm	$(X - \bar{X})^2$
142	169
162	49
160	25
$\bar{X}$ = 155	Σ243

σ = 11

5.4.2 Range

MDA = 1.96 $\sqrt{BKg}$ = 24 cpm
MDA = 24 cpm = 3.65 E-7 uCi/ml
(24) (10^4) = 2.4 E5 cpm
Range of ratemeter 10 to 10^7

5.4.3 Sensitivity

Based on Ns = 1.96 $\sqrt{\frac{Nb}{2RC}}$

Time constant for second decade = 3.5 sec.

$$Ns = 1.96 \sqrt{\frac{155}{\frac{(2)(3.5)}{60}}} = 71 \text{ cpm}$$

5.4.4 Accuracy

A primary calibration was made which established the ratio of the transfer standard sources to the liquid standard sources and the counting rate of the transfer standard source. The counting rate for the transfer standard, based on 6 counts, is 8.50 E4 cpm, = 115 cpm. This is equivalent to 8.50 E4 cpm ± 0.3% at 95% CL. This counting rate when corrected for decay will be R_t for future calibrations.

The calibration factor at the 3 concentrations used in the primary liquid calibration agree within ± 5% of the mean.

Transfer Std. Source Ct	BKg	Net Ct	$(X - \bar{X})^2$
85206	142	85064	1089
8506-*		8492-	12321
85264	164	85100	4761
851--		849--	17161
85364	160	85204	29929
852--		850--	961
		$\bar{X}$ 85031	Σ66222

$\sigma = \sqrt{\frac{66222}{5}}$ = 115 cpm

* original data rounded

5.4.5 Precision

Based on 6 counts of the transfer standard.

$\bar{X}$ = 8.50 E4, σ = 115, 1.96σ = 225 cpm

$\frac{225}{8.50\ E4}$ = 1.2 E-5 which is much less than 10% $\bar{X}$.

5.4.6 Response Time

Bkg = 155 cpm

$$Ns = 1.96 \sqrt{\frac{155}{\frac{(2)(3.5)}{60}}} = 71.44 \text{ cpm}$$

$$Ns = \frac{71 \text{ cpm}}{6.68 \text{ E7 cpm/uCi/ml}} = 1.07 \text{ E-6 uCi/ml}$$

With a time constant of 3.5 sec for the second decade, the instrument will easily see the required detection level of 4E-6 uCi/ml. The time delays in the alarm circuit etc. are insignficant (milli seconds).

5.4.7.1 Temperature

The ratemeter and power supply are located in the main Control Room which is designed for human habitability under normal and analyzed abnormal conditions and will never exceed 104°F.

Detector

- o Normal operating temperature per vendor is 0-60°C.
- o The effect of temperature on the calibration (counting efficiency) is not defined.
- o Under normal and analyzed abnormal conditions the ambient temperature is maintained for human comfort. Calibration drift (counting eff) in this temperature range, if any, is typically ignored in analytical counters. Energy calibration does change.
- o Under very abnormal operating conditions the temperature of the stream being sampled may approach 60°C. However, it is unlikely that the detector would reach this temperature. Per Kaman spec. sheet max. temp. = 100°F (38°C). Undefined changes in PM tube performance (i.e., increase/decrease in noise level) and energy calibration would be expected. This should not have a deleterious effect on the intended purpose of the instrument.

Pump/Motor/Rotameter: This range of temperatures should have minimal effect. The water should never freeze in this system. Per vendor spec. components rated for 60°C rise above ambient of 40°C.

Ratemeter Module: Per vendor specifications ± 5% change over range of 0-60°C. However, ambient temperature at the location of the ratemeter will never exceed 40°C (= 104°F) even after LOCA.

5.4.7.2 Pressure

This range of pressure should not affect any component in the system. Also, all components are open to the turbine building or control room atmosphere and will, therefore, never see these extremes.

5.4.7.3 Humidity

Detector (scintillator/preamp) - Vendor gives no operating specifications. Since storage in a humidity range of 0-95% is approved by vendor, operation in this range of humidities should be permissible. The calibration and accuracy will not be affected.

Other components at skid - The motor, pump, flow meter etc. should not be affected by humidity.

Ratemeter/Recorder - No effect expected on ratemeter as it is in Control Room. No recorder on this instrument.

5.4.7.4 Other Environmental Effects

Detector - None expected.

Motor - None expected.

Pump, flow meter, check valve - Foreign material in the plant service water - i.e., resin beads, blow sand, etc. - causes clogging problem which decreases flow rate. Occasional flushing is needed. Visual inspections and the low flow alarm adequately monitor this problem.

Ratemeter - None expected.

5.4.7.5 Power

The detector including preamp, ratemeter, and recorder are powered from instrument power buses in the control room. This power supply is stabilized and variations of 15% will not be seen.

Per Kaman specs: for the ratemeter 90 - 130 VAC, 50-60 Hz is acceptable. Kaman spec for the recorder power supply and recorder indicate that the recorder would easily meet a -10% + 5% variation in power supply.

Motor/pump - no significant effect.

5.4.7.6 Electrical Effects

This has been a problem. Kaman instrumentation specs indicate that the power supply for the recorder is sensitive to RF. Experience indicates that the system is sensitive to RF generated at either the sample rack or the ratemeter locations.

Use of radios is being controlled administratively to eliminate this problem.

5.4.7.7 Mechanical Effects

The TSW is not seismic I qualified. However, the equipment in the control room i.e., ratemeter recorder etc. is in a seismically qualified rack and is identical in design and manufacture to other seismically qualified units such as the remote air intake monitors (WOA's). Likewise the detector and sample rack is not seismically qualified but probably could be. This requirement is probably fully met but documentation is not available.

5.4.8 Radiation Alarm

The ratemeter is equipped with two upscale alarms (Hi and Hi Hi) which can be set at any point over the range of the instrument. These alarms are latching type and must be manually reset. The alarms illuminate a light at the ratemeter and open a solenoid which causes a trouble light on an annunciator panel to illuminate and a buzzer to sound.

The alarms are reset and the set point of each alarm can be checked from the face of each count ratemeter.

The alarm setpoints can be adjusted externally from the meter face for the Hi and Hi-Hi alarms. An exception was requested for this requirement, however, the alarm setpoints can be adjusted externally for this instrument, meeting the intent of this requirement.

5.4.9 Failure Alarm

The ratemeter provides a latching alarm in case of power failure, HV below the HVINOP setpoint, or counting rate below a setpoint value.

5.4.10 Calibration

a) Primary calibration of the TSW monitor was performed on site by circulating three different concentrations of a NBS traceable Cs-137 solution through the sample chamber.

b) A Transfer Standard source (Cs-137), and three sources (Ba-133) which are also NBS traceable, activity were counted. The 3 Ba-133 sources are used to determine the system's response v.s. activity. The energy response of the system was also evaluated and the low energy cut-off was set to 80 Kev.

c) The Transfer Standard source, the linearity sources, and energy response sources are small (about 1" diameter) solid sources. The detector to source geometry is precisely maintained by using the Kaman Calibrator which is a shielded jig. The Transfer Standard count was used to establish a baseline for use in subsequent periodic calibrations. Cs-137 is used for calibration per FSAR Table 11.5-2.

d) The surface area of the Transfer Standard is not the same as the surface area of the detector window. When the detector is in the sample chamber which is a marinelli beaker, 3 π geometry is approximated which cannot be easily reproduced in a calibration jig. The Transfer Standard source and detector is precisely repositionable in the calibrator and therefore error in source positioning is negligible.

e) As this is a liquid sampling system, the loss in the sample line is expected to be negligible. An exception was taken to this requirement in the December 8, 1983 memo to NRR on ANSI 13.10.

f) The flow rate measuring device (rotameter) was calibrated in October 1983. Presently, there are no plans for periodic recalibration.

g) A remotely actuated check source is provided.

h) Calibrated electric signals are provided by the ratemeter and externally generated signals can be inputted at the ratemeter. In both cases the signals are inputted downstream of the gain and discriminator circuits in the ratemeter.

Comparison of the TSW Monitor to FSAR Requirements

11.5.1.2.2 Systems Required for Plant Operation

a. Provide continuous indication of radiation levels in the main control room.

Yes - Dial indication only no recorder--TSW-RIS-5, BD RAD-24

b. Provide warning of increasing radiation levels indicative of abnormal conditions by alarm annunciation.

Yes - Ratemeter has 3 latching type alarms, Failure, Hi and Hi Hi. The failure alarm and Hi Hi alarm activate an annunciator on other control panels. All alarms light on panel but the Hi alarm does not annunciate.

c. Insofar as practical, provide self-monitoring of components to the extent that power failure of component malfunction causes annunciation and, for systems initiating protective action, channel trip.

Yes - Failure alarm (down scale, low HV, and no power) causes annunciation.

d. Monitor a sample representative of the bulk stream or volume.

Yes - Draws 2-4 gpm from 18" header.

e. Have provisions for calibration, function and instrumentation checks.

Yes - 3 built-in calibration checks for the ratemeter. Provisions for inputting an external signal into ratementer.

Cs-137 check source for overall system check.

f. Have sensitivities and range compatible with anticipated radiation levels and technical specification limits.

Yes - See ANSI 13.10 information.

g. Register full scale output if radiation detection exceeds full scale.

Doubtful - However, alarm will latch.

If PM tube is driven to current output, meter reading will probably drop to zero.

Comparison of the TSW to Applicable

General Design Criteria of 10CFR50, Appendix A Requirements

13 - Operable under expected normal and abnormal conditions?

Yes - Environment normally controlled for human access and comfort as this monitor is located in the turbine generator building.

60 - Control radioactive effluent? Is adequate hold up volume provided.

The TSW measures the radioactivity in-leakage into the Service Water System, manual action is needed for control if control becomes necessary.

Holdup volume is not provided. However, the plant service water system can be shutdown in emergencies and the circulating water blowdown system flow to the river terminated.

64 - Monitoring radioactive releases

The TSW monitors one effluent stream, which has a very low potential for release of radioactivity, under normal and abnormal operating conditions. It will probably continue to operate in accident conditions but is not required. The discharge is to the Circ Water Basin, and can be terminated as stated in GDC 60.

ANSI 13.10 (Section 5.4)

OFF GAS PRE-TREATMENT RADIATION MONITOR

System Objective

The objective of the "Off Gas Pre-Treatment Radiation Monitor" is to provide indication and record of gross gamma radiation level in the effluent, upstream of the Off Gas Charcoal Recombiner System.

System Description

This monitoring system normally samples from downstream side of the hydrogen recombiner units prior to the charcoal beds. The aggregate monitoring system consists of a gamma sensitive ion chamber detector, indicator and trip unit (monitor) and a strip chart recorder. No automatic trip functions are associated with the system, there are two upscale alarms set at radiation levels approaching the Technical Specification limit the Hi alarm corresponding to an action level and downscale (inop).

The detector (ionization chamber) is located outside of, and against, the off-gas pipe inside a shielded cubicle on the 441' elevation of the Turbine Building.

5.4.1 Detection Capability

Does not apply to this system. The gamma sensitive ion chamber is used for detecting gamma flux level. The chamber yields a direct current proportional to the gamma radiation level in which it operates. An ionization chamber was chosen for this monitor as it will respond to mixed fission products. It is used to alert Chemistry to sample and perform an isotopic analysis of the offgas gas stream.

5.4.1.1 Detection in Gaseous Streams

Does not apply (see 5.4.1 explanation).

5.4.1.2 Detection in Liquid Streams

Does not apply (see 5.4.1 explanation).

5.4.2 Range

The instrument range is from 10^0 mR/hr to 10^6 mR/hr in 6 (six) evenly spaced decades. The input current range is from 3.33 x 10^{-13} to 3.33 x 10^{-7} ampers. The normal background is expected to be 400 mR/hr or less and with a range of 10^6 mR/hr, the MDA times 10^4 is not applicable to this monitoring function.

5.4.3 Sensitivity

For a gamma responding system that reads out in mR/hr the "Response Time" is the characteristic used for sensitivity. The following is the system response times:

6 sec (3.33×10^{-13} to 3.33×10^{-12} amp)
1 sec (3.33×10^{-12} to 3.33×10^{-11} amp)
1 sec (3.33×10^{-13} to 3.33×10^{-7} amp)

For specific radiation levels, the conversion to ampers can be made by multiplying the radiation level by the chamber sensitivity (the normal sensitivity is 3.7×10^{-10} ampers/R/hr). The ranges stated above can be determined in mR/hr/R/hr by the same method. The RC time constant for the various decades can be found by dividing the response time by 2.2.

5.4.4 Accuracy

The detector was subjected to a 9.18 curie NBS Traceable Cs-137 source at approximate gamma levels of 100 mR/hr (.1R/hr), 1000 mR/hr (1R/hr), 5000 mR/hr (5R/hr) and 10,000 mR/hr (10R/hr). A NBS traceable calibrated set of condenser "R" chambers was used as the reference standard for determining R_t (true quantity) in the percent error equation. The following are the results of the 6-22-84 calibration:

NOTE: A primary radiological calibration was completed on 11-28-83 with the results matched against the ELFS criterion. The 6-22-84 radiological calibration results were matched against a ± 20% relative error criterion.

Monitor Number	R_t Corrected Condenser "R" Reading	R_r Control Room Meter Reading	Percent Error
Type NA05			
Cat #327X7316001			
Serial #TNNKG-029	138 mR/hr	120 mR/hr	13%
	842 mR/hr	800 mR/hr	5%
	5286 mR/hr	5000 mR/hr	5%
	7956 mr/hr	7750 mR/hr	3%

The above was determined using:

$$\text{percent error} = \frac{R_t - R_r}{R_t} \times 100$$

5.4.5 Precision

The system used is as follows:

1) Based on the source strength (total curies) and the conversion to R/hr exposures were made to estimate distances. The specific source was an Amerisham - Cs-137 source of 9.45 curies.

- o Source strength at factory = 9.45 curies
- o Source strength 471 days later on 12-9-83 = 9.18 curies
- o From Rad Health Handbook - 10 curie source reads 3.3R/hr/meter.
- o Using this conversion a 9.18 curie source reads 3.026 R/hr/meter.

This information was used to determine the approximate distance the detector would be placed from the source center. The inverse square formula was used for these distance estimates with:

I_1 = 3.026 R/hr R_1 = 1 meter I_2 = Desired reading R_2 = ?

The center of "a" condenser "R" chamber was placed at the center of R_2. The exposure time was based on the condenser "R" chambers range, requiring that the final exposure be near or above the mid point of the range. The exposure reading was then corrected for inherent error (as recommended by the mfg.), barometric conditions and temperature. This result is R_t.

Each detector was placed, in turn, at the R_t location and exposed. This result is R_r.

The final error determination is:

$$\% \text{ error} = \frac{R_t - R_r}{R_t} \times 100$$

The definition of precision applies only to the distance R_r is from the traceable standard R_t. Repeatability of measurements between the source and condenser R chamber and the source and detectors substantiates precision easily within $\pm$ 10%.

5.4.6 Response Time

Does not apply, but is the time in seconds stated for the specific decades in Section 5.4.3. The RC time constant would be that stated response time divided by 2.2.

5.4.7.1 Temperature

The detector temperature upper response = 200°C (392°F). This exceeds the ANSI criteria of 60°C. Logarithmic Radiation Monitor (LRM) temperature = 5 to 50°C and will be sufficient as the readout is in the Main Control Room that is habitable through all analyzed accidents.

5.4.7.2 Pressure

Detector operating pressure 250 psig or 12,925 torrs.

5.4.7.3 Humidity

Relative humidity range for the LRM is 20 to 98% (with no condensation). The chamber is not normally used where temperatures and humidity conditions are such that moisture cannot collect inside the connectors.

5.4.7.4 Other Environmental Effects

Manufacturers specifications were followed for installation and operation. Industry history substantiates durability and resistance to adverse environmental effects. The detector is in a shielded closed room and will not be exposed to corrosive elements.

5.4.7.5 Power Requirements

The power supply is from a stable and predictable source (RDS, Reactor Protection System).

5.4.7.6 Electrical Effects

Not applicable

5.4.7.7 Mechanical Effects

Not applicable

5.4.8 Radiation Alarm

Not applicable

5.4.9 Failure Alarm

A HV-INOP Trip Circuit is employed on this system. The circuit will indicate a trip condition whenever the LRM high voltage level becomes abnormally low or whenever the front panel mode selector switch is in any position other than operate.

5.4.10 Calibration

The system was calibrated agains (using) NBS traceable condenser "R" chambers. A Cs-137 source of sufficient strength was used (see above) to allow a quantative response for three different intensities. The system can be placed in any of four different test and calibration configurations (HiCAL, LOCAL, ZERO and TRIP TEST).

The detectors are inspected and verified in working condition at the time of receipt. System operation and readout adjustment is done at the time of radiological calibration. Trip functions are tentatively set at the time of radiological calibration and, as backgrounds warrant, are adjusted using calibrated electrical impulses. The trips are adjusted to comply with the WNP-2 Technical Specifications. No check sources are incorporated in this system.

OFF GAS PRE-TREATMENT RADIATION MONITOR CALIBRATION

Discussion

This monitoring system was radiologically re-calibrated on 6-22-84 to comply with ANSI 13.10 "American National Standard Specification and Performance of On-Site Instrumentation for Continuously Monitoring Radioactivity in Effluents". A previous radiological calibration was made on 11-23-83 with the results matched against the ELFS criterion. The 6-22-84 radiological calibration results are matched against a ± 20% relative error.

Method

Calibration was conducted per PPM 12.13.1, "Off Gas Pre-Treatment Radiation Monitor Calibration". A brief summary of the operation is as follows:

- Using an approximate 9.08 curie Cs-137 source (NBS Traceable AMERSHAM) NBS traceable condenser "R" chambers were exposed at distances approximating 100 mR/hr, 1000 mR/hr, 5000 mR/hr and 10,000 mR/hr.
- After completing the condenser "R" exposure the detector was placed in the same location, exposed and control room meter read.
- The control room meter is matched against the condenser "R" chamber results for ± 20% relative error accuracy.

Results

1) 100 mR/hr (.1 R/hr) exposure:

   - Condenser "R" reading = 18 mR/8 min = 135 mR/hr
   - Correction factor for condenser "R" chamber:

     C_T (Temp) = for 77.8°F (25.4°C) = 1.01
     C_B (Barometer) = for 29.63 in Hg = 1.03
     C_R (Condenser "R" chamber [Correction Factor Technique]) = 0.984

     $(C_T)(C_B)(C_R) = (1.01)(1.03)(0.984) = 1.02$

   - Actual condenser "R" reading = (1.02)(135 mR/hr) = 137.7 or 138 mR/hr
   - Control room meter reading = 120 mR/hr
   - Relative error:

$$\frac{138 \text{ mR/hr} - 120 \text{ mR/hr}}{138 \text{ mR/hr}} \times 100 = 13\%$$

2) 1000 mR/hr (1R/hr) exposure:

- o Condenser "R" reading = 110 mR/8 min = 825 mR/hr
- o Correction factor is the same as 100 mR/hr expsoure = 1.02
- o Actual condenser "R" reading = (1.02)(825 mR/hr) = 841.5 or 842 mR/hr
- o Control room meter reading = 800 mR/hr
- o Relative error:

$$\frac{842 \text{ mR/hr} - 800 \text{ mR/hr}}{842 \text{ mR/hr}} \times 100 = 5\%$$

3) 5000 mR/hr (5R/hr) exposure:

- o Condenser "R" reading = 950 mR/11 min = 5182 mR/hr
- o Correction factor is the same as 100 mR/hr expsoure - 1.02
- o Actual condenser "R" reading = (1.02)(5182 mR/hr) = 5286 mR/hr
- o Control room meter reading = 5000 mR/hr
- o Relative error:

$$\frac{5286 \text{ mR/hr} - 5000 \text{ mR/hr}}{5286 \text{ mR/hr}} \times 100 = 5\%$$

4) 10,000 mR/hr (10R/hr) exposure:

- o Condenser "R" reading = 1040 mR/8 min = 7800 mR/hr
- o Correction factor is the same as 100 mR/hr expsoure - 1.02
- o Actual condenser "R" reading = (1.02)(7800 mR/hr) = 7956 mR/hr
- o Control room meter reading = 7750 mR/hr
- o Relative error:

$$\frac{7956 \text{ mR/hr} - 7750 \text{ mR/hr}}{7956 \text{ mR/hr}} \times 100 = 5\%$$

Conclusion: All exposures are within $\pm$ 20% relative error.

Equipment

1) 100 mR/hr (.1 R/hr) exposure:

Thermometer	WPPSS #10158, Cal. Due Date 3-2-85, Case # 19158-02	
Barometer	WPPSS #32854, Cal. Due Date 8-3-84, Case # 31859-02	
Stopwatch	WPPSS #39192, Cal. Due Date 12-22-84, Case # 39192-02	

Condenser "R" Chamber 188-0.025R Cal. Due Date 10-14-84 # 12768

2) 1000 mR/hr (1 R/hr) exposure:

Thermometer, Barometer and Stopwatch = Same as 100 mR/hr exposure
Condenser "R" Chamber 130-0.25R Cal. Due Date 10-14-84 # 12750

3) 5000 mR/hr (5 R/hr) exposure:

Thermometer, Barometer and Stopwatch = Same as 100 mR/hr exposure
Condenser "R" Chamber 552-25R Cal. Due Date 10-14-84 # 12270

4) 10,000 mR/hr (10 R/hr) exposure:

Thermometer, Barometer and Stopwatch = Same as 100 mR/hr exposure
Condenser "R" Chamber 552-2.5R Cal. Due Date 10-14-84 # 12270

Monitor Information

o Monitor/Detector Serial Number: Type NA05
Cat# 237X7316001
Serial# TNNKG-029

o Control Room Module H13-604

o Background Before Calibration 0 mR/hr
Background After Calibration 0 mR/hr

High Voltage 240 volts

ANSI 13.10 (Section 5.4)

MAIN STEAM LINE MONITOR

System Description

The objective of the Main Steam Line Radiation Monitoring System is to monitor for gross release of fission products from the fuel passing through the main steam lines from the reactor to the high pressure turbine. Upon detection of a gross release of fission products from the fuel, this monitoring system initiates a prompt scram and isolation of the reactor.

Four gamma sensitive ion chambers monitor the gross gamma radiation from the main steam lines. The detectors are physically located near the main steam lines just downstream of the outboard main steam line isolation valves in the steam tunnel. The detectors are geometrically arranged so that the system is capable of detecting significant increases in radiation level for any number of steam lines.

5.4.1 Detection Capability

Does not apply to this system. The gamma sensitive ion chamber is used for detecting gamma flux level. The chamber yeilds a direct current proportional to the gamma radiation level in which it operates. Ionization chambers were chosen for these monitors as they will respond to mixed fission products and N-16 gammas.

5.4.1.1 Detection in Gaseous Streams

Does not apply (see 5.4.1 explanation).

5.4.1.2 Detection in Liquid Streams

Does not apply (see 5.4.1 explanation).

5.4.2 Range

The instrument range is from 10^0 mR/hr to 10^6 mR/hr in 6 (six) evenly spaced decades. The input current range is from 3.33×10^{-13} to 3.33×10^{-7} ampers. The range of the instrument provides two decades of reading above the alarm setpoint that shuts off all steam flow. As these monitors are only required to read to three times background at 100% power, the range of the instruments are sufficient.

5.4.3 Sensitivity

For a gamma responding system that reads out in mR/hr the "Response Time" is the characteristic used for sensitivity. The following is the system response times:

6 sec (3.33×10^{-13} to 3.33×10^{-12} amp)
1 sec (3.33×10^{-12} to 3.33×10^{-11} amp)
1 sec (3.33×10^{-13} to 3.33×10^{-7} amp)

For specific radiation levels, the conversion to ampers can be made by multiplying the radiation level by the chamber sensitivity (the normal sensitivity is 3.7×10^{-10} ampers/R/hr). The ranges stated above can be determined in mr/hr/R/hr by the same method. The RC time constant for the various decades can be found by dividing the response time by 2.2.

5.4.4 Accuracy

Each detector was subjected to a 9.17 curie NBS Traceable Cs-137 source at approximate gamma levels of 100 mR/hr, 1R/hr, 5R/hr. An NBS traceable calibrated set of condenser "R" chambers was used as the reference standard for determining R_t (true quantity) in the percent error equation. The following are the results of that determination.

Monitor Number	R_t Condenser "R" Reading (Correct E)	R_r System Reading	Percent Error
3C-TWV-52-026	100 mR/hr	86 mR/hr	14%
	930 mR/hr	1012 mR/hr	12%
	4800 mR/hr	4587 mR/hr	5%
3B-TWV-52-030	88 mR/hr	95 mR/hr	-8%
	927 mR/hr	824 mR/hr	11%
	4625 mR/hr	4000 mR/hr	14%
3A-TWV-52-025	97 mR/hr	100 mR/hr	3%
	950 mR/hr	900 mR/hr	6%
	4900 mR/hr	4250 mR/hr	13%
3D-TNNK6-001	95 mR/hr	100 mR/hr	6%
	940 mR/hr	910 mR/hr	3%
	4400 mR/hr	4300 mR/hr	2%

The above was determined using:

$$\text{percent error} = \frac{R_t - R_r}{R_t} \times 100$$

5.4.5 Precision

The system used is as follows:

1) Based on the source strength (total curies) and the conversion to R/hr exposures were made to estimate distances. The specific source was an Amerisham - Cs-137 source of 9.45 curies.

   - o Source strength at factory = 9.45 curies
   - o Source strength 471 days later on 12-9-83 = 9.18 curies
   - o From Rad Health Handbook - 10 curie source reads 3.3R/hr/meter.
   - o Using this conversion a 9.18 curie source reads 3.026 R/hr/meter.

   This information was used to determine the approximate distance the detector would be placed from the source center. The inverse square formula was used for these distance estimates with:

   I_1 = 3.026 R/hr R_1 = 1 meter I_2 = Desired reading R_2 = ?

   The center of "a" condenser "R" chamber was placed at the center of R_2. The exposure time was based on the condenser "R" chamber's range, requiring that the final exposure be above the mid point of the range. The exposure reading was then corrected for inherent error (as recommended by the mfg.), barometric conditions and temperature. This result is R_t.

   Each detector was placed, in turn, at the R_t location and exposed. This result is R_r.

   The final error determination is:

   $$\% \text{ error} = \frac{R_t - R_r}{R_t} \times 100$$

   The definition of precision applies only to the distance R_r is from the traceable standard R_t.

5.4.6 Response Time

Does not apply, but is the time in seconds stated for the specific decades in Section 5.4.3. The RC time constant would be that stated response time divided by 2.2.

5.4.7.1 Temperature

The detector temperature upper response = 200°C (392°F). This exceeds the ANSI criterion of 60°C. Logarithmic Radiation Monitor (LRM) temperature = 5 to 50°C and will be sufficient as the readout is in the Main Control Room that is habitable through all analyzed accidents.

5.4.7.2 Pressure

Detector operating pressure 250 psig or 12,925 torrs.

5.4.7.3 Humidity

Relative humidity range for the LRM is 20 to 98% (with no condensation). The chamber is not normally used where temperatures and humidity conditions are such that moisture cannot collect inside the connectors.

5.4.7.4 Other Environmental Effects

Manufacturers specifications were followed for installation and operation. Industry history substantiates durability and resistance to adverse environmental effects.

5.4.7.5 Power Requirements

The power supply is from a stable and predictable source (RDS, Reactor Protection System). In the event this power source is interrupted the one out of 2 taken twice logic initiates a "C" signal that prompts MSIV closure and reactor isolation.

5.4.7.6 Electrical Effects

Not applicable

5.4.7.7 Mechanical Effects

Not applicable

5.4.8 Radiation Alarm

Not applicable

5.4.9 Failure Alarm

A HV-INOP Trip Circuit is employed on this system. The circuit will indicate a trip condition whenever the LRM high voltage level becomes abnormally low or whenever the front panel mode selector switch is in any position other than operate.

5.4.10 Calibration

The system was calibrated agains (using) NBS traceable condenser "R" chambers. A Cs-137 source of sufficient strength was used (see above) to allow a quantative response for three different intensities. The system can be placed in any of four different test and calibration configurations (HiCAL, LOCAL, ZERO and TRIP TEST).

A secondary source is not used for the MSL monitors calibrations and placement of the Cs-137 source is controlled by measured placement of the detector in the same configuration as the Condenser "R" chamber. This was more elaborately explained in 5.4.5, Precision, above.

The detectors are inspected and verified in working condition at time of receipt. System operation and readout adjustment is done at the time of radiological calibration. Trip functions are tentatively set at the time of radiological calibration and will be adjusted as backgrounds dictate, using calibrated electrical impulses as required by the WNP-2 Technical Specifications. No check sources are incorporated in this system.

ANSI 13.10 REVIEW

Primary Containment Air Monitoring Systems

EPN

Sample Rack	Detectors	Ratemeter	Recorder
CMS-SR-20	CMS-RE-12-1A CMS-RE-12-3A	CMS-RIS-12-1A CMS-RIS-12-3A	CMS-RR-12A CMS-RR-12A
CMS-SR-21	CMS-RE-12-1B CMS-RE-12-3B	CMS-RIS-12-1B CMS-RIS-12-3B	CMS-RR-12B CMS-RR-12B

General Discription

The Primary Containment Air Monitoring system consists of two redundant subsystems, one to measure particulates (1A and 1B), and one to measure noble gases (3A and 3B). Additionally, there is a charcoal cartridge in each subsystem to trap the halogens. These systems are used to monitor the concentration of noble gases and airborne particulates in the primary containment atmosphere during normal and most abnormal operating conditions but not accident conditions. The concentration can be related to the leak rate of primary coolant into the drywell. The major contributors to the activity are the noble gases, daughters of noble gases, activated corrosion products, and fission products.

The sample for each sample rack is withdrawn form the drywell at the 536' elevation. The 1 inch sample lines are equipped with isolation valves which are located in the drywell and are heat traced. CMS-SR-20 obtains its sample near the containment wall at an azimuth of 195°. CMS-SR-21 obtains its sample at an azimuth of 45°. The isolation valves can be manually opened or closed from the control room at the rate meter. These isolation valves will automatically close and the sample pump will trip to off on a "F" signal (high drywell pressure greater than 2.0 psi) or an "A" signal (low reactor water level). All trips and alarms must be manually reset before the monitors can be restored to operation. The flow through the sampling system is controlled manually by adjusting the bypass flow through the vacuum pump. The sample racks are located in separate rooms that are insulated and cooled to assure an environment that is acceptable for instrument operation after an accident.

At the sample rack, the sample passes through a particulate monitor, a charcoal cartridge, a noble gas monitor, a flow meter a vacuum pump and back to the drywell. There is also a sample pressure sensor in the sample rack that closes valves in the sample line and shuts off the vacuum pump and heat trace. This is separate from the isolation valving at the drywell.

The particulate monitors consists of a beta detector viewing moving tape filter in a 3 inch thick 4π lead shield. The beta detector is identical to the ones used in the low range noble gas monitors and is described below. The moving tape filter is a 2.5 inch wide fiberglass backed cellulose filter. The filter tape speed can be set at 0.5, 1 or 2 inches per hour or manually stepped in 3 inch increments. Normally the speed is set at 1/2 inch per hour.

The noble gas monitor consists a sample chamber containing a beta detector. The sample, chamber which contains 2.2 liters of sample and the detector, is 4π shielded with 3 inches of lead. The flow indicator is a 0-6 SCFM rotameter with low flow detection/alarm capabilities. Normally the flow is adjusted to 4 cfm. The vacuum pump is a metal bellows type.

Each detector is a 2 inch diameter by 30 mil thick NE 102 plastic scintillator optically coupled to a photo-multipler tube and followed by a preamplifier. The signal is sent to a 6 decade (10 to 10^7 cpm) log ratemeter which is located in the main control room. The ratemeter provides power to the detector, displays the counting rate, and provides alarm functions. The ratemeter has three internal calibration points and provisions to input a calibrated signal. An alarm test function is also provided.

A 1 μCi Cl-36 check source is provided at the detector for the noble gas monitors and a LED is provided at the detectors for the particulate monitors to check the overall system response. Both are actuated from the control room.

Recorders that continuously record the counting rates are provided in the main control room. The counting rate is also inputted to TDAS.

The CMS monitors are Seismic I, except for the detectors, and Quality Class I qualified. However, they provide no control function and are not required to operate during or after an accident. However, per FSAR Section 11.5.1.2.2 the CMS air monitors are to meet the criteria in FSAR Section 11.5.1.2.1 except item g. Comparison of the Primary Containment Air Monitoring Systems (CMS-RIS-12-1A and 1B CMS-RIS-12-3A and 3B) to ANSI 13.10 "Standards of Performance".

5.4.1 Detection Capabilities

The Primary Containment Air Monitoring System consists of the redundant subsystems, one to measure particulates (1A and 1B), and one to measure noble gases (3A and 3B). Additionally, there is a charcoal cartridge in each subsystem to trap the halogens. These systems are used to monitor the concentration of noble gases and airborne particulates in the primary containment atmosphere during normal and most abnormal operating conditions but not accident conditions. The concentration can be related to the leak rate of primary coolant into the drywell. The major contributors to the activity are expected to be noble gases, daughters of noble gases, activated corrosion products, and fission products.

The sample for each subsystem is drawn from the drywell at the 536 foot level. The sample lines are 1 inch and are equipped with isolation valves at the drywell wall and also at the sample rack. These sample lines are heat traced. Typically, the flow rate through each subsystem is 4.0 cfm.

The four detectors are identical to each other and also to the detectors in all of the low range noble gas monitors. The detectors consist of a 2 inch by 30 mil thick NE 102 scintillator optically coupled to a PM tube and followed by a preamp. The noble gas detector is immersed in a chamber containing 2.2 liters of sample. The particulate detector views a moving tape filter. The detectors and sample chamber or filter tape is shielded by a 4 π 3 inch thick lead shield. This type and thickness of scintillator maximizes the response to beta radiation while minimizing the response to gamma radiation.

Since the containments air monitors are not effluent monitors, some of the requirements in ANSI 13.10 are not strictly applicable. Specifically, the minimum detection levels given in ANSI 13.10, Table I and the required range of 10^4 MDL is not applicable.

5.4.1.1 Detection in Gaseous Streams

The typical backgound count rate due to the expected concentrations of airborne activity in the drywell is not adequately defined at this time and must be based on experience. The follwoing provides the MDA and LLD based on the background observed at the time of calibration. The background, at least for particulate monitors, is expected to increase to a much higher count rate as fuel burn up increase and the leak rate approaches the limiting rate.

The CMS airborne monitors employe a shielded detector system to reduce the effect of ambient radiation levels and results in a low detection level. The LLD for these monitors was determined using the Technical Specification definition. The MDA's were determined using the method typically used in the industry and by the ANSI 13.10 method using the RC time constant. The LLD and the MDA's are expressed at the 95% confidence level. The time constant, per vendor specification, is 12 seconds on the first decade and 3.5 seconds on the second decade.

Detector	Background (cpm)	Calibration Factor	Tech Spec LLD = $4.66\sqrt{Bkg}$	Typical MDA = $1.96\sqrt{Bkg}$	ANSI 13.10 MDA = $1.96\sqrt{\frac{Bkg}{2RC}}$
12-1A	27	4.17E5[1]	24 cpm 5.7E-5 uCi[3] 2.8E-12 uCi/cc[4]	10 cpm 2.4E-5 uCi 1.2E-12 uCi/cc	16 cpm 3.8E-5 uCi 1.9E-12 uCi/cc
12-1B	42	5.83E5[1]	30 cpm 5.1E-5 uCi[3] 2.5E-12 uCi/cc[4]	13 cpm 2.2E-5 uCi 1.1E-12 uCi/cc	20 cpm 3.4E-5 uCi 1.7E-12 uCi/cc
12-3A	9	7.86E7[2]	14 cpm 1.8E-7 uCi/cc	6 cpm 7.6E-8 uCi/cc	9 cpm 1.1E-7 uCi/cc
12-3B	110	7.86E7[2]	49 cpm 6.2E-7 uCi/cc	21 cpm 2.7E-7 uCi/cc	61 cpm 7/8E-7 uCi/cc

1. cpm/ uCi of Cs-137 on the filter.

2. 7.864E7 cpm/ uCi/cc is the efficiency provided by vendor for Kr-85 in the 10^4 cpm range. Field calibration indicates 12-3A reads 6% lower and 12-3B reads 1% higher.

3. Detectable activity on filter paper, i.e. $\frac{\text{LLD}}{\text{Calib. Factor}}$.

4. This is the concentration that will deposit the detectable activity on the filter in 4 hours at 3.0 cfm.

5.4.1.2 Detection in Liquid Streams

Not applicable.

5.4.2 Range

The required range per ANSI 13.10 should be 10^4 MDA's is calculated by multiplying the MDA'a given in Section 5.4.1.1 by 10^4. The resulting values should be within the detector range 10 to 10^7 cpm.

Detector	Tech Spec LLD	Typical MDA	ANSI 13.10 MDA
12-1A	2.5E5	1.0E5	1.6E5
12-1B	3.0E5	1.3E5	2.0E5
12-3A	1.4E5	6E4	9E4
12-3B	4.9E5	2.1E5	6.1E5

5.4.3 Sensitivity

The sensitivity ($Ns = 1.96 \sqrt{\frac{Bkg}{2RC}}$) was calculated in section 5.4.1.1. The time constants used were 12 seconds for the first decade and 3.5 seconds for the second decade.

5.4.4 Accuracy

For the two particulate monitors, a primary calibration was made. This calibration establishes the ratio of the transfer standard to the standard source used in actual counting geometry. The error in the primary source at the 95% Cl is $\pm$ 6%. The error associated with the counting rate of the transfer standard and the primary standard, based on two 5 minute counts of each source, is as follows:

12-1A

Transfer Source Net cpm	Primary Source Net cpm
81915	45453
81655	45293
$\bar{X} = 81785$	$\bar{X} = 45373$
$\sigma = \pm 130$	$\sigma = \pm 80$
$\frac{1.96\sigma}{\bar{X}} = 0.3\%$	$\frac{1.96\sigma}{\bar{X}} = 0.3\%$

The summing the errors to get the total error:

$$\text{Total error} = \sqrt{(6)^2 + (0.3)^2 + (0.3)^2} = \pm 6\%$$

12-1B

Transfer Source Net cpm	Primary Source Net cpm
84076	63473
83383	63603
$\bar{X}$ = 83729	$\bar{X}$ = 63539
$\sigma = \pm 346$	$\sigma = \pm 66$
$\frac{1.96\sigma}{\bar{X}} = 0.8\%$	$\frac{1.96\sigma}{\bar{X}}$ 0.2%

$$\text{Total error} = \sqrt{(6)^2 + (.8)^2 + (0.2)^2} = \pm 6\%$$

The $\bar{X}$ for the transfer source will be used at Rt in subsequent calibrations.

For the two noble gas monitors, the accuracy was calculated using the formula

$$\% \text{ error} = \frac{(R_t - R_r)}{R_t} (100)$$

R_t = counting rate of the transfer standard established by the vendor at the time of primary calibration = 9.83E5 cpm/ uCi.

R_r = counting rate of the transfer standard when filed calibrated in cpm/ uCi.

12-3A

$$\% \text{ error} = \frac{9.83E5 - 9.25E5}{9.83E5} = 6\%$$

12-3B

$$\% \text{ error} = \frac{9.83E5 - 9.92E5}{9.83E5} = 0.9\%$$

5.4.5 Precision

For the two particulate monitor the precision can be determined from the two 5 minute counts of the transfer standard.

12-1A

From Section 5.4.4, $\bar{X}$ = 81785 cpm and σ = 130 cpm.

1.96σ = 255 cpm which is less than 10% of $\bar{X}$.

From Section 5.4.4 $\overline{X}$ = 83729 cpm and σ = 346 cpm.

1.96σ = 678 cpm which is less than 10% of $\overline{X}$.

Since the detectors, countrate meter, etc., are identical, the precision for the two noble gas monitors will be about the same magnitude.

5.4.6 Response Time

Not all of the CMS air monitors maintain background readings within the required accuracy for effluent monitors. However, these monitors do not monitor effluents.

5.4.7.1 Temperature

The ratemeter, recorder, and power supply are located in the main control room. The control room is designed for human habitability under normal and analyzed abnormal conditions. The temperature in the control room will not exceed 104°F.

The sample racks are located in rooms which are insulated and cooled to assure an environment that is acceptable for the operation of these instruments.

Ratemeter - Per ventor specification, ± 5% change over a temperature range of 0 - 60°C (0-140°F).

Recorder - Per vendor specification, the normal operating range is 4 - 49°C (40 - 120°F). The operating limit is -18 - 60°C (0-140°F). The temperature effect is ~ 0.2% of span for 40°F to 120°F.

Power Supply (for Recorder) - Per vendor specifications operating range and limits are the same as for the recorder. The temperature effects are DC ± 0.5% and AC ± 1% for a ± 40°F based on 80°F midpoint operating range.

Detector - Per vendor specifications the normal operating temperature is 0 - 60°C (32-140°F). The effect on the calibration is not defined. The sample line is heat traced to 135°F.

Blower/Motor/Rotameter - The range of temperatures will have minimal effect if any. The rotameter calibration changes with the density of air.

5.4.7.2 Pressure

Except for the sample chambers and detectors, the components are open to room atmosphere. The vacuum in the drywell plus the vacuum head resulting from drawing the sample is seen across the detector. This negative pressure drop is within the acceptable range. Upon positive pressure, the sample racks are isolated.

5.4.7.3 Humidity

Detector (scintillator/preamp) - Vendor gives no operating specifications. Since storage in a humidity range 0-95% is approved by the vendor, operation in this range of humidities should be permissible. The calibration and accuracy will not affected.

Other components at skid - The motor, blower, flow meter etc. should not be affected by humidity.

Ratemeters/Recorders - No effect expected on the ratemeters or recorders because of the controlled atmosphere in the Control Room.

5.4.7.4 Other Environmental Effects

There are no anticipated environmental conditions that will cause a significant effect on these monitors.

5.4.7.5 Power

The detector including preamps, ratemeters, and recorders are powered from instument power buses in the control room. This power supply is stabilized and variations of 15% will not be seen.

Per Kaman specs: for the ratemeter 90 - 130 VAC, 50-60 Hz is acceptable. Kaman spec for the recorder power supply and recorder indicate that the recorder would easily meet a -10% + 5% variation in power supply.

Motors/blowers - no significant effect.

5.4.7.6 Electrical Effects

This has been a problem. Kaman instrumentation specs indicate that the power supply for the recorders are sensitive to RF. Experience indicates that the system is sensitive to RF generated at either the sample rack or the ratemeter location. The use of radios is being controlled administratively to eliminate this problem.

5.4.7.7 Mechanical Effects

Except for the detectors, the CMS air sampling systems are Seismic Class I. The detectors are identical to detectors that have been qualified. Therefore, this requirement is met.

5.4.8 Radiation Alarm

The ratemeters are equipped with two upscale alarms (Hi and Hi Hi) which can be set at any point over the range of the instrument. These alarms are latching type and must be manually reset. The alarms illuminate a light at the ratemeter and open a solenoid which causes a trouble light on an annunciator panel to illuminate and a buzzer to sound. The alarms are reset and the setpoint of each alarm can be checked from the face of each count ratemeter.

The Hi and Hi Hi alarm points can be adjusted at the meter face. The low high voltage alarm and the downscale alarm setpoints are adjusted internally but the instrument does not have to be removed from service to adjust them.

5.4.9 Failure Alarm

The ratemeter provides a latching alarm in case of power failure, HV below the HVINOP setpoint, or counting rate below a setpoint value.

5.4.10 Calibration

A. Particulate Monitors

a) The primary calibration of the particulate monitors was performed on site by counting a NBS traceable Cs-137 beta source in the filter chamber.

b) A transfer standard source (Sr-90) and three linearity sources (also Sr-90) which are also NBS traceable were counted. These sources were precisely and reproducibily positioned under the detector using a vendor furnished "calibrator" calibration jig. The linearity sources are used to determine response vs. activity.

The response vs. beta energy was investigated using a Pm-147, a Tc-99, a Cl-36, and a Sr-90 source.

c) The surface area of the transfer standard is not the same as surface area of the detector window. The transfer standard source and the linearity sources are about 1 inch in diameter. The detector to source geometry in the calibrator is precisely maintained and is reproducable. The transfer standard count will be used as the basis of subsequent period calibrations.

d) DOP testing - An exception was taken to the ANSI 13.10 criteria in the December 8, 1983 memo.

e) The flow rate measuring devices were calibrated 9/83.

f) The particulate monitors have a LED at the detector to check the overall response of the system. The noble gas monitors have a 1 uCi Cl-36 check source. Both of these devices are activated from the ratemeter.

g) Calibrated electronic signals are provided by the ratemeter and externally generated signals can be inputted at the ratemeter.

B. Noble Gas Monitor

a) NBS Traceable - Three each of ^{133}Xe and ^{85}Kr NBS certified gases were used in the primary calibrations. The gases were introduced into the known volume standard Kaman gas chambers. The detectors used were "generic" Kaman beta scintillator units. The counting and analysis, carried out on the WNP-1 digital system, was completed and entered onto claibration report sheets. This report was forwarded to WNP-2 as part of the equipment package. The total calibration errors, including NBS gas calibration errors, ranged from 9.7%, a low activity sample, to 1.6%, a high activity sample at the 95% confidence level.

b) Transfer Calibration Sources - Disk sources of ^{90}Sr were used at the same time as the above mentioned gas calibration. A response factor was developed relating ^{90}Sr to Kr^{45}. A further study of 25 different detectors response to the primary and secondary ^{90}Sr transfer sources indicated the true "generic" quality of the detectors. A mean error of 2.6% and 4.3% respectively at the 95% confidence level indicates a very good group. Further, the response to Kaman's standard and WNP-1's secondary transfer sources were within 0.6% at 95% C.L. These secondary sources were and are periodically analyzed on beta detectors which are calibrated with NBS and NBS traceable sources.

c) Constant Geometry - The vendor, Kaman, has a shielded portable constant geometry rack (field calibrator). Demonstrated reproducability of source placement is within $\pm$0.3%.

d) DOP Testing - There is no anticipated problem of noble gas and sample lines. DOP testing not required and an exception was taken to the ANSI 13.10 criteria in the December 8, 1983, memo.

e) Flow Rate Devices - Each sample skid has a rotometer that ranges from 0 to 6 cfm, a measureable range of 0.5 to 5.5 is repeatable to within 20% at any reading.

Coupled to flow rate measurement is the pressure measurement on each monitor skid. Each skid is provided with a vacuum gauge that reads from 0 to 30 inches at $\pm$ 2% of reading according to the vendor.

f) Check Source - Each unit has a solenoid activated check source composed of ^{36}Cl. These solenoids are activated at the RIS module in the control room.

g) Electronic Calibration Signals - Each RIS module has 1) an internal oscillator which allows a sweep across the output range for alarm test and 2) a calibration signal input (pulse) for accurately establishing the setpoints.

Attachment 10

ANSI 13.10 COMPARISONS

Intermediate Range Monitors

REA-RIS-19A
TEA-RIS-13A
WEA-RIS-14A

5.4.1 Detection Capabilities

The monitors in this report are an offline noble gas detection unit. These monitors are intended to extend the range of the normal range monitors. This is accomplished by a switching valve which is activated as long as a Hi Hi trip is indicated on the low range monitor. The normal sample flow is then allowed to be sensed by these monitors. The units have a modified beta scintillator, the coupling between the beta scintillating plastic and the photomultiplier tube is decreased. It also allows for further sensitivity refinement by altering the high voltage operating point. To ensure only noble gases are detected, particulate filters and charcoal cartridges are placed ahead of the detector. The detector senses the radiation and returns a current signal to the RIS module. The sampled gas is routed to the normal monitoring system exhaust port.

5.4.1.1 Detection in Gaseous Streams

These monitors, when placed on line, will continuously monitor a sample of the effluent stream. Their purpose is to extend the range of gaseous activity to assure continuous monitoring during an accident situation will occur. The MDL used in the following table will be upper range of the low range monitor. See Table 1 for a summary of system parameters.

5.4.1.2 Not applicable

5.4.2 Range

The range requirement is exceeded; see Table 2.

5.4.3 Sensitivity

The sensitivity is noted as uCi/ml in Column 7, Table 1, also in Table 2.

ANSI 13.10 Comparison: Table 1

Detector	Isotope	Background (Installed) PMU (1) OMA (2) Sb pmu (3) Sb oma (4)	Calibration factor (2), CF PMU/uCi/ml (1) OMA/Log(uCi/cc) (2)	Detection Limits in uCi/ml Tech. Spec. $LLD = \frac{4.66\ Sb}{Cf}$	Normal $MDA = \frac{1.96\ Sb}{Cf}$	ANSI 13.10 $MDA = \frac{1.96\ Ns}{Cf}$	Long Range Monitor Upper Limit uCi/cc
REA-RIS-19A	^{133}Xe	1 (0.714) 0.892 1 (3.69E-3) .00181	144.2 (1) 1.11374 (2)	6.93E-3 uCi/cc 1.79E-3 uCi/cc	6.93E-3 uCi/cc 1.77E-3 uCi/cc	(4)	0.28
TEA-RIS-13A	^{133}Xe	1 (0.622) 0.745 1 (0.0584) 0.034	102.5 (1) 1.25007 (2)	9.76E-3 uCi/cc 7.14E-3 uCi/cc	9.76E-3 uCi/cc 5.48E-3 uCi/cc	(4)	0.23
WEA-RIS-14A	^{133}Xe	1 (0.751) 0.735 1 (4.98E-3) 0.00247	106.7 (1) 1.12843 (2)	9.37E-3 uCi/cc 1.23E-3 uCi/cc	9.37E-3 uCi/cc 1.21E-3 uCi/cc	(4)	0.23

Notes:
1. PMU means panel meter units.
2. The calibration factor for PMU/uCi/cc is calculated for 1 uCi/cc. The calibration factor for OMA, which is now measured in volts, is the slope of the semilog plot; the intercept must also be used.
3. The lowest scale reading on the panel meter is 1, this is used for the MDA, LLD limit.
4. The electronics is not a pulse system. The MDS results in the normal column will apply.

5.4.4 Accuracy

The systems described in this report were calibrated with ^{133}Xe gas. The gas was introduced into the system, circulated until no activity or voltage changes were apparent. Two gas samples were removed and analyzed on a HPGe system with an ND6620 analyzer. This was repeated for each level of ^{133}Xe gas level. See the individual reports for primary calibration errors. The calibration procedure requires instrument to meet the $\pm$ 20 percent accuracy as defined by $(R_R - R_T) \times 100/R_T$. Recorder accuracy is $\pm$ 1% of span.

5.4.5 Precision

The precision of this instrument is stated to the $\pm$ 20 percent on all ranges by the vendor. The precision indicated in Table 2 is that of a series of solid source activations, the data indicates the $\pm$ 20 percent error can be bettered.

5.4.6 Response Time

These monitors are used to indicate accident situations and have no control functions. The response time is constant for all ranges; it is two seconds.

5.4.7 Temperature

The RIS module, low voltage power supply and recorder are located in the Main Control Room. The Control Room is designed to be habitable under normal conditions; see Technical Specification 3/4.7.2, an 85°F (29.4°C) limit. The FSAR limit is 104°F (40°C). For the allowable temperature range, calibration drift would be very small and is typically ignored.

5.4.7.1 Temperature

The detector module, which houses the high voltage supply utilizes temperature compensating components. The overall range at the unit is from -20°C to 50°C. The recorder has a normal range from 15 to 40°C, extreme range fro -9 to 50°C without loss of accuracy.

5.4.7.2 Pressure

The vendor pressurized the system for 10 minutes at 5 PSI, no pressure loss was indicated. During calibration a vacuum test was made. The systems were able to hold a 10 inch mercury vacuum.

5.4.7.3 Humidity

No statement by vendor about the humidity range for operation. However, moisture condensing out inside the detector will cause circuit board damage. The recorder humidity range is from 0 to 90% relative humidity.

ANSI 13.10 Comparison: Table 2

Monitor	Range	Sensitivity	Accuracy	Precision
	(1) Meter Scale (2) Voltage Output (3) ^{133}Xe (meter)uCi/cc (4) ^{133}Xe (voltage)uCi/cc	$N_5 = 1.96 \ (N_b/2\ RC)^{1/2}$ (1) uCi/cc MDA to MDA x 10^4 Yes or No	$\frac{R_R - R_T}{R_T} \cdot 100\%$ Primary Cal = N/A	$\overline{X}_n$ n = number of determinations $\pm$ % error at 1 σ
REA-RIS-19A	1 to 10^5 (1) 0.714 to 5.0 (2) 6.93E-3 to 9.63E+2 (3) 1.77E-3 to 3.16E+2 (4)	6.80E-3 at 1 PMU 9.49E-4 (volt) 10^4 Range Yes	N/A	$\overline{X}_3 \pm 0.21\%$
TEA-RIS-13A	1 to 10^5 (1) 0.622 to 5.0 (2) 6.76E-3 to 9.76E+2 (3) 7.14E-4 to 8.06E+2 (4)	9.56E-3 at 1 PMU 7.62E-4 (volt) 10^4 Range Yes	N/A	$\overline{X}_4 \pm 0.45\%$
WEA-RIS-14A	1 to 10^5 (1) 0.745 to 5.0 (2) 9.37E-3 to 9.37E+2 (3) 1.23E-3 to 5.24E+2 (4)	9.18E-3 at 1 PMU 1.36E-3 (volt) 10^4 Range Yes	N/A	$\overline{X}_4 \pm 0.11\%$

Note 1: This module does not meet the normal description for the units used in the sensitivity equation.

5.4.7.4 Corrosive Atmosphere

No specification and no corrosive atmospheric conditions are expected.

5.4.7.5 Power Requirements

The detector and associated electronics in the detector casing derive their power from the ratemeter module. The ratemeter module requires 115 VAC, 60 cycle, 15 watts maximum. No specification about the range of voltages was made.

The recorder power requirements are 120V (107 to 127), 50/60 Hz.

5.4.7.6 Electrical Effects

RIS module was not tested due to ban of radios in the Control Room at the time of calibration. Vendor states "the instrument will not respond to stray electromagnetic or electrostatic fields such as generated by a diesel engine or an electric overhead crane". No statement made about effect of RFI on the recorders was found.

5.4.7.7 Mechanical Effects

The intermediate range noble gas monitors were designed for seismic category II qualification.

5.4.8 Radiation Alarms

The ratemeter is equipped with two upscale alarms which can be set at any point over the range of the instrument. The circuitry latches the alarm even though the detector input may have returned to normal; the alarms must be manually reset. There are two alarm lights on each module. There are no additional off board alarms.

There is an alarm test circuit that ramps the RIS in order to check the alarm trip points. Alarm trip points may also be checked by depressing the appropriate alarm reset pushbutton and holding.

5.4.9 Failure Indicators

A downscale or H.V. failure light (INOP) is on each RIS module which illuminates when tripped. A signal will be sent to Board S, Ann Panel P851-S1 to illuminate a BD-RAD-24 trouble light and a buzzer will sound. The failure indicator must be manually cleared.

5.4.10 Calibration

a. Primary calibration consisted of introducing ^{133}Xe gas into the detector chamber via a gas rack, then pumping the gas through the closed loop. Upon the count stabilization, two samples were withdrawn by use of inline 100 cc gas vials. This was done for three points in order to develop a calibration curve. The samples were then analyzed on a HPGe detector and ND6620 gamma analyzer. The gamma analyzer and detectors have been calibrated with NBS traceable gas samples provided for by an outside laboratory. Additional calibration was done by utilizing liquid sources in the same geometry and comparing aliquots of the liquid solution directly with NBS certified sources. The two calibrations are within a five percent error. The individual gas samples were analyzed for a time to attain 50,000 counts or better in the ^{133}Xe 81 Kev peak; thus counting statistics would become an unimportant error.

b. The transfer calibration sources are ^{137}Cs sources fabricated in-house. Their activities were determined directly against the ^{137}Cs NBS reference standard utilizing the high resolution gamma analyzer system. The set of transfer/linearity sources includes one NBS reference standard ^{137}Cs.

c. The transfer and linearity sources are positioned on the face of the detector and centered. Source repositioning has been reproducable to better than 0.3%.

d. DOP Testing

There is no anticipated problem with noble gases and sample lines. DOP testing is not required.

e. The flow rate monitor is an air velocity monitor. It is rated at 2% accuracy of full scale. The flow range is from 0 inches to 8 inches of water. This unit acquires the noble gas sample from the low range noble gas detector. When switched, the flow meter on the WEA can be used and the flow controllers on the REA and TEA system can be used. The flow meter on the off skid locations are accurate to $\pm$ 10% of its reading.

f. Check Sources

This unit does not have a radioactive check source. Instead it utilizes a pulsed LED from an oscillator circuit housed in the detector assembly. The oscillator is controlled from the RIS module in the Control Room.

g. Electronic Calibration

Same as f above. The oscillator can be controlled by a front panel switch on the RIS module to calibrate the panel meter and the 4-20 ma output signals.

Attachment 11

ANSI 13.10 (SECTION 5.4)

REACTOR BUILDING EXHAUST PLENUM RADIATION MONITORING SYSTEM

SYSTEM OBJECTIVE

The objective of this monitoring system is to monitor the concentration of radioactivity in the reactor building ventilation system exhaust duct prior to its discharge from the building. To initiate appropriate action in the event pre-determined activity levels are exceeded.

SYSTEM DESCRIPTION

The system consists of 4 seperate monitoring channels, each with:

- a GM detector
- Indicator and trip unit
- Recorders, with channel A&C and B&D sharing a recorder respectively

The indicator and trip unit is arranged in a one-out-of-two logic with:

- Radiation High High (RAHH) trip in channels A or C causing standby gas treatment train "A" to start and the outboard primary containment vent and purge valves to close (if open) - and - the outboard reactor building ventilation valves to close (if open).
- RAHH in either channel B or D will cause standby gas treatment train "B" to start and the inboard valves as mentioned above to close.

There are sources (bugs) installed at the sensor (approximately 0.2 uci Sr^{90}) to provide a small upscale reading (live zero).

The following are the control room panels where the meters (readouts) are located:

REA-RIS-609A (Channel "A"); Panel H13-P606

REA-RIS-609C (Channel "C"); Panel H13-P606

REA-RIS-609B (Channel "B"); Panel H13-P633

REA-RIS-609D (Channel "D"); Panel H13-P633

5.4.1 Detection Capability

Included in a seperate packet is the $\overline{E}$ calculation for the plenum monitoring system. The summary on Page 1 of the packet substantiates that Cs-137 is the correct isotope for calibration as the energy from accident initiation and the preceeding hour is almost identical to the Cs-137 gamma energy, .669 mev vs. .661 mev respectively.

5.4.1.1 Detection In Gaseous Steams

This monitoring system monitors the reactor building final effluent stream for the purpose of initiating a signal (when tripped) that isolates secondary containment and starts standby gas (see "SYSTEMS DESCRIPTION" above). When the series of events occur initiating a trip signal, this monitoring system is no longer required to function. Included are two packets that provide isotopic profiles for the systems' operation, they are:

- o Setpoint calculation for reactor building plenum monitor
- o $\bar{E}$ calculations for the plenum monitor.

5.4.1.2 Detection In Liquid Streams

Not Applicable

5.4.2 Range

The monitoring system has a range of 10^{-2}mr/hr to 10^{2}mr/hr in 4 (four) evenly spaced decades. The monitor's respond to energy from 80 Kev to 7 mev with the average energy dependence of $\pm$ 20% over 100 Kev to 3 mev. The criteria of 10^{4} MDA is not applicable for this function.

5.4.3 Sensitivity

As this monitoring system performs an isolation and system initiating function it is approprate to consider the time when the monitoring system is tripped and completes those functions. All instrument and valve closure times meet the less than, or equal to, 13 sec time limit as indicated in Sections 3/4 3.2, "ISOLATION ACTUATION INSTRUMENTATION" and 3.6.5.2, "SECONDARY CONTAINMENT AUTOMATIC ISOLATION VALVES" of the WNP-2 Technical Specifications. This indicates that the sensitivity of the system is capable of performing their designed function.

5.4.4 Accuracy

Each detector was subjected to a 96 mci C_s-137 source at the below mentioned distances. The distances and source intensity were matched to facilitate responses on the lower and near the upper ends of the condenser "R" scale. The results are as follows: A NBS traceable set of condenser "R" chambers was used as the reference standard for determing R_t (true quantity) in the percent error equation:

$$\text{percent error} = \frac{(R_t - R_r)}{R_t} \times 100$$

Where:

R_t = true value

R_r = indicated quantity

Channel	R_t Condenser "R" Corrected Reading	R_r System Reading Control Room	Percent Error
A	87.9 mr/hr	80 mr/hr	9%
A	13.4 mr/hr	12 mr/hr	11%
B	81 mr/hr	90 mr/hr	11%
B	12.4 mr/hr	13 mr/hr	5%
C	83 mr/hr	90 mr/hr	8%
C	15 mr/hr	15 mr/hr	No Error
D	61 mr/hr	65 mr/hr	7%
D	16.8 mr/hr	16 mr/hr	3%

The above R_r were taken from the control room meters (readouts) and the chart (recorder) presentations. The meters and charts tracked the same.

5.4.5 Precision

The system used to determine precision is as follows:

A 96 mCi C-137 source was hung inside the plenum. The source can be moved to as close to the detectors as possible and at approximately 65" away from the detector, 65" being the most manageable distance before being hampered by the duct (plenum) wall.

The approximate distances of 65" and 25" were chosen because:

1. They tested both lower and upper sections of the systems' monitoring scale.

2. Provide points that allowed electronic adjustment of the "0" (zero) and SPAN.

A set of NBS tracable victoreen condenser "R" chamber was used as the standard for the percent error evaluations. A condenser "R" chamber was exposed for times that allowed the final exposure to be near or above the middle of it's scale.

Using the classic relative error formula $\frac{(R_t - R_r)}{R_t}$ x 100 = % error

The above determinations were made.

The above procedure was conducted individually for each of the four detectors. The measuring, timing and environmental devices (used for temp and barometric pressure correction factors) were the same for all exposures. The results and percent error calculations are clustered such that precision is displayed by their consistancy and repeatability.

5.4.6 Response Time

Does not apply as an instrument response time only. This monitoring system performs definite protective functions - and - it is more appropriate to consider the entire system's response time. The relay response time is 10 milliseconds to an input step of 100 microamperes. As stated in the sensitivity system, this monitor performed their required trip function initiation within the time limitations.

5.4.7.1 Temperature

The operating temperatures are as follows:

- o Monitor - 0 to 50°C
- o Detector preamplifier - 30° to 70°C

5.4.7.2 Pressure

The detector is capable of continuous operation under 500 to 2500 torr pressure.

5.4.7.3 Humidity

This system is not used where temperatures and humidity conditions are such that moisture can not collect inside the connectors or the detectors.

5.4.7.4 Other Environmental Effects

Manufacturer's specifications were followed for installation and operation. Industry history substantiates durability and resistance to adverse environmental effects. This is a seismically class I system and the detectors are supported accordingly.

5.4.7.5 Power Requirements

The power supply is from a stable and predictable power source. In the event this power source is interrupted the 1 out of 2 taken twice logic initiates a "Z" signal that prompts system trip activation.

5.4.7.7 Mechanical Effects

Not Applicable

5.4.8 Radiation Alarm

Not Applicable

5.4.9 Failure Alarm

A HV-INOP trip circuit is employed on this system. The circuit will initiate a trip condition whenever the high voltage level becomes abnormally low.

5.4.10 Calibration

Prior to conducting a radiological calibration the following instrument calibration and preparation is made:

- Power supply and response is checked
- Set amplifier "O"
- Check meter and recorder response and condition
- Check and set trip alarm set points
- Perform all vendor recommended test and preparations

REA - RE - 9A,B,C,D
File

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

INTEROFFICE MEMORANDUM

DISTRIBUTION: MAIL DROP:

- [ ] WNP-1 FILE
- [x] WNP-2 FILE 917Y
- [ ] WNP-3 FILE
- [ ] ADMIN. FILE

JD Parry	1020
DE Larson	1020
D Ottley/lb	1020
Rad Prog Files	1020

DATE: January 3, 1984

TO: Vern Shockley

FROM: Dave Ottley David Ottley

SUBJECT: $\bar{E}$ CALCULATIONS FOR THE PLENUM MONITOR

REFERENCE: 1) F.E. Owen to R.G. Graybeal 3-9-83, "Radiation Monitor - Control Room Intake and Reactor Building Plenum" 50E-FEO-83-006

As per your request, the Average Gamma Energy $\bar{E}$ for the radio-nuclides expected within the Reactor Building Plenum Monitor was calculated.

Four scenarios were used:

Routine	Release	.364 MEV
LOCA	1 hour	.669 MEV
LOCA	8 hour	.309 MEV
LOCA	1 day	.157 MEV

These were also compared with the $\bar{E}$'s, previously estimated in Reference 1, based on isotopic percent concentration.

Isotope and curie content for the routine release scenario was obtained from the WNP-2 FSAR Table 11.3-7, "Gaseous Waste System Release". For the LOCA scenarios, content was obtained from FSAR Table 15.6-13, "Loss-of-Coolant Accident" (Design Basis).

The nuclide concentration was multiplied by the approximate energies and photon abundances obtained from the Radiological Health Handbook and summed, thus calculating the $\bar{E}$.

The attached summary and accompanying tables can be consulted for detailed calculations. If you have any questions, please call me at 8048.

Ē CALCULATION, PLENUM MONITOR, SUMMARY

	Routine Release	LOCA 1 Hr.	LOCA 8 Hr.	LOCA 1 Day
REF. 1		.469	.149	.081
Kryptons	.057	.294	.072	.002
Xenons	.305	.102	.076	.048
Iodines	.002	.273	.161	.089
Total	.364 MEV	.669 MEV	.309 MEV	.157 MEV

Ē CALCULATION, PLENUM MONITOR, ROUTINE RELEASE

ISOTOPE	CURIE (FROM FSAR)	CONCENTRATION	MEV (FROM RHH)	ABUNDANCE	CONTRIBUTION MEV
Kr-85m	3	.018	.150	.74	.002
			.305	.13	.001
Kr-87	3	.018	.403	.84	.006
			2.57	.35	.016
			.85	.16	.002
Kr-88	3	.018	2.40	.35	.015
			.19	.35	.001
			.85	.23	.004
			1.15	.14	.003
			2.19	.18	.007
Xe-133	66	.405	.081	.37	.012
Xe-135m	46	.282	.527	.80	.119
Xe-135	34	.209	.250	.91	.047
			.61	.03	.004
Xe-138	7	.043	.16	.33	.002
			.26	1.00	.011
			.42	.40	.007
			.51	.08	.002
			1.78	.66	.051
			2.02	.58	.050

Ē CALCULATION, PLENUM MONITOR, ROUTINE RELEASE (Continued)

ISOTOPE	CURIE (FROM FSAR)	CONCENTRATION	MEV (FROM RHH)	ABUNDANCE	CONTRIBUTION MEV
I-131	.17	.001	.364	.82	---
I-133	.68	.004	.53	.90	.002
Tritium	<.01	<.01			---
Particulates	<.01	<.01			---
Subtotals					
Krypton's		.054			.057
Xenon's		.939			.305
Iodine's		.005			.002
TOTALS		1.00			.364

Ē = .364 MEV

Ē CALCULATION, PLENUM MONITOR, 1 HOUR

ISOTOPE	CURIE (FROM FSAR)	CONCENTRATION	MEV (FROM RHH)	ABUNDANCE	CONTRIBUTION MEV
I-131	2.2E7	.030	.364	.82	.009
			.637	.07	.001
I-132	2.4E7	.033	.67	1.44	.032
			.773	.89	.023
			.955	.22	.007
			.52	.20	.003
I-133	4.7E7	.064	.53	.90	.031
I-134	2.6E7	.036	.85	.95	.029
			.89	.65	.021
			.55	.08	.002
			.41	.08	.001
			.61	.18	.004
			1.15	.10	.004
			1.79	.05	.003
			1.62	.05	.003
			1.46	.04	.002
I-135	4.0E7	.055	1.14	.37	.023
			1.28	.34	.024
			1.72	.19	.018
			1.46	.12	.010
			1.80	.11	.011
			.86	.11	.005
			1.04	.09	.005
			.42	.07	.002

Ē CALCULATION, PLENUM MONITOR, 1 HOUR (Continued)

ISOTOPE	CURIE (FROM FSAR)	CONCENTRATION	MEV (FROM RHH)	ABUNDANCE	CONTRIBUTION MEV
Kr-83m	9.9E6	.014	.009	.09	---
Kr-85m	3.8E7	.052	.150	.74	.006
			.305	.13	.002
Kr-85	1.4E6	.002	.514	.41	---
Kr-87	4.7E7	.064	.403	.84	.022
			2.57	.35	.058
			.85	.16	.009
Kr-88	8.6E7	.118	2.40	.35	.099
			.19	.35	.008
			.85	.23	.023
			1.15	.14	.019
			2.19	.18	.047
			.17	.07	.001
Kr-89	2.6E2	.0000004	.23	.85	---
			.60	1.00	---

Ē CALCULATION, PLENUM MONITOR, 1 HOUR (Continued)

ISOTOPE	CURIE (FROM FSAR)	CONCENTRATION	MEV (FROM RHH)	ABUNDANCE	CONTRIBUTION MEV
Xe-131m	9.0E5	.001	.164	.02	---
Xe-133m	4.7E6	.006	2.33	.14	---
Xe-133	1.9E8	.260	.081	.37	.008
Xe-135m	3.6E6	.005	.527	.80	.002
Xe-135	1.7E8	.233	2.50	.91	.053
			.61	.03	.004
Xe-137	3.5E3	.000008	.455	.33	---
Xe-138	8.8E6	.012	.16	.33	.001
			.26	1.00	.003
			.42	.40	.002
			.51	.08	.001
			1.78	.66	.014
			2.02	.58	.014
Subtotals					
Iodine's		.218			.273
Krypton's		.25			.294
Xenon's		.517			.102
TOTALS		.99			.669

Ē = .669 MEV

Ē CALCULATION, PLENUM MONITOR, REF. 1
1 HOUR

ISOTOPE	CONCENTRATION	ENERGY	ABUNDANCE	CONTRIBUTION (MEV)
Kr-83m	.02	.009	.09	---
Kr-85m	.04	.150	.74	.004
Kr-87	.05	.403	.84	.017
		2.57	.35	.045
		.85	.16	.007
Kr-88	.11	2.40	.35	.092
		.19	.35	.007
		.85	.23	.023
		1.15	.14	.018
		2.19	.18	.043
		.17	.07	.001
Xe-133m	.01	2.33	.14	---
Xe-133	.48	.081	.37	.014
Xe-135m	.12	.527	.80	.051
Xe-135	.13	.250	.91	.030
		.61	.03	.002
Xe-138	.04	.16	.33	.002
		.26	1.00	.010
		.42	.40	.007
		.51	.08	.002
		1.78	.66	.047
		2.02	.58	.047
	1.00			.469 MEV

$\bar{E}$ CALCULATION, PLENUM MONITOR, 8 HOURS

ISOTOPE	CURIE (FROM FSAR)	CONCENTRATION	MEV (FROM RHH)	ABUNDANCE	CONTRIBUTION MEV
I-131	2.1E7	.053	.364	.82	.016
			.637	.07	.002
I-132	2.9E6	.007	.67	1.44	.007
			.773	.89	.005
			.955	.22	.001
			.52	.20	.001
I-133	3.7E7	.093	.53	.90	.044
I-134	1.0E5	.0003	.85	.95	---
I-135	1.9E7	.048	1.14	.37	.020
			1.28	.34	.021
			1.72	.19	.016
			1.46	.12	.008
			1.80	.11	.010
			.86	.11	.005
			1.04	.09	.004
			.42	.07	.001

$\bar{E}$ CALCULATION, PLENUM MONITOR, 8 HOURS (Continued)

ISOTOPE	CURIE (FROM FSAR)	CONCENTRATION	MEV (FROM RHH)	ABUNDANCE	CONTRIBUTION MEV
Kr-83m	7.2E5	.002	.009	.09	---
Kr-85m	1.3E7	.033	.150	.74	.004
			.305	.13	.001
Kr-85	1.4E6	.004	.514	.41	.001
Kr-87	1.0E6	.003	.403	.84	.001
			2.57	.35	.002
Kr-88	1.5E7	.038	2.40	.35	.032
			.19	.35	.003
			.85	.23	.007
			1.15	.14	.006
			2.19	.18	.015
Kr-89	---	---	.60	1.00	---

$\bar{E}$ CALCULATION, PLENUM MONITOR, 8 HOURS (Continued)

ISOTOPE	CURIE (FROM FSAR)	CONCENTRATION	MEV (FROM RHH)	ABUNDANCE	CONTRIBUTION MEV
Xe-131m	8.8E5	.002	.164	.02	----
Xe-133m	4.3E6	.011	.233	.14	----
Xe-133	1.4E8	.475	.081	.37	.014
Xe-135m	1.9E2	----	.527	.80	----
Xe-135	1.0E8	.250	.250	.91	.057
			.61	.03	.005
Xe-137	----	----	4.55	.33	----
Xe-138	1.1E2	----	2.02	.58	----
Subtotals					
Iodine's		.201			.161
Krypton's		.08			.072
Xenon's		.738			.076
TOTALS		1.02			.309

$\bar{E}$ = .309 MEV

$\overline{E}$ CALCULATION, PLENUM MONITOR, REF. 1
8 HOURS

ISOTOPE	CONCENTRATION	ENERGY	ABUNDANCE	CONTRIBUTION (MEV)
Kr-83m	.01	.009	.09	---
Kr-85m	.02	.150	.74	.002
Kr-87	---	2.57	.35	---
Kr-88	.02	2.40	.35	.017
		.19	.35	.001
		.85	.23	.004
		1.15	.14	.003
		2.19	.18	.008
Xe-133m	.01	2.33	.14	---
Xe-133	.61	.081	.37	.018
Xe-135m	.08	.527	.80	.034
Xe-135	.25	.250	.91	.057
		.61	.03	.005
Xe-138	---	2.02	.58	---
	1.00			.149 MEV

E CALCULATION, PLENUM MONITOR, 1 DAY

ISOTOPE	CURIE (FROM FSAR)	CONCENTRATION	MEV (FROM RHH)	ABUNDANCE	CONTRIBUTION MEV
I-131	2.0E7	.077	.364	.82	.023
			.637	.07	.003
I-132	2.3E4	.00009	.67	1.44	---
I-133	2.2E7	.085	.53	.90	.040
I-134	3.2E1	---	.85	.95	---
I-135	3.5E6	.013	1.14	.37	.006
			1.28	.34	.006
			1.72	.19	.004
			1.46	.12	.002
			1.80	.11	.003
			.86	.11	.001
			1.04	.09	.001
Kr-83m	1.8E3	.000007	.009	.09	---
Kr-85m	1.1E6	.004	.150	.74	---
Kr-85	1.4E6	.005	.514	.41	.001
Kr-87	1.6E2	---	2.57	.35	---
Kr-88	2.9E5	.001	2.40	.35	.001
Kr-89	---	---	.60	1.00	---

$\overline{E}$ CALCULATION, PLENUM MONITOR, 1 DAY (Continued)

ISOTOPE	CURIE (FROM FSAR)	CONCENTRATION	MEV (FROM RHH)	ABUNDANCE	CONTRIBUTION MEV
Xe-131m	8.5E5	.003	.164	.02	---
Xe-133m	3.5E6	.013	.233	.14	---
Xe-133	1.7E8	.654	.081	.37	.020
Xe-135m	---	---	.527	.80	---
Xe-135	3.0E7	.115	.250	.91	.026
			.61	.03	.002
Xe-137	---	---	4.55	.33	---
Xe-138	---	---	2.02	.58	---
Subtotals					
Iodine's		.175			.089
Krypton's		.01			.002
Xenon's		.785			.048
TOTALS		.97			.157

$\overline{E}$ = .157 MEV

Ē CALCULATION, PLENUM MONITOR, REF. 1
1 DAY

ISOTOPE	CONCENTRATION	ENERGY	ABUNDANCE	CONTRIBUTION (MEV)
Kr-83m	---	.009	.09	---
Kr-85m	---	.150	.74	---
Kr-87	---	2.57	.35	---
Kr-88	---	2.40	.35	---
Xe-133m	.01	2.33	.14	---
Xe-133	.76	.081	.37	.023
Xe-135m	.02	.527	.80	.008
Xe-135	.20	.250	.91	.046
		.61	.03	.004
Xe-138	---	2.02	.58	---
	.99			.081 MEV