LA CROSSE BOILING WATER REACTOR (LACBWR)

OFFSITE DOSE CALCULATION MANUAL

Prepared by Seymour J. Raffety (2/28/94)

Health Physics Review [illegible] 2/28/94

Quality Assurance Review [illegible] 2/28/94

Approved by [illegible] 2/28/94

February 1994

Revision 2

Dairyland Power Cooperative
3200 East Avenue South
La Crosse, WI 54602-0817

9403080256 940228
PDR ADOCK 05000409
R PDR

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1. INTRODUCTION

The purpose of the Offsite Dose Calculation Manual (ODCM) is to describe the methodology and parameters to be used in the calculation of instantaneous release rate alarm setpoints and dose commitments due to radioactive materials released in liquid and gaseous effluents from the La Crosse Boiling Water Reactor (LACBWR) during SAFSTOR to areas beyond the Effluent Release Boundary. (Diagram 1.1)

The purpose of the Radiological Environmental Monitoring Program required by LACBWR Technical Specification 4.8 is to provide measurements of radiation and radioactive materials attributed to the La Crosse Boiling Water Reactor in those environmental dose pathways and for those radionuclides which may result in the highest potential radiation dose equivalents to individuals beyond the Effluent Release Boundary.

The LACBWR Technical Specifications enumerate the requirements as follows:

Specification 4.7.1.2*

"The concentration of radioactive material released in liquid effluents at any time to areas beyond EFFLUENT RELEASE BOUNDARY shall be limited to the concentrations specified in 10 CFR Part 20, Appendix B, Table II, Column 2, issue of

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* A request for revision of this T.S. removing the words "issue of December 30, 1982," has been submitted to the NRC by letter dated November 5, 1993. As of January 1, 1994 Dairyland Power Cooperative will comply with the current 10CFR20 as required by regulation.

December 30, 1982, for radionuclides other than dissolved or entrained noble gases. For dissolved or entrained noble gases, the concentration shall be limited to 6×10^{-4} µCi/ml total activity concentration."

Specification 4.7.1.3

"The dose or dose commitment to a MEMBER OF THE PUBLIC from radioactive materials in liquid effluents released to areas beyond EFFLUENT RELEASE BOUNDARY shall be limited:

a. During any calendar quarter to ≤ 1.5 mRem to the total body and to ≤ 5 mRem to any organ, and

b. During any calendar year to ≤ 3 mRem to the total body and to ≤ 10 mRem to any organ."

Specification 4.7.2.2

"The dose rate due to radioactive materials released in gaseous stack effluents to areas beyond the EFFLUENT RELEASE BOUNDARY shall be limited to the following:

a. The dose rate limit for noble gases shall be ≤ 500 mRem/yr to the total body and ≤ 3000 mRem/year to the skin, and

b. The dose rate limit for H-3 and for all radionuclides in particulate form with half-lives greater than 8 days, shall be ≤ 1500 mRem/year to any organ."

Specification 4.7.2.3

"The air dose to a MEMBER OF THE PUBLIC due to noble gases released in gaseous effluents to areas beyond EFFLUENT RELEASE BOUNDARY shall be limited to the following:

a. During any calendar quarter, to ≤ 5 mRad for gamma radiation and ≤ 10 mRad for beta particle radiation, and

b. During any calendar year, to ≤ 10 mRad for gamma radiation and ≤ 20 mRad for beta particle radiation."

Specification 4.7.2.4

"The dose to a MEMBER OF THE PUBLIC from H-3, and all radionuclides in particulate form with half-lives greater than 8 days, in gaseous effluents released to areas beyond EFFLUENT RELEASE BOUNDARY shall be limited to the following:

a. During any calendar quarter to ≤ 7.5 mRem to any organ, and

b. During any calendar year to ≤ 15 mRem to any organ."

Specification 4.7.4

"The dose equivalent to any MEMBER OF THE PUBLIC due to releases of radioactivity and radiation, shall be limited to $\leq$ 25 mRem to the total body or any organ (except the thyroid, which is limited to $\leq$ 75 mRem) over a period of one calendar year."

Specification 4.8.1

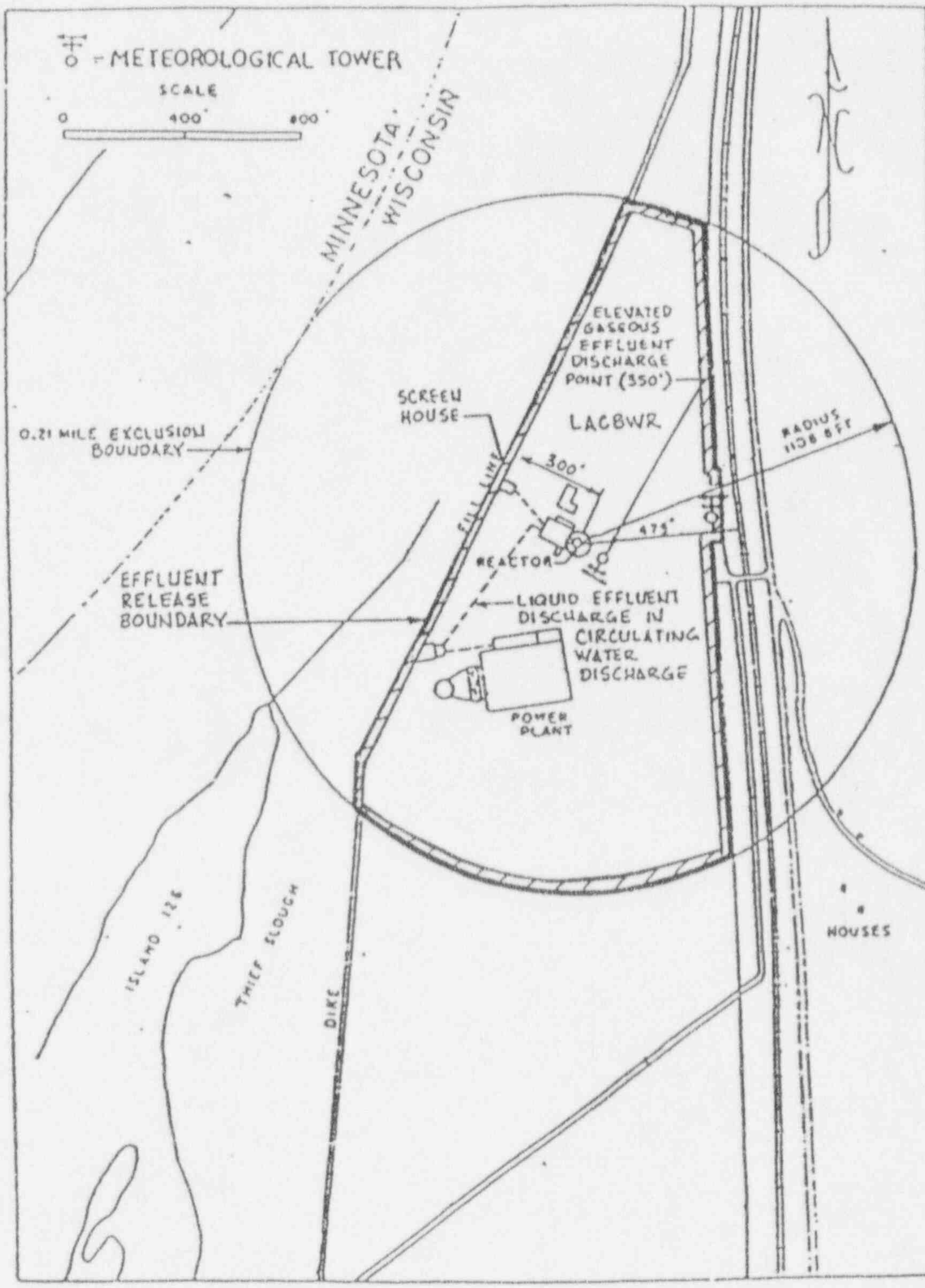
"The Radiological Environmental Monitoring Program shall be conducted as specified in Table 4.8.1-1. An Interlaboratory Comparison Program for annual analyses of radioactive materials shall be conducted."

This manual contains calculation methods for determining effluent monitoring instrumentation alarm setpoints and also provides derived site specific dose factors for LACBWR. The site specific dose factors enable the calculation of cumulative dose contributions to be performed at least once every calendar quarter, as required by the LACBWR Technical Specifications, to demonstrate compliance with the aforementioned requirements.

This manual also contains a summary of the Radiological Environmental Monitoring Program which supplements the radiological effluent monitoring and dose assessment program by verifying through sample collection and analysis that the measurable concentrations of radioactive materials and levels of radiation released from the plant effluents are not higher than those expected on the basis of effluent measurements and offsite dose calculation.

Diagram 1.1

SITE MAP
INCLUDING EFFLUENT RELEASE BOUNDARY



2. LIQUID RELEASES

2.1 Compliance with Specification 4.7.1.2

To assure compliance with Technical specification 4.7.1.2, radioactivity monitor alarm setpoints are calculated for each radioactive liquid effluent line monitor as a function of the maximum effluent flow rate and the minimum dilution flow rate. The following equation is used to calculate setpoints:

$$\frac{af}{k(F + f)} \leq C \qquad (2.1)$$

where:

C = the effluent concentration limit implementing 10 CFR 20 for LACBWR, in μCi/ml.

a = the setpoint (in CPS above background) of the radioactivity monitor measuring the radioactivity concentration in the effluent line prior to dilution and subsequent release; the setpoint, which is inversely proportional to the volumetric flow of the effluent line (f) and proportional to the volumetric flow of the dilution stream plus the effluent stream (F + f), represents a value which, if exceeded, could result in concentrations exceeding the limits of 10 CFR 20.

k = the conversion factor, cps per μCi/ml, for the liquid waste effluent monitor based upon most recent calibration of the monitor.

f = the effluent line volumetric flow setpoint as measured at the radiation monitor location, in gallons per minute.

F = the dilution stream (LACBWR & Genoa Station No. 3 [G-3] Condenser Cooling Water) volumetric flow, in gallons per minute.

Since f << F, Equation 2.1 is satisfied when the following discharge line radioactivity monitor setpoint is met:

$$a \leq \frac{kCF}{f} \qquad (2.2)$$

Calculation of Instantaneous Allowable Release Rates

LACBWR's liquid radwaste is released in batches. In order to assess the required radioactive liquid effluent line monitor setpoint, a, the following step-by-step method for obtaining data will be performed. The form presented in Figure 2.1 may be used as a worksheet for these calculations. The alarm setpoint calculation may be performed on an annual basis if the setpoint is determined to be sufficiently conservative so as to prevent exceeding 0.5 MPC at the discharge point where MPC is the isotope weighted effluent concentration release limit for a typical LACBWR waste batch based on 10CFR20, appendix B, Table 2, Col. 2 values.

1. Go to Figure 2.1 Enter the date on the form.

2. Enter the concetration C_i (µCi/ml) for each isotope i, in a typical LACBWR waste batch.

3. The values of f and F are determined and recorded at the top of Figure 2.1. F is the minimum volumetric dilution flow rate during releases at the LACBWR - G-3 outfall which is equal to the LACBWR condenser cooling water flow rate plus the G-3 condenser cooling water volumetric flow, in gallons per minute. The value f is the maximum radioactive liquid release flow rate (GPM) for the batches discharged during the period. A value of 17 GPM is normally specified for f.

4. The quantities $\sum C_i$, and $\sum C_i/MPC_i$ are determined and recorded.

5. The monitor conversion factor, k, determined at last primary calibration is recorded on Figure 2.1, in cps (net) per µCi/ml.

6. The alarm setpoint, a (cps), with a 0.5 factor for conservatism, for the monitor measuring radioactivity in the liquid effluent line is then determined by

$$a = \frac{0.5\, kF \sum C_i}{f \sum C_i/MPC_i} \qquad (2.3)$$

2.2 Compliance with Specification 4.7.1.3

To demonstrate compliance with Technical Specification 4.7.1.3, dose contributions are calculated at a maximum interval of once every calendar quarter for all radionuclides identified in liquid effluents released to unrestricted areas using the methodology presented in NRC Regulatory Guide 1.109 Rev.1, October 1977. This methodology takes the form of the following general equation:

$$D_{a\tau} = \sum_{i} (A_{ai\tau} \sum_{j=1}^{m} C_{ij}/F_j) \qquad (2.4)$$

where:

$D_{a\tau}$ = the cumulative dose commitment to the total body or any organ τ of an individual in age group a from the liquid effluents released in m batches, in mRem.

C_{ij} = the total quantity of radionuclide i, released by batch j, in Ci.

$A_{ai\tau}$ = the site-related ingestion dose commitment factor to the total body or any organ τ of an individual in age group a for each identified principal gamma and/or beta emitter, in mRem-gal-min^{-1}-Ci^{-1}.

F_j = the average dilution water flow rate during batch release j in gallons/minute.

Equation 2.4 requires the use of a dose factor $A_{ai\tau}$ for each nuclide, organ and individual in age group a which includes the factors which determine the ultimate dose received such as pathway transfer factors (e.g., bioaccumulation factors), pathway usage factors, ingestion dose factors and dilution factors. The following philosophy and site-specific conditions determine the site-specific factors incorporated into the liquid effluent dose calculation model:

1. Liquid Dose Pathways

Due to LACBWR's status as a fresh water site, there is no invertebrate pathway. The drinking water pathway is not included, since the nearest community which obtains its drinking water supply from the Mississippi River is located at Davenport, Iowa, which is 195 miles downstream. The drinking water pathway represents < 0.01% of the dose to any organ. The irrigated foods pathway is not included since the river water is not used for irrigation in this area and the shoreline deposits pathway is insignificant for the Mississippi river. The only significant dose pathway is the dose commitment due to ingestion of fish from the Mississippi River waters.

2. Dilution

The liquid effluent flow from the waste tanks is diluted by the combined total circulating water flow for condenser cooling at both LACBWR and G-3. For offsite dose calculations, no dilution by the Mississippi River flow is considered. However, in previous issues of this ODCM dilution in Thief Slough before reaching the Mississippi River was considered. Also, under SAFSTOR conditions batch discharges of liquid effluent normally take place during less than 35 hours per month (< 5% of the time). Therefore, no fish in the river are continuously exposed to an undiluted radioactive environment produced by LACBWR liquid effluent as assumed in the calculation of the published bioaccumulation factors for fish. To account for these conditions, the very conservative dilution factor, D = 20.6, will be used in the calculation of off-site doses from LACBWR liquid effluent.

Based on the above site-specific criteria, the dose factor A_{ait} is defined as follows:

$$A_{ait} = K_o \, (UF_a)(BF_i)(DF_{ait})(1/D) \qquad (2.5)$$

where:

K_o = a units conversion constant, 5.03×10^5 =

$(10^{12}$ pCi/Ci x .2642 gal/ℓ) / (8760 hrs/yr x 60 min/hr).

UF_a = fish consumption usage factor for an individual in age group a, in kg/yr.

BF_i = the bioaccumulation factor in fish for nuclide i, in pCi/kg per pCi/ℓ.

$DF_{ai\tau}$ = the ingestion dose factor for age group a for nuclide i, in organ τ in mRem/pCi.

D = a conservative factor accounting for the intermittent exposure of the fish to LACBWR effluent and dilution in Thief Slough, D = 20.6.

Calculation of Dose Commitments to Liquid Effluents

The equations for this calculation have been formatted on a LOTUS spreadsheet. The values of UF_a, BF_i, and $DF_{ai\tau}$ specified in NRC Regulatory Guide 1.109 Rev.1, October 1977 and constants such as K_o and D have been entered on the spreadsheet.

To perform the calculation the following information is entered in the appropriate cells of the spreadsheet for each liquid batch released during the period of interest:

1. Date
2. Release interval, hrs
3. Waste volume, gal
4. Condenser cooling water flow rate, GPM
5. Activity concentration of each isotope, i, in waste, µCi/ml.

The spreadsheet program will then calculate and display the total quarterly dose in mRem to the total body and each organ of an individual in each age group. The cumulative calendar year doses and percentage of Technical Specification limits are also calculated. This spreadsheet will also print the data tables for the liquid effluent section of the annual report.

Figure 2.1

LIQUID RELEASE MONITOR
ALARM SETPOINT DETERMINATION

Date ____________________

Maximum Liquid Release Rate for Period, f= ____________ GPM
Minimum Dilution Flow Rate for Period, F= ______________ GPM

Nuclide i	Average Concentration (in Tanks), C_i (μCi/ml)	MPC_i (10 CFR Part 20, Appendix B Table 2, Col. 2)	C_i/MPC_i
Co-60		3 E-06	
Cs-137		1E-06	
Mn-54		3E-05	
Ce-144		3E-06	
Zn-65		5E-06	
Cs-134		9 E-07	
Ru(Rh)-106		3E-06	
Sr-90		5 E-07	
Fe-55		1 E-04	
Ag-110m		6 E-06	
$\sum C_i$ =		$\sum_i C_i/MPC_i$ =	

Monitor Conversion Factor, k = ________________ $\frac{\text{cps(net)}}{\mu\text{Ci/ml}}$

$$\underset{\text{(alarm setpoint)}}{a} \leq \frac{0.5\,kF \sum C_i}{f \sum C_i/MPC_i} = \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ cps above background}$$

3. GASEOUS RELEASES

3.1 Compliance with Specification 4.7.2.2

To assure compliance with Technical Specification 4.7.2.2, alarm setpoints are established for the gaseous effluent monitor. These setpoints are calculated or checked annually, or as required by procedure, to confirm that the current setpoints are set correctly for one- or two-stack blower operation.

During SAFSTOR, the offgas treatment system from the condenser to the stack is no longer in operation since the plant is shut down. The principal potential gaseous release pathway is from the Containment Building ventilation exhaust system. The only noble gas potentially available for release from the facility is Kr-85. The irradiated fuel assemblies stored in the Fuel Element Storage Well (FESW) contain essentially all the Kr-85 inventory. There is a very small potential for a Kr-85 release from the Waste Treatment and Turbine Building ventilation exhaust systems. This would be possible only if FESW water containing Kr-85 were transferred to the Spent Resin Receiving Tank (SRRT) or the Waste Water Tanks (WWT). Activity in particulate form and H-3 can theoretically by released via any of these release pathways. There will be no radioiodine (I-131, I-133) releases since they are no longer being produced and, since shutdown, any residual activity has decayed to insignificant levels.

3.1.1 Specification 4.7.2.2 a - Noble gases

The following mathematical relationships shall be used to implement the above specification for noble gas (Kr-85) release alarm setpoints:

$$\dot{D}^{T} = K' \, Q \, (\chi/Q) \, (DFB)$$

$$= K' \, Q_v F_s \, (\chi/Q) \, (DFB) \quad (3.1)$$

$$\dot{D}^{S} = K' \, [\, 1.11 \, Q \, (\chi/Q) \, DF^{Y} + Q \, (\chi/Q) \, (DFS)]$$

$$= K' \, Q_v F_s \, (\chi/Q) \, (1.11 \, DF^{Y} + DFS) \quad (3.2)$$

where:

$\dot{D}^{T}$ = the dose rate in mRem/yr to the total body of an individual beyond the EFFLUENT RELEASE BOUNDARY due to Kr-85. This value is to be less than 500 mRem/yr.

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

F_s = volume flow rate in stack, cc/sec.

Q = average Kr-85 release rate, µCi/sec.

Q_v = average Kr-85 release concentration, µCi/cc.

(χ/Q) = atmospheric dispersion coefficient for instantaneous releases. (For the ALERT alarm setpoint, 6.05 E-5 sec/m^3 is used, based upon Regulatory Guide 1.3 criteria. For the High alarm setpoint, 3.90 E-6 sec/m^3 is used, based upon actual historical monthly average χ/Q values at the worst case receptor location.)

DFB = the total body gamma dose factor for exposure to a semi-infinite cloud of Kr-85 = 1.61 E-05 mRem-m^3 per pCi-yr.

$\dot{D}^{S}$ = the dose rate to the skin of an individual at or beyond the EFFLUENT RELEASE BOUNDARY due to Kr-85. This value is to be less than 3000 mRem/yr.

1.11 = the ratio of the tissue to air energy absorption coefficients over the energy range of photons of interest. This converts dose (mRad) to dose equivalent (mRem).

DF^{γ} = the gamma air dose factor for exposure to semi-infinite cloud of Kr-85 = 1.72 E-05 mRad-m^3 per pCi-yr.

DFS = the skin beta dose factor for exposure to a semi-infinite cloud of Kr-85 = 1.34 E-03 mRem-m^3 per pCi-yr.

NOTE: Equations 3.1 and 3.2 incorporate the use of the semi-infinite plume model. The model assumes receptor submersion in a plume of uniform concentration, which is semi-infinite in geometry, having as its only boundary the ground plane. Due to the meteorology and topography at the La Crosse Site, the worst receptor locations are a bluff 1300 m SSE and a bluff 600 m ENE of the facility. At these locations the receptor is submerged in the plume.

Calculation of Instantaneous Release Rate Monitor Setpoints for Noble Gases (Kr-85)

Equations 3.1 and 3.2 are used to calculate the controlling instantaneous release rate setpoints for dose rates to the total body and skin of an individual due to Kr-85 for one- and two-blower operation.

The DFB, DF^{γ} and DFS values for Kr-85 are multiplied by the appropriate χ/Q value, the conversion constants and the stack flow rate for one- or two-stack blower operation to obtain the values for TBF, SFG and SFB which are then inserted into the following equations to determine gaseous release monitor alarm setpoints, Q_{vs}:

$$Q_{vs} \text{ (Whole Body)} = \frac{(500 \text{ mRem/yr})}{(\text{TBF})} \tag{3.3}$$

$$Q_{vs} \text{ (Skin)} = \frac{(3000 \text{ mRem/yr})}{(\text{SFG} + \text{SFB})} \tag{3.4}$$

where:

$TBF = (1E6)(\chi/Q)(DFB)(F_s)$

$SFG = (1.11E6)(\chi/Q)(DF^{\gamma})(F_s)$

$SFB = (1E6)(\chi/Q)(DFS)(F_s)$

The smaller of the two values calculated is used for the setpoint. This instantaneous release rate setpoint is very conservative since it is the average release rate allowed for a whole year.

The following step-by-step procedure may be used in conjunction with the equations found on Figure 3.1 to calculate the instantaneous release rate limits for Kr-85 for one- or two-stack blower operation:

1. On Figure 3.1, enter the date that the alarm setpoint calculation is performed.
2. Note the appropriate value for χ/Q.
3. Note the appropriate value of F_s and the number of stack blowers operating for the condition being calculated.
4. Using the equations at the top of Figure 3.1, calculate the values of TBF, SFG and SFB for one- and two-blower operation and for all appropriate χ/Q's, using the DFB, DF^{γ} and DFS values for Kr-85 listed on Figure 3.1.
5. Calculate the values of Q_{vs} for each case. Select the smallest Q_{vs} value for each χ/Q which will become the ALERT and HIGH alarm setpoints for the noble gas monitor.
6. The Q_{vs} values (alarm setpoints) for 1989 are tabulated on Figure 3.2.

<u>NOTE:</u> These values will not change during SAFSTOR unless the TS limits are changed, the χ/Q values are changed, the dose factors are changed or the volume flow rate in the stacks changes.

3.1.2 Specification 4.7.2.2 b - H-3 and Particulates

The following mathematical relationship shall be used to implement Specification 4.7.2.2 for H-3 and Particulates with $T_{1/2}$ > 8 days alarm setpoints:

$$\dot{D}_{P\tau} = \sum_i P_{i\tau} Q_{Pi} (\chi/Q) \tag{3.5}$$

where:

$\dot{D}_{P\tau}$ = the dose rate to organ τ of an individual at or beyond the EFFLUENT RELEASE BOUNDARY, due to H-3 and particualtes with half-lives greater than 8 days. This value is to be less than 1500 mRem/yr.

$P_{i\tau}$ = the dose parameter for organ τ, for radionuclide i, for the inhalation pathway, in mRem-m^3 per µCi-yr.

χ/Q = the atmosphere dispersion coefficient in sec/m^3

Q_{Pi} = release rate of nuclide i, in µCi/sec.

Calculation of Release Limits for H-3 and Particulates with Half-Lives Greater than 8 days

Since it is impractical to measure instantaneous release rates for radionuclides other than noble gases, the alarm setpoints for radionuclides other than noble gases are expressed in terms of total accumulated activity on sample media for a specified sampling time, ΔT, which is monitored as µCi by the stack effluent monitor.

Equation 3.6 is used to calculate the release rate limit for all H-3 and particulates with half-lives greater than 8 days. This equation is based on the dose rate to an infant due to inhalation of these radionuclides. In accordance with NUREG-0133, the infant will always receive the maximum dose rate under the exposure conditions for Specification 4.7.2.2. The atmospheric dispersion coefficients (χ/Q) used are 6.05 E-5 sec/m^3 for the calculation of the ALERT alarm setpoint and 3.9 E-6 sec/m^3 for the HIGH alarm setpoint.

Alarm Setpoint Calculations for H-3 and Particulates with Half-Lives Greater than 8 days

$$Q_{P\tau} = \frac{1500 \text{ mRem/yr}}{\sum_i [P_{i\tau} \text{ (inhalation)} \times R_{Pi}] (\chi/Q)} \quad (3.6)$$

where:

$Q_{P\tau}$ = the maximum allowed total release rate of a typical mixture of radionuclides in µCi/sec conservatively derived from the allowed annual average dose rate to organ τ and very conservative χ/Q.

R_{Pi} = the ratio of the activity of nuclide i, to the total activity of all nuclides other than noble gases in a typical mixture being released.

χ/Q = the atmospheric dispersion coefficient as given above for ALERT or HIGH alarm respectively, in sec/m^3.

Resolution of the $P_{i\tau}$ term in Equation 3.6 yields:

$$P_{i\tau} \text{ (inhalation)} = (10^6 \text{ pCi/μCi}) \text{ (BR) } (DFA_{i\tau}) \quad (3.7)$$

where:

$DFA_{i\tau}$ = the inhalation dose factor for an infant, for the i^{th} radionuclide, for organ τ, in mRem/pCi.

BR = infant breathing rate, in m^3/yr.

To calculate the alarm setpoint in terms of total μCi deposited on filter or cartridge sample media, the following equation is used:

$$Q_{sa} = \frac{\text{Lowest } Q_{P\tau} \times \Delta F}{F_s} \quad (3.8)$$

where:

Q_{sa} = the activity in μCi (deposited on sample media in sample time ΔT) which initiates an appropriate alarm in the stack effluent monitor.

$Q_{P\tau}$ = μCi/sec

F_s = stack flow rate, cc/sec

ΔF = total flow through sample media (cc), in sample time ΔT, corrected to stack gas conditions. ΔT is normally 7 days.

The procedure outlined below is used to calculate the release limits for radionuclides other than noble gases. This will be done at least an annual basis.

NOTE: This procedure is applicable for the determination of either Alert or High alarms by utilizing the appropriate value for χ/Q in the equation.

1. Start on Figure 3.3 Enter the date, the alarm setpoint being calculated (alert or High) and the appropriate χ/Q value to be used.

2. Enter the average release rate for the period, Q_{Pi}, in µCi/sec, of each identified radionuclide. At the bottom of the form, compute and enter the sum $\sum_i Q_{Pi}$.

3. In the column labeled R_{Pi}, enter the ratio of the average period release rate of nuclide i to the average total period release rate, $\sum_i Q_{Pi}$, for the period.

4. For each organ τ, as noted at the top of the form, calculate and enter the value of $(\chi/Q)\ (R_{Pi})\ P_{i\tau}$(inhalation) for each nuclide. $P_{i\tau}$ (inhalation) values are found on Table 3.1. At the bottom of the column, for each organ, enter the value of $\sum_i R_{Pi}\, P_{i\tau}\, (\chi/Q)$ for that organ.

5. Go to Figure 3.4. Enter the date and the alarm setpoint being determined.

6. Using the equation at the top of Figure 3.4, calculate the release rate limits, $Q_{P\tau}$, for each organ τ.

7. Select the lowest value of $Q_{P\tau}$, enter at the bottom of Figure 3.4 under appropriate blower operation. Multiply the $Q_{P\tau}$ number times the total sample flow through the sample media, cc, and divide this by the appropriate blower flow rate, cc/sec, to determine the Q_{sa} in µCi and use these as alarm setpoints.

3.2 Compliance with Specification 4.7.2.3

To demonstrate compliance with Technical Specification 4.7.2.3, dose contributions are calculated for any Kr-85 released to unrestricted areas using the following expressions:

$$D^{\gamma}(r, \theta) = 3.17 \times 10^{-2}\ DF^{\gamma}\ Q\ [\chi/Q](r, \theta) \qquad (3.9)$$

$$D^{\beta}(r, \theta) = 3.17 \times 10^{-2}\ DF^{\beta}\ Q\ [\chi/Q](r, \theta) \qquad (3.10)$$

where:

$D^{\gamma}(r, \theta)$ = the dose commitment to the maximum individual due to the gamma radiation from Kr-85 at location (r,θ), in mRad.

$D^{\beta}(r, \theta)$ = the dose commitment to the maximum indivudual due to the beta radiation from Kr-85 at location (r, θ), in mRad.

Q = the total release of Kr-85 in gaseous effluents for the relase period, in µCi.

3.17×10^{-2} = pCi/µCi divided by sec/yr

$[\chi/Q](r, \theta)$ = the annual average atmospheric dispersion constant for long-term releases at location (r, θ), in sec/m^3. Since the collection of hourly meteorological data is no longer required or performed at the LACBWR site, a conservative value based on historical site specific annual average χ/Q values will be used. This value is 1.82E-6 sec/m^3.

DF^{γ} and DF^{β} = the gamma and beta air dose factors for exposure to a uniform semi-infinite cloud of Kr-85 in (mRad-m^3/pCi-yr). Numerical values are 1.72E-5 and 1.95E-3 respectively. (Ref. NRC Regulatory Guide 1.109 Rev. 1, October 1977)

Calculation of Gamma and Beta Air Dose Commitments

In accordance with the Technical Specifications, the gamma and beta air dose commitments are to be calculated once per calendar quarter and yearly. Equations 3.9 and 3.10 are used to perform these calculations. Since the only noble gas that needs to be considered at LACBWR is Kr-85, and since a conservative constant value is used for χ/Q, these equations reduce to:

$$D^{\gamma} = 9.923E\text{-}13Q \qquad (3.9a)$$

$$D^{\beta} = 1.125E\text{-}10Q \qquad (3.10a)$$

The following step-by-step procedure is used in conjunction with Figure 3.5 to calculate the quarterly cumulative dose commitments due to Kr-85.

1. Go to Figure 3.5. Enter the Date. Enter the period covered by the calculations.
2. Enter the total Kr-85 activity released in the gaseous effluent during the period being considered, in µCi.
3. Calculate the dose commitments $D^{\gamma}(r, \theta)$ and $D^{\beta}(r, \theta)$ due to Kr-85 using the equations on Figure 3.5.
4. Calculate the percent of the current quarterly and annual technical specification limits and enter on Figure 3.5.

3.3 Compliance with Specification 4.7.2.4

To demonstrate compliance with Technical Specification 4.7.2.4, dose contributions are calculated for H-3, and particulates with half-lives greater than 8 days, identified in gaseous effluents released to unrestricted areas using the methodology presented in NRC Regulatory Guide 1.109 Rev 1, October 1977. This methodology takes the form of the following general equation:

$$D_{\tau a}(r,\theta) = \sum_{P} \sum_{i} M^{P}_{i\tau a} \, W(r,\theta) \, Q_i \qquad (3.11)$$

where:

$D_{\tau a}(r,\theta)$ = the dose commitment to organ τ of an individual in age group a, at distance r in sector θ from the release point, due to the release to the atmosphere of radionuclides other than noble gases, in mRem.

$W(r, \theta)$ = the average dispersion parameter for estimating the dose to an individual at the receptor location (r, θ), for the period of release, in sec/m^3 or m^{-2} as required by the characteristics of the exposure pathway.

Q_i = the total activity of each radionuclide i, other than noble gases, in gaseous effluents for the release period of interest, in µCi.

$M^{P}_{i\tau a}$ = the dose conversion factor for exposure pathway P to organ τ of an individual in age group a, for each identified radionuclide i. The units of $M^{P}_{i\tau a}$ are $(mRem\text{-}m^2)/\mu Ci$ or $(mRem\text{-}m^3)/\mu Ci\text{-}sec)$ as required so that the product $M^{P}_{i\tau a}$ $W(r, \theta)$ is mRem/µCi.

Equation 3.11 may be expanded to the following form where each term is the incremental dose received via one of the three major dose pathways.

$$D_{\tau a}(r, \theta) = \sum_{i} D^{G}_{i\tau a}(r,\theta) + D^{A}_{i\tau a}(r, \theta) + D^{D}_{i\tau a}(r, \theta) \qquad (3.12)$$

where the first term on the right is the external dose from direct exposure to activity deposited on the ground plane, the second term is the dose from inhalation of radionuclides in air, and the third term is the dose from ingestion of foods contaminated by atmospheric releases of radionuclides.

Applying the methodology of R.G. 1.109 Rev. 1, equation 3.12 is expanded as follows:

$$
\begin{aligned}
D_{\tau a}(r,\theta) = {} & \sum_i M^{G}_{i\tau a}\, Q_i\,(D/Q)(r,\theta) \qquad (3.13)\\
& + \sum_i M^{A}_{i\tau a}\, Q_i(\chi/Q)(r,\theta)\\
& + \sum_i M^{DV}_{i\tau a}\, Q_i\,(D/Q)(r,\theta) + (M^{DV}_{14\tau a}\, Q_{14} + M^{DV}_{T\tau a}\, Q_T)\,(\chi/Q)(r,\theta)\\
& + \sum_i M^{Dm}_{i\tau a}\, Q_i\,(D/Q)(r,\theta) + (M^{Dm}_{14\tau a}\, Q_{14} + M^{Dm}_{T\tau a}\, Q_T)\,(\chi/Q)(r,\theta)\\
& + \sum_i M^{DM}_{i\tau a}\, Q_i\,(D/Q)(r,\theta) + (M^{DM}_{14\tau a}\, Q_{14} + M^{DM}_{T\tau a}\, Q_T)\,(\chi/Q)(r,\theta)\\
& + \sum_i M^{DL}_{i\tau a}\, Q_i\,(D/Q)(r,\theta) + (M^{DL}_{14\tau a}\, Q_{14} + M^{DL}_{T\tau a}\, Q_T)\,(\chi/Q)(r,\theta)
\end{aligned}
$$

where:

$(\chi/Q)(r,\theta)$ = the annual average atmospheric dispersion factor for a receptor at the distance r in sector θ from the release point, in sec/m^3. For the LACBWR in the SAFSTOR mode the value for this term is conservatively taken to be the largest historical (1983-1987) undecayed/undepleted χ/Q for a real receptor and is 1.82E-6 sec/m^3.

$(D/Q)(r, \theta)$ = $1.82E\text{-}9m^{-2}$. This is based on the relationship $D/Q = V_d\ \chi/Q$ where V_d = the deposition velocity in m/sec. V_d is generally $\leq$ 1E-3m/sec for dry deposition of submicron aerosols which may be released from the LACBWR facility during SAFSTOR (Ref Whicker, F. W. and Schultz, V., Radioecology: Nuclear Energy and the Environment, Vol II, CRC Press, Inc., Boco Raton, Florida, 1982.

$M^{G}_{i\tau a}$ = $1.0E6\ S_F\ DFG_{i\tau}\ (1-e^{-\lambda_i t_b})/\lambda_i$ and according to R.G. 1.109 the dose to all internal organs (τ) for all age groups (a) is taken to be the same as the total body dose.

$M^{A}_{i\tau a}$ = $3.17E\text{-}2\ BR_a\ DFA_{i\tau a}$

and for the ingestion pathway (DV) for produce (non-leafy-vegetables, fruits, and grains)

$$M^{DV}_{i\tau a} = 1.1E2\ DFI_{i\tau a}\ U^{V}_{a}\ f_g \exp(-\lambda_i t_h)(r(1-\exp(-\lambda_{Ei}\ t_e))/\ Y_v\lambda_{Ei} + B_{iv}\ (1-\exp(-\lambda_i\ t_b))/\ P\lambda_i)$$

for all radionuclides except C-14 and H-3

$$M^{DV}_{14\tau a} = 22\ DFI_{14\tau a}\ U^{V}_{a}\ f_g\ p$$ for C-14

$$M^{DV}_{T\tau a} = 12\ DFI_{T\tau a}\ U^{V}_{a}\ f_g\ /H$$ for tritium

for the ingestion pathway (Dm) for milk

$$M^{Dm}_{i\tau a} = 1.1E2\ DFI_{i\tau a}\ U^{m}_{a}\ F_{mi}\ Q_F \exp(-\lambda_i\ t_f)(f_p\ f_s\ (1-\exp(-\lambda_i\ t_h\ )) + \exp(-\lambda_i\ t_h\ )) \times\ (r(1-\exp(-\lambda_{Ei}\ t_e))/Y_v\lambda_{Ei} + B_{iv}(1-\exp(-\lambda_i\ t_b\ ))/P\lambda_i\ )$$

for all radionuclide except C-14 and H-3

$$M^{Dm}_{14\tau} = 22DFI_{14\tau a}\ U^{m}_{a}\ F_{mi}\ Q_F\ \ p(\exp(-\lambda_{14} t_f))$$ for C-14

$$M^{Dm}_{T\tau a} = 12DFI_{T\tau a}\ U^{m}_{a}\ F_{mi}\ Q_F \exp(-\lambda_T t_f)/H$$ for tritium

for the ingestion pathway (DM) for meat

$$M^{DM}_{i\tau a} = 1.1E2\ DFI_{i\tau a}\ U^{M}_{a}\ F_{fi}\ Q_f \exp(-\lambda_i t_s)\ (f_p f_s(1-\exp(-\lambda_i t_h)) + \exp(-\lambda_i t_h)) \times (r(1-\exp(-\lambda_{Ei}\ t_e))/Y_v\lambda_{Ei}+B_{iv}(1-\exp(-\lambda_i t_b))/P\lambda_i)$$

for all radionuclides except C-14 and H-3

$M^{DM}_{14\tau a} = 22\, DFI_{14\tau a} U^{M}_{a} F_{f14}\, Q_F\, p(\exp(-\lambda_{14} t_s))$ for C-14

$M^{DM}_{T\tau a} = 12\, DFI_{T\tau a}\, U^{M}_{a}\, F_{fT} Q_F \exp(-\lambda_T t_s)/H$ for tritium

For the ingestion pathway (DL) for leafy vegetables:

$$M^{DL}_{i\tau a} = 1.1E2 DFI_{i\tau a} U^{L}_{a} f_e \exp(-\lambda_i t_h)(r(1-\exp(-\lambda_{Ei} t_e))/Y_v \lambda_{Ei} + B_{iv}(1-\exp(-\lambda_i t_b))/P\lambda i)$$

for all radionuclides except C-14 and H-3.

$M^{DL}_{14\tau a} = 22 DFI_{14\tau a} U^{L}_{a} f_e p$ for C-14

$M^{DL}_{T\tau a} = 12 DFI_{T\tau a} U^{L}_{a} f_e/H$ for tritium

The values used for the various parameters in the above equations are those recommended in NRC Regulatory Guide 1.109 Rev.1 for the maximum exposed individual.

Parameter	Dimensions	Description/Source
1.0E6	pCi/μCi	
DFG_{ii}	mRem-m²/pCi-hr	from table E-6 in R.G.
$DFA_{i\tau a}$	mRem/pCi inhaled	from table E-7 thru E-10 in R.G.
$DFA_{14\tau a}$	mRem/pCi inhaled	from table E-7 thru E-10 in R.G.
$DFA_{T\tau a}$	mRem/pCi inhaled	from table E-7 thru E-10 in R.G.
$DFI_{i\tau a}$	mRem/pCi ingested	from tables E-11 thru E-14 in R.G.
$DFI_{14\tau a}$	mRem/pCi ingested	from tables E-11 thru E-14 in R.G.

$DFI_{T\iota a}$		mRem/pCi ingested	from tables E-11 thru E-14 in R.G.
S_F	= 0.7	dimensionless	attenuation factor accounting for shielding by residential structures
λ_i		hr^{-1}	radiological decay constant for nuclide i.
t_b	= 1.31×10^5	hr	period of long-term buildup for activity in soil (nominally 15 yrs)
3.17×10^{-2}		$pCi - yr/\mu Ci - sec$	
BR_a		m^3/yr	inhalation rate for age group a. Table E-5 in R.G.
1.1×10^2		$pCi - yr/\mu Ci - hr$	
U_a^V		kg/yr	consumption rate of produce for individual in age group a. Table E-5 of R.G.
f_g	= 0.76	dimensionless	fraction of produce ingested that is grown in garden of interest.
t_h		hr	time delay between harvest of vegetation or crops and ingestion.
	= 0		for pasture grass by animals
	= 2160		for stored feed by animals
	= 24		for leafy vegetables by man
	= 1440		for produce by man
r	= 0.2	dimensionless	fraction of deposited activity retained on crops, leafy vegetables, or pasture grass.

λ_{Ei}	$= \lambda_i + \lambda_W$	hr^{-1}	the effective removal rate constant for radionuclide i from crops.
λ_W	= .0021	hr^{-1}	removal rate constant for activity on plant or leaf surfaces by weathering ($\simeq$ to 14 day half-life)
t_e		hr	period of crop, leafy vegetable, or pasture grass exposure during growing season.
	= 720		for grass-cow-milk-man pathway
	= 1440		for crop/vegetation-man pathway
Y_v		kg/m^2	agricultural productivity (measured in wet weight)
	= 0.7		for grass-cow-milk-man pathway
	= 2.0		for produce or leafy vegetables ingested by man
B_{iv}		dimensionless	pCi/kg in vegetation per pCi/kg in soil for nuclide i. Table E-1 in R.G.
P	= 240	kg/m^2	effective surface density of soil (dry weight)
22		$pCi-yr-m^3/\mu Ci-kg-\sec$	
p		dimensionless	the ratio of the total annual release time for C-14 to the total annual time during which photosynthesis occurs with the condition that $p \leq 1.0$
	= 1.0		for continuous C-14 releases.
12		$pCi-g-yr/\mu Ci-kg-\sec$	

H	= 8.0	g/m^3	average absolute humidity of the atmosphere at location (r,0)
U_a^m		liters/yr	consumption rate of milk for individual in age group a. Table E-5 of R.G.
F_{mi}		day/l	factor for estimation of activity of nuclide i in milk from that in animal feed (pCi/l in milk per pCi/d ingested by the animal) Table E-1 in R.G.
Q_F	= 50	kg/day	feed or forage consumption rate (wet weight) by milk cow or beef cattle
t_f	= 48	hr	transport time from animal feed-milk-man.
f_p	= 0.5	dimensionless	fraction of the year that animals graze on pasture.
f_s	= 1.0	dimensionless	fraction of daily feed that is pasture when the animal is on pasture
U_a^M		kg/yr	consumption rate of meat & poultry for individual in age group a. Table E-5 of R.G.
F_{fi}		day/kg	factor for estimation of activity of nuclide i in meat from that in animal feed (pCi/kg in meat per pCi/day ingested by the animal) Table E-1 in R.G.
t_s	= 480	hr	average time from slaughter of meat animal to consumption of meat
U_a^L		kg/yr	consumption rate of leafy vegetables for individual in age group a. Table E-5 in R.G.
f_e	= 1.0	dimensionless	fraction of leafy vegetables grown in garden of interest.

Calculations of Dose Commitments due to Gaseous Release other than Noble Gases

In accordance with Technical Specifications, the maximum commitment to a MEMBER OF THE PUBLIC from H-3 and all radionuclides in particulate form with half-lives greater than 8 days shall be determined at least quarterly.

To perform this calculation Eq 3.13 has been formatted on a LOTUS spreadsheet. The quantity in curies of each nuclide (i) released to the atmosphere from the LACBWR facility during the calendar quarter is entered in the appropriate cell of the spreadsheet. The spreadsheet program calculates and displays the total quarterly dose in mRem to the total body and each organ of an individual in each of 4 age groups and the cumulative calender year dose to the total body and each organ. It also determines the maximum exposed organ (and its dose) for each age group each quarter and the dose to the maximum exposed organ in all age groups. The quarterly and cumulative calendar year doses to the maximum exposed organ are compared to the T.S. limits and the relation in terms of percent of the limit is displayed. The maximum incremental organ dose received thru each of the three major pathways is also determined for each age group each quarter.

3.4 Compliance with Specification 4.7.4

Technical specification 4.7.4 specifies a limit for the total annual whole body or organ dose equivalent to any MEMBER OF THE PUBLIC due to all releases of radioactive materials beyond the EFFLUENT RELEASE BOUNDARY and direct radiation from the reactor containment and radioactive waste storage tanks.

The maximum dose to a MEMBER OF THE PUBLIC from each of the release pathways for radioactive materials is determined according to the methodology presented in the appropriate section of this ODCM.

The maximum potential dose to a MEMBER OF THE PUBLIC from direct radiation from the containment and radioactive waste storage tanks is determined by TLD dosimeters located at various locations around the perimeter of the LACBWR access controlled area and the EFFLUENT RELEASE BOUNDARY for the environmental monitoring program. For compliance with this Specification, the actual maximum possible exposure to an actual MEMBER OF THE PUBLIC from direct radiation may be determined from maximum possible exposure times relative to the continuous exposure dose measured by the TLD's. Conservative maximum possible exposure times will be determined by actual observation of the areas of interest by LACBWR management and/or security personnel.

For conservatism, for compliance with T.S. 4.7.4 the maximum total dose to any MEMBER OF THE PUBLIC will be assumed to be the sum of the maximums from each dose pathway even though the actual maximally exposed individual for each of the pathways could not be the same person.

Table 3.1

INFANT DOSE FACTORS P_{ic} (INHALATION) FOR H-3 AND PARTICULATE GASEOUS RELEASE MONITOR ALARM SETPOINT DETERMINATIONS

In Units of mRem-m^3/µCi-yr

Nuclide	Whole Body	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI
H-3	6.47 E2	*	6.47 E2	6.47 E2	6.47 E2	6.47 E2	6.47 E2
MN-54	4.98 E3	*	2.53E4	*	4.98 E3	1.00 E6	7.06 E3
C0-60	1.18 E4	*	8.02 E3	*	*	4.51 E6	3.19 E4
ZN-65	3.11 E4	1.93 E4	6.26 E4	*	3.25 E4	6.47 E5	5.14 E4
SR-90	2.59 E6	4.09 E7	*	*	*	1.12 E7	1.31 E5
RU-106	1.09 E4	8.68 E4	*	*	1.07 E5	1.16 E7	1.64 E5
CS-134	7.45 E4	3.96 E5	7.03 E5	*	1.90 E5	7.97E 4	1.33 E3
CS-137	4.55 E4	5.49 E5	6.12 E5	*	1.72 E5	7.13 E4	1.33 E3
CE-144	1.76 E5	3.19 E6	1.21 E6	*	5.38 E5	9.84 E6	1.48 E5

Values in this table are derived from Tables E-5 and E-10 in App. E of NRC Regulatory Guide 1.109 Rev. 1, October 1977.

* No data available.

Date________________

Figure 3.1

NOBLE GAS (KR-85) RELEASE MONITOR ALARM
SETPOINT CALCULATIONS

Calculation for Alarm Condition (ALERT or HIGH)____________

χ/Q = _________ No. of Stack Blowers = _______ F_s = _______________

Equations:

$$TBF = (1E6)(\chi/Q)(DFB)(F_s)$$

$$SFG = (1.11\,E6)(\chi/Q)(DF^{\gamma})(F_s)$$

$$SFB = (1E6)(\chi/Q)(DFS)(F_s)$$

where:

(χ/Q) = 6.05 E-5 sec/m^3 (ALERT) or 3.90 E-6 sec/m^3 (HIGH)

$$DFB = 1.61\,E\text{-}05\ \frac{\text{mRem-m}^3}{\text{pCi-yr}}$$

$$DF^{\gamma} = 1.72\,E\text{-}05\ \frac{\text{mRad-m}^3}{\text{pCi-yr}}$$

$$DFS = 1.34\,E\text{-}03\ \frac{\text{mRem-m}^3}{\text{pCi-yr}}$$

F_s = 1.65 E7 cc/sec (1 blower) or 3.304 E7 cc/sec (2 blowers)

$$TBF = \_\_\_\_\_\_\_\_\_\_\_\_\ \frac{\text{mRem-cc}}{\mu\text{Ci-yr}}$$

$$SFG+SFB = \_\_\_\_\_\_ + \_\_\_\_\_\_ = \_\_\_\_\_\_\_\_\_\_\ \frac{\text{mRem-cc}}{\mu\text{Ci/yr}}$$

$$Q_{vs}\ \text{(whole body)} = \frac{500\ \text{mRem/yr}}{TBF} = \_\_\_\_\_\_\_\_\_\_\ \mu\text{Ci/cc}$$

$$Q_{vs}\ \text{(skin)} = \frac{3000\ \text{mRem/yr}}{(SFG + SFB)} = \_\_\_\_\_\_\_\_\_\_\ \mu\text{Ci/cc}$$

Figure 3.2

NOBLE GAS (Kr-85) RELEASE MONITOR
ALARM SETPOINT SUMMARY
(μCi/cc in stack effluent)

Q_{vs}	ALERT SETPOINT		HIGH SETPOINT	
	1 BLOWER	2 BLOWERS	1 BLOWER	2 BLOWERS
WHOLE BODY	3.11 E-2	1.55 E-2	4.82 E-1	2.40 E-1
SKIN	2.21 E-3	1.10 E-3*	3.43 E-2	1.71 E-2*

* Since Kr-85's beta dose equivalent component is significantly higher than its gamma dose component, the noble gas monitor alarm setpoints will always be based upon the Q_{vs} for skin dose. Since the alarm setpoints for 2 blowers are the most restrictive, they may be used for all operating conditions without exceeding the limits for instantaneous release.

Figure 3.3 Date____________

H-3 AND PARTICULATE GASEOUS RELEASE MONITOR ALARM SETPOINT DETERMINATION

Alarm being calculated (Alert or High) ________________ χ/Q ______________ sec/m^3 *

Nuclide i	Q_{Pi}	R_{Pi}	$(\chi/Q)\ R_{Pi}\ P_{i\tau}$(inhalation) **						
			W Body	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI
H-3									
Mn-54									
Co-60									
Zn-65									
Sr-90									
Ru(Rh)10									
Cs-134									
Cs-137									
Ce-144									
$\sum_i Q_{Pi}$ =		$\sum_i$ =							

* For alert alarm use 6.05 E-5 sec/m^3 for χ/Q and for High Alarm use 3.90 E-6 sec/m^3

** $P_{i\tau}$ (inhalation) values found in Table 3.1.

DATE________________

Figure 3.4

H-3 AND PARTICULATE GASEOUS RELEASE MONITOR ALARM SETPOINT SUMMARY

Calculation for (Alert or High) ________________ alarm.

$$Q_{P\tau} = \frac{1500 \text{ mRem/yr}}{\sum_i [P_{i\tau}(\text{inhalation}) \times R_{Pi} \times \chi/Q]}$$

$Q_{P\tau}$ = maximum allowed total release rate, µCi/sec to meet TS dose rate limit to organ τ.

τ	$\sum_i (\chi/Q)\, R_{Pi}\, P_{i\tau}(\text{inhalation})$*	$Q_{P\tau}$ (µCi/sec)
Whole Body		
Bone		
Liver		
Thyroid		
Kidney		
Lung		
GI-LLI		

* From Figure 3.3

One-Blower Operation

$$Q_{sa} = \frac{\text{Lowest } Q_{P\tau} \times \Delta F}{1.650E7}$$

where:

ΔF = corrected total flow through sample media, cc

$$Q_{sa} = \frac{\_\_\_\_\ \mu\text{Ci/sec x}\ \_\_\_\_\ \text{cc}}{1.650\ \text{E7 cc/sec}}$$

= __________ µCi

(SPING Ch. 01 ____ Alarm Setpoint)

Two-Blower Operation

$$Q_{sa} = \frac{\text{Lowest } Q_{P\tau} \times \Delta F}{3.304E7}$$

$$Q_{sa} = \frac{\_\_\_\_\ \mu\text{Ci/sec x}\ \_\_\_\_\ \text{cc}}{3.304\ \text{E7 cc/sec}}$$

= ______________µCi

(SPING Ch. 01 _______ Alarm Setpoint)

Date__________

Figure 3.5

AIR DOSE COMMITMENT TO A MEMBER OF THE PUBLIC FROM NOBLE GAS (Kr-85) RELEASE
TECHNICAL SPECIFICATION 4.7.2.3

Release Period ______________ Total Kr-85 Act. Released, Q = ____________μCi

Dose Calculation for Release Period

D^{γ} = 9.923 E-13 Q = ____________mRad
D^{β} = 1.125 E-10 Q = ____________mRad

Technical Specification Limits

	Gamma	Beta Particle
Calendar Quarter	≤ 5 mRad	≤10 mRad
Calendar Year	≤10mRad	≤20 mRad

Current Air Dose Commitment Record for Calendar Year __________

	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Calendar Year	
	Gamma	Beta	Gamma	Beta	Gamma	Beta	Gamma	Beta	Gamma	Beta
Dose, mRad										
% of T.S.										

4. RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

4.1 Compliance with Specification 4.8.1

The Radiological Environmental Monitoring (REM) Program specific assessment locations, sampling media, sampling frequencies and sample analyses are listed on Tables 4.1 and 4.2 and on Diagram 4.1.

4.2 REM Program Description

The Radiological Environmental Monitoring Program is conducted to comply with the requirements of Technical Specifications and in accordance with 10 CFR 50 Appendix I. The REM Program provides measurements of radiation and of radioactive materials in those exposure pathways and for those radionuclides which could potentially lead to radiation doses to Members of the Public resulting from plant effluents. Environmental samples are taken within the surrounding areas of the plant and in selected control or background locations.

The monitoring program at the LACBWR facility includes monitoring of liquid and gaseous releases from the plant, as well as environmental samples of suface air, river water, river sediment, milk, fish, and penetrating radiation.

An annual Interlaboratory Comparison Program is provided to ensure that independent checks on the precision and accuracy of the measurements of radioactive material in environmental samples are performed to demonstrate that the results are reasonably valid.

The sampling frequency of the various environmental samples and the analyses performed on these samples are shown in Table 4.1.

The environmental penetrating radiation dose is measured by thermo-luminescent dosimeters consisting of four lithium fluoride (LiF) chips. The TLD's are located in the vicinity of the plant on poles, trees or adjacent to air sampling locations. The TLD's are collected at least semi-annually, shipped and then analyzed by a contractor.

Air samples are collected continuously at three sites, two of which are within one mile of the plant and the third used as a control, located eighteen miles north of the plant in La Crosse, Wisconsin. Particulate air samples are collected at the rate of approximately 30-60 lpm with Gelman Air Samplers. The air filter consists of a glass fiber filter with an associated pore size of approximately 0.45 μm. The particulate filters are analyzed weekly for gross beta activity with a low background gas flow internal proportional counter, and quarterly particulate composites from each location are gamma analyzed for individual isotopic concentration.

River water is collected monthly. River water samples above, at and below the plant site are collected and are gamma analyzed for isotopic concentration.

A milk sample is collected from one farm within one mile of the plant on a monthly basis during the grazing season. The milk samples are gamma-scanned for radionuclides with at least an eight-day half-life.

Fish samples are collected at least semi-annually from Pool #8 above the plant and Pool #9 below the plant. Samples of the edible portions of the fish are gamma isotopically analyzed.

River sediment (silt) samples are collected twice per year at, above and below the G-3 condenser cooling water discharge point (LACBWR's discharge point) in Pool #9. These samples are gamma isotopically analyzed.

Vegetation is collected from the local area at the time of harvest. These samples are gamma isotopically analyzed.

Table 4.1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample	Number of Samples and Sample Locations	Sampling and Collection Frequency	Type and Frequency of Analysis
1. AIRBORNE PARTICULATES	Minimum of three (3) separate sample locations in area surrounding plant.	Continuous operation of sampler with sample collection as required by dust loading, but at least weekly.	1) Particulate filter sampler. Analyze for gross beta radioactivity ≥ 24 hours following filter change. Perform gamma isotopic analysis on each sample when gross beta activity is > 10 times the control sample (La Crosse). 2) A composite of particulate filters from each location will be gamma analyzed at least once per quarter.
2. DIRECT RADIATION	Minimum of eight (8) locations, at least 4 TLD chips at each location.	At least semiannually.	1) Gamma dose - at least semi-annually.
3. WATERBORNE (River Surface)	Three (3) samples, one at each of the following locations: 1) Above Outfall 2) At Outfall 3) Below Outfall	Monthly.	1) Gamma isotopic analysis monthly on each sample. 2) Tritium analysis on composite sample from each location quarterly.

Table 4.1 - (cont'd)

RADIOLOGICAL ENVIRONMENTAL MO[illegible]NG PR[illegible]GRAM

Exposure Pathway and/or Sample	Number of Samples and Sample Locations	Sampling and Collection Frequency	Type and Frequency of Analysis
4. RIVER SEDIMENT	Three (3) samples, one from each of the following locations: 1) Above Outfall 2) At Outfall 3) Below Outfall	Semi-annually.	1) Gamma isotopic analysis on each sample.
5. INGESTION			
a. Fish	One (1) sample of two (2) different species in area important as a recreational or commercial species.	At least semi-annually.	1) Gamma isotopic analysis of the edible portions of each sample.
b. Milk	One (1) sample (one location).	At least monthly when animals are on pasture (May thru October).	1) Gamma isotopic analysis on each sample.
c. Vegetation	One (1) sample (various locations possible).	At time of harvest.	1) Gamma isotopic analysis of the edible portion of each composite sample.

Table 4.2

PERMANENT ENVIRONMENTAL MONITORING STATION LOCATIONS

LOCATION NO.	LOCATION *	AIR SAMPLE	MILK
1	Pedretti Farm		x
2	P. Malin Farm		x
3	A. Malin Farm		x
4	Dam No. 8	x	
5	Trailer Court	x	
6	Crib House	x	
7	DPC Main Office	x	
8	Radio Tower	x	

* Refer to Diagram 4.1

Diagram 4.1

PERMANENT ENVIRONMENTAL MONITORING LOCATIONS