H.B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2
OFF-SITE DOSE CALCULATIONAL MANUAL
(ODCM)

Revision 3

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1.0 INTRODUCTION

The Off-Site Dose Calculation Manual (ODCM) provides the information and methodologies to be used by H. B. Robinson Steam Electric Plant Unit 2 (HBR) to assure compliance with Specifications 3.9.1, 3.9.2, 3.9.3, 3.9.4, 3.9.5, and 3.9.6 of the H. B. Robinson Technical Specification. These portions are those related to liquid and gaseous radiological effluents. They are intended to show compliance with 10CFR20, Appendix I of 10CFR50, and 40CFR190.

The ODCM is based on "Radiological Effluent Technical Specifications for PWRs (NUREG 0472, Rev. 3, Draft 7), "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants" (NUREG 0133), and guidance from the United States Nuclear Regulatory Commission (NRC). Specific plant procedures for implementation of this manual are presented in H. B. Robinson Unit 2 Plant Operating Manual. These procedures will be utilized by the operating staff of HBR to assure compliance with technical specifications.

The ODCM has been prepared as generically as possible in order to minimize the need for future revisions. However, some changes to the ODCM will be expected in the future. Any such changes will be properly reviewed and approved as indicated in the Administrative Control Section, Specification 6.16.2, of the HBR Technical Specifications.

2.0 LIQUID EFFLUENTS

2.1 MONITOR ALARM SETPOINT DETERMINATION

This methodology determines the monitor alarm setpoint that indicates if the concentration of radionuclides in the liquid effluent released from the site to unrestricted areas exceeds the concentrations specified in 10CFR20, Appendix B, Table II, Column 2, for radionuclides other than dissolved or entrained noble gases or exceeds a concentration 2×10^{-4} µCi/ml for dissolved or entrained noble gases. Two methodologies may be utilized to calculate monitor alarm setpoints. Section 2.1.1 determines a fixed setpoint based on the worst case assumptions that I-131 is the only nuclide being discharged. This is consistent with the limit of 10CFR20, Appendix B, Footnote 3.a. Section 2.1.2 methodology determines the setpoint based on the radionuclide mix via analysis prior to release to demonstrate compliance with 10CFR20, Appendix B, limits and may also be used as an alternative method for calculating setpoints.

2.1.1 Setpoint Based on Iodine-131

The following method applies to liquid releases via the discharge canal when determining the alarm/trip setpoint for the Condensate Polisher Liquid Waste Monitor (RMS-37) and the Steam Generator Blowdown Monitor (RMS-19) during operational conditions when there is no primary to secondary leaks. This methodology complies with Specification 3.9.1.1 of the RETS by satisfying the following equation:

$$\frac{cf}{f + F} \leq C$$

where:

C = The effluent concentration limit (Specification 3.9.1.1) implementing 10CFR20 for the site in µCi/ml.

c = The setpoint, in μCi/ml, of the radioactivity monitor measuring the radioactivity concentration in the effluent line prior to dilution and subsequent release; the setpoint represents a value which, if exceeded, would result in concentrations exceeding the limits of 10CFR20 in the unrestricted area.

f = The waste effluent flow rate in gpm.

F = The dilution water flow rate in gpm.

2.1.1.1 Determine c (the effluent monitor setpoint) in [μCi/ml] for each of the dilution water flow rates.

where: $c = \frac{C(F+f)}{f}$

C = 3×10^{-7} μCi/ml, the effluent concentration limit based on 10CFR20, Appendix B, for I-131.

F = Dilution water flow rate (gpm).

= 160,000 gpm from one circulating water pump[1], Unit 2.
= 250,000 gpm from two circulating water pumps[1], Unit 2.
= 400,000 gpm from three circulating water pumps[1], Unit 2.

or

= 50,000 gpm from one circulating water pump[2], Unit 1.
= 80,000 gpm from two circulating water pumps[2], Unit 1.

f = The maximum acceptable discharge flow rate prior to dilution (gpm).

= 60 gpm for the Waste Disposal System Liquid Effluent Monitor[3].

= 480 gpm for the Steam Generator Blowdown Monitor.

= 450 gpm for the Steam Generator Blowdown Monitor while draining a steam generator.

= 390 gpm for the Condensate Polisher Liquid Waste Monitor.

2.1.1.2 Determine CR (calculated monitor count rate in corrected counts per minute [ccpm]) attributed to the radionuclides for each of the dilution water flow rates.

CR = (c) (E)

E = The applicable effluent monitor efficiency located in the Plant Operating Manual, Volume 15, Curve Book. Use the radioactivity concentration "c" to find CR.

2.1.1.3 Determine SP (the monitor alarm/trip setpoint including background [cpm] for each of the dilution water flow rates.

$$SP = (T_m)(CR) + Bkg + 3.3\sqrt{\frac{Bkg}{2\tau}}$$

where: T_m = Fraction of the radioactivity from the site that may be released via the monitored pathway to ensure that the site boundary limit is not exceeded due to simultaneous releases from several pathways.

= .50 for the Steam Generator Blowdown Monitor (RMS-19).

= .25 for the Condensate Polisher Liquid Waste (RMC-37).

Bkg = the monitor background.

$3.3\sqrt{\frac{Bkg}{2\tau}}$ = statistical variance on the background (Bkg) count rate (CPM) at a 99.95% confidence level at a RC time constant τ (minutes). This is included to prevent inadvertent high/trip alarms due to random counts on the monitor.

2.1.2 Setpoint Based on an Analysis of Liquid Prior to Discharge

The following method applies to liquid releases via the discharge canal when determining the alarm setpoint for the Waste Disposal System Liquid Effluent Monitor (RMS-18), the Steam Generator Blowdown Monitor (RMS-19), and the Condensate Polisher Liquid Waste Monitor (RMS-37) when an analysis of the activity of the principal gamma emitters has been made prior to or during the release.

2.1.2.1 Determine D (the minimum acceptable dilution factor):

$$D = S\sum_i \frac{Ci}{MPC_i} \quad \text{or}$$

$$D = S[\Sigma g \frac{C_g}{MPC_g} + \frac{C_a}{MPC_a} + \frac{C_A}{MPC_A} + \frac{C_t}{MPC_t} + \frac{C_{Fe-55}}{MPC_{Fe-55}}]$$

C_i = Radioactivity concentration of radionuclide "i" in the liquid effluent prior to dilution (µCi/ml) from analysis of the liquid effluent to be released.

C_g = The concentration of each measured gamma-emitting radionuclide observed by gamma spectroscopy including noble gases.

C_a = The measured concentration of alpha-emitting radionuclides observed by gross alpha analysis of the monthly composite sample.

C_s = The measured concentration of Sr-89 and Sr-90 in liquid waste as determined by analysis of the quarterly composite sample.

C_t = The measured concentrations of H-3 in liquid waste as determined by analysis of the monthly composite sample.

C_{Fe-55} = The measured concentration of Fe-55 in liquid waste as determined by analysis of the quarterly composite sample.

MPC_i = MPC_g, MPC_a, MPC_s, MPC_t, and MPC_{Fe-55} are limiting concentrations of the appropriate gamma-emitting radionuclides, alpha-emitting radionuclides, strontium radionuclides, tritium, and iron-55 from 10CFR20, Appendix B, repsectively.

S = 2, A safety factor used as a conservatism to assure that the radionuclide concentrations are less than the limits specified in 10CFR20, Appendix B, at the point of discharge.

2.1.2.3 Determine c the monitor setpoint concentration [μCi/ml] attributed to the radionuclides for the dilution water flow rate available during the release.

$$c = (\sum_g C_g) (\frac{F+f}{D\ f}) (Tm)$$

where:

C_g = The total radioactivity concentration of gamma-emitting radionuclides in liquid effluent prior to dilution (μCi/ml).

f = The maximum approved discharged flow rate prior to dilution (gpm).

= 60 gpm for the Waste Disposal System Liquid Effluent Monitor[3].

= 480 gpm for the Steam Generator Blowdown Monitor.

= 450 gpm for the Steam Generator Blowdown Monitor while draining a steam generator.

= 390 gpm for the Condensate Polisher Liquid Waste Monitor.

F = Dilution water flow rate (gpm).

= 160,000 gpm from one circulating water pump[1], Unit 2.
= 250,000 gpm from two circulating water pumps[1], Unit 2.
= 400,000 gpm from three circulating water pumps[1], Unit 2.

or

= 50,000 gpm from one circulating water pump[2], Unit 1.
= 80,000 gpm from two circulating water pumps[2], Unit 1.

T_m = Fraction of the radioactivity from the site that may be released via the monitored pathway to ensure that the site boundary limit is not exceeded due to simultaneous releases from more than one pathway.

= .25 for the Waste Disposal System Liquid Effluent Monitor (RMS-18).

= .50 for the Steam Generator Blowdown Monitor (RMS-19).

= .25 for the Condensate Polisher Liquid Waste.

If it is determined that $\frac{F+f}{D\ f} < 1$, the release cannot be made. Reevaluate the discharge flow rate prior to dilution and/or the dilution flow rates.

If $\frac{F+f}{D\ f} > 1$, the release may be made.

2.1.2.4 Determine SP (the monitor alarm setpoint [ccpm].

$$SP = (c)\ (E_m) + Bkg + 3.3\sqrt{\frac{Bkg}{2\tau}}$$

where:

E_m = The applicable effluent monitor efficiency based on "c," from the efficiency curves located in the Plant Operating Manual, Volume 15, Curve Book.

Bkg = The monitor background.

$3.3\sqrt{\frac{Bkg}{2\tau}}$ = Statistical variance on the background (Bkg) count rate (CPM) at a 99.95% confidence level at a RC time constant τ (minutes). This factor is included to prevent inadvertent high/trip alarms due to random counts on the monitor.

2.2 COMPLIANCE WITH 10CFR20 (LIQUIDS)

Liquid effluents from H.B. Robinson Unit 2 (HBR) will occur both continuously and on a batch basis. The following sections discuss the methodology which will be utilized by the HBR to show compliance with 10CFR20.

2.2.1 Continuous Releases

Steam generator blowdown is continuously released from HBR. Each operational working day grab samples will be taken of steam generator blowdown. These samples are composited at the rate of 4 ml/gpm/sgr. An aliquot of the SG composite is analyzed each week for I-131 and various other fission, activation, and corrosion products, as outlined in Table 4.10-1 of the technical specification for HBR. Samples are to be maintained until the end of the month for monthly composites. Monthly gross alpha and tritium analysis are performed on this composite. Quarterly composites are made from the monthly composites for strontium and iron-55 analysis. Steam generator volumes are based on blowdown rates. Dissolved and entrained gases will be analyzed monthly via grab sample. Compliance with 10CFR20 during actual release is established through the steam generator blowdown effluent monitor alarm setpoint. This setpoint is based upon I-131 as noted in Section 2.1. However, if a continuous release should occur in which the effluent monitor alarm setpoint is exceeded, then actual compliance with 10CFR20 may be determined utilizing the actual radionuclide mix and the following equation:

$$Conc_i = \frac{C_{ic} V_c}{V_{dc}} \qquad (2.2\text{-}1)$$

where:

$Conc_i$ = Concentration of radionuclide "i" at the unrestricted area, μCi/ml;

$D\tau$ = Cumulative total dose to any organ τ or the total body from continuous and batch releases, mrem;

$$= D_{\tau b} + D_{\tau c}$$

The quarterly limits given above represent one half the annual design objective of Section II.A of Appendix I of 10CFR50. If any of the limits in Expressions 2.3-4 through 2.3-7 are exceeded, a special report pursuant to Technical Specification 6.9.3.2 must be filed with the NRC. This report complies with Section IV.A, of Appendix I of 10CRF50.

2.3.2 Projection of Doses

Doses resulting from the release of liquid effluents will be projected once per 31 days. These projections will include a safety margin, based upon expected operational conditions, which will take into consideration both planned and unplanned releases.

Projected dose will be calculated as follows:

$$PD = \frac{31\ (DA + DB)}{(TE)} + M \qquad (2.3\text{-}8)$$

where:

PD = projected doses in mrem.
DA = dose accumulated during current quarter in mrem.
DB = projected dose from this release.
TE = time elapsed in quarter in days.
M = safety margin in mrem.

If the projected doses exceed 0.2 mrem to the whole body or 0.6 mrem to any organ when averaged over a calendar quarter, the liquid rad-waste equipment will be operated to reduce the radioactive materials in the liquid effluent.

3.0 GASEOUS EFFLUENTS

3.1 MONITOR ALARM SETPOINT DETERMINATION

This methodology determines the monitor alarm setpoint if the dose rate in the unrestricted areas due to radionoble gases in the gaseous effluent released from the site to areas at and beyond the site boundary exceeds 500 mrem/year to the whole body or exceeds 3000 mrem/year to the skin using a conservative mix (GALE Code).

The methodology described in Section 3.1.2 provides an alternative means to determine monitor alarm setpoints when an analysis is performed prior to release.

3.1.1 Setpoint Based on Conservative Radionuclide Mix (Ground and Mixed Mode Releases

Releases through the steam generator flash tank vent can only occur through this vent when significant primary-to-secondary leakage exists within the steam generators and the blowdown is not going through heat recovery. Detection of primary-to-secondary leakage is accomplished most effectively by continuously monitoring the condenser vacuum pump vent (RMS-15). Steam generator blowdown is continuously monitored by RMS-19 as a liquid pathway.

The following method applies to gaseous releases via the plant vent and condenser vacuum pump vent when determining the high-alarm setpoint for the plant vent gas monitor (RMS-14) and condenser vacuum pump vent gas monitor (RMS-15), and the Fuel Handling Basement Exhaust Monitor (RMS-20), using the GALE code during the following operational conditions:

- Continuous release via the plant vent (RMS-14).
- Continuous release via the condenser vacuum pump vent (RMS-15).
- Continuous release via the Fuel Handling Basement Exhaust (RMS-20).

3.1.1.1 Determine the "mix" (noble gas radionuclides and composition) of the gaseous effluent.

Determine S_i, the fraction of the total noble gas radioactivity in the gaseous effluent comprised by noble gas radionuclide "i," for each individual noble gas radionuclide in the gaseous effluent or use the Si from Table 3.1-1 when using GALE Code.

$$S_i = \frac{A_i}{\sum_i A_i} \qquad (3.1\text{-}1)$$

A_i = The radioactivity of noble gas radionuclide "i" in the gaseous effluent from Table 3.1-1.

3.1.1.2 Determine the Q_m, the maximum acceptable total release rate [μCi/sec] of all noble gas radionuclides in the gaseous effluent based upon the whole body exposure limit of 500 mrem/year by:

$$Q_m = \frac{500}{(\overline{X/Q}) \sum_i K_i S_i} \qquad (3.1\text{-}2)$$

$(\overline{X/Q})$ = The highest calculated annual average relative dispersion factor for any area at or beyond the unrestricted area boundary for all sectors (sec/m^3).

= 8.1 E-5 sec/m^3 (Continuous Ground Release) from Table A-1, Appendix A.

= 9.9 E-7 sec/m^3 (Continuous Elevated Release) from Table A-10, Appendix A, only with upper wind speed $\leq$ 9 mph.

K_i = The total whole body dose factor due to gamma emissions from noble gas radionuclide "i" (mrem/yr/ μCi/m^3) from Table 3.1-2.

3.1.1.3 Determine Q_m, the maximum acceptable release rate [μCi/sec] of all gas radionuclides in the gaseous effluent based upon the skin exposure limit of 3000 mrem/yr by:

$$Q_m = \frac{3000}{(\overline{X/Q}) \sum_i [(L_i + 1.1 M_i) S_i]} \qquad (3.1\text{-}3)$$

$L_i + 1.1M_i$ = The total skin dose factor due to emissions from noble gas radionuclide "i" (mrem/yr/μCi/m^3) from Table 3.1-2.

3.1.1.4 Determine C_m, the maximum acceptable total radioactivity concentration [μCi/cc] of all noble gas radionuclides in the gaseous effluent.

$$C_m = \frac{2.12\ E\text{-}3\ Q_m}{F} (T_m)\ (SF) \qquad (3.1\text{-}4)$$

NOTE: Use the <u>lower</u> of the Q_m values obtained in Sections 3.1.1.2 and 3.1.1.3. This will protect both the skin and total body from being exposed to the limit.

where:

T_m = Fraction of the radioactivity from the site that may be released via the monitored pathway to ensure that the site boundary limit is not exceeded due to simultaneous releases from several pathways.

= 0.91 for Plant Vent Gas Monitor (RMS-14).

= 0.01 for the Condenser Vacuum Pump Vent Monitor (RMS-15).

= 0.06 for the Fuel Handling Basement Exhaust Monitor (RMS-20).

= 0.01 for the E&RC Building Hood Exhaust Monitor (RMS-22).

F = The maximum acceptable effluent flow rate at the point of release (cfm).

= 60,000 cfm for plant vent.

= 200 cfm for the condenser vacuum pump vent.

= 10,200 cfm for the fuel-handling building.

= 11,500 cfm for the E&RC building hood exhaust.

2.12 E-3 = Unit conversion constant to convert µCi/sec/cfm to µCi/cc. $[\frac{sec - ft^3}{min - cc}]$

SF = An engineering factor used to provide a margin of safety for cumulated measurement uncertainties. = 0.5

3.1.1.5 Determine CR, the calculated monitor count rate above background attributed to the noble gas radionuclides [cpm], by:

$$CR = (C_m)(E_m) \qquad (3.1\text{-}5)$$

where:

E_m = Obtained from the applicable effluent monitor efficiency curve located in the Plant Operating Manual, Volume 15, Curve Book. Use the radioactivity concentration "C_m" to find CR.

3.1.1.6 Determine the HSP, the monitor high-alarm setpoint including background [cpm], by:

$$HSP = CR + background + 3.3\sqrt{\frac{Bkg}{2\tau}} \qquad (3.1\text{-}6)$$

where:

$3.3\sqrt{\frac{Bkg}{2\tau}}$ = Statistical variance on the background (Bkg) counting rate quoted at the 99.95% confidence level at a RC time constant τ (minutes). This term is included to prevent inadvertent high alarm trips due to random fluctuations in the monitor background.

3.1.2 Setpoint Based on Sample Analysis Prior to Release

The following method applies to gaseous releases when determining the high-alarm setpoint with prior sample analysis and using the maximum acceptable effluent flow rate at the point of release. The method applies to the following conditions.

Batch Releases

- Containment purge.*
- Containment pressure relief.
- Waste gas decay tanks.

Continuous Releases

- Plant vent.
- Condenser vacuum pump vent.
- Fuel handling basement exhaust.
- Environmental and Radiation Control Building Hood Exhaust.
- Containment purge.

* Batch containment purge is considered as 1 volume of containment air removed.

3.1.2.1 Determine R_i, the noble gas release rate [μCi/sec] for radionuclide "i":

$$R_i = 472 (C_i) (F). \quad (3.1\text{-}7)$$

where:

472 = A conversion factor to convert cfm to cc/sec.

C_i = The radioactivity concentration of noble gas radionuclide "i" from analysis* of gaseous effluent (μCi/cc) from the Condenser Vacuum Pump Vent, Plant Vent (stack), Fuel Handling Basement Exhaust, and the Environmental & Radiation Control (E&RC) Building Hood Exhaust.

Containment Purge--**

(μCi/cc_i from analysis of Containment Vent) (0.368) +
(μCi/cc_i from analysis of Plant Vent) (0.632)

Containment Pressure Relief--**

(μCi/cc_i from analysis of Containment Vent) (0.040) +
(μCi/cc_i from analysis of Plant Vent) (0.960)

Waste Gas Decay Tanks--

(μCi/cc_i from analysis of WGDT) (0.0017) +
(μCi/cc_i from analysis of Plant Vent) (0.9983)

Waste Gas Decay Tanks during Containment Purge--

(μCi/cc_i from analysis of WGDT) (0.0011) +
(μCi/cc_i from analysis of Plant Vent) (0.631) +
(μCi/cc_i from analysis of C.V.) (0.368)

NOTES:

*If there are no isotopes identified in the sample, the LLD's for Xe-133 and Kr-85 may be used as actual values for the purpose of the setpoint calculation.

**$\mu Ci/cc_i$ from analysis for CV when RMS-12 is lined up on the CV.

0.368 = Dilution correction factor for C.V. Purge $= \frac{35,000 \text{ CFM}}{(60,000 + 35,000) \text{ CFM}}$

0.632 = Dilution correction factor for Plant Vent during C.V. Purge $= \frac{60,000 \text{ CFM}}{(60,000 + 35,000) \text{ CFM}}$

0.040 = Dilution correction factor for C.V. Pressure Relief $= \frac{2500^* \text{ CFM}}{(60,000 + 2500^*) \text{ CFM}}$

0.960 = Dilution correction factor for Plant Vent during C.V. Pressure Relief $= \frac{60,000 \text{ CFM}}{(60,000 + 2500^*) \text{ CFM}}$

0.0017 = Dilution correction factor for Waste Gas Decay Tank $= \frac{100 \text{ CFM}}{(60,000 + 100) \text{ CFM}}$

0.9983 = Dilution correction factor for Plant Vent during WGDT Release $= \frac{60,000 \text{ CFM}}{(60,000 + 100) \text{ CFM}}$

0.0011 = Dilution correction factor for Waste Gas Decay Tank during a Continuous C.V. Purge and Plant Vent Release $= \frac{100 \text{ CFM}}{(60,000 + 35,000 + 100) \text{ CFM}}$

0.631 = Dilution correction factor for Plant Vent during a Continuous C.V. Purge and Plant Vent Release $= \frac{60{,}000 \text{ CFM}}{(60{,}000 + 35{,}000 + 100) \text{ CFM}}$

0.368 = Dilution correction factor for Continuous C.V. Purge during WGDT Release $= \frac{35{,}000 \text{ CFM}}{(60{,}000 + 35{,}000 + 100) \text{ CFM}}$

F = The maximum acceptable effluent flow rate at the point of release (CFM)

= 200 CFM for the condenser

= 60,000 CFM for the plant vent

= 10,200 CFM for the fuel handling basement exhaust

= 11,500 CFM for the E&RC building hood exhaust

= 95,000 CFM for the containment vessel purge plus plant vent

= 62,500 CFM for the containment vessel pressure relief

= 60,100 CFM for the waste gas decay tank

= 95,100 CFM for the waste gas decay tank during a continuous containment vessel purge

= 35,000 CFM for containment vessel purge or continuous release

*2500 CFM--Refer to Appendix B.4 for additional information

3.1.2.2 Determine the monitor alarm setpoint based on total body and skin dose rate:

a. Determine dose rate for total body (mrem/yr).

$$DR_{TB} = (\overline{X/Q})\ \Sigma_i\ K_i\ R_i \qquad (3.1\text{-}8)$$

where:

$\overline{X/Q}$ = The highest calculated annual average relative dispersion factor for any area at or beyond the unrestricted area boundary for all sectors (sec/m^3) from Appendix A.

= 8.1 E-5 sec/m^3 (continuous ground release) from Table A-1, Appendix A.

= 9.9 E-7 sec/m^3 (continuous elevated release) from Table A-10, Appendix A, only with upper wind speeds of $\leq$ 9 mph.

= 5.1 E-5 sec/m^3 (Batch Ground Release) from Table A-7, Appendix A.

= 2.9 E-6 sec/m^3 (Batch Elevated Release) from Table A-16, Appendix A, only with upper wind speeds of $\leq$ 9 mph.

K_i = The total whole body dose factor due to gamma emissions from noble gas radionuclide "i" (mrem/yr/µCi/m^3) from Table 3.1-2.

b. Determine dose rate for skin (mrem/yr).

$$DR_{SK} = \overline{X/Q}\ \Sigma_i\ (L_i + 1.1\ M_i)\ R_i \qquad (3.1\text{-}9)$$

where:

$L_i + 1.1\,M_i$ = The total skin dose factor for noble gas emission "i" radionuclide (mrem/yr/µCi/m^3) from Table 3.1-2

c. Determine the noble gas emission Projected Dose Rate Ratio (PDRR) for Total Body and Skin.

$$PDRR_{TB} = \frac{DR_{TB}}{500} \qquad (3.1\text{-}10)$$

$$PDRR_{SKIN} = \frac{DR_{SKIN}}{3000} \qquad (3.1\text{-}11)$$

500 = The allowable total body dose rate due to noble gas gamma emissions in mrem/yr.

3000 = The allowable skin dose rate due to noble gas beta emissions in mrem/yr.

d. Determine the maximum monitor setpoint concentration (µCi/cc) for total body and skin.

$$\text{Maximum Monitor Total Body Setpoint} = \frac{(\Sigma_i Ci)}{(PDRR_{TB})}\,(SF)\,(T_m) \qquad (3.1\text{-}12)$$

$$\text{Maximum Monitor Skin Setpoint} = \frac{(\Sigma_i Ci)}{(PDRR_{SKIN})}\,(SF)\,(T_m) \qquad (3.1\text{-}13)$$

where:

SF = An engineering factor used to provide a margin of safety for cumulative uncertainties of measurements.

= .5

T_m = Fraction of the radioactivity from the site that may be released via the monitored pathway to ensure that the site boundary limit is not exceeded due to simultaneous releases from several pathways.

= 0.91 for the Plant Vent Gas Monitor (RMS-14).

= 0.01 for the Condenser Vacuum Pump Vent Monitor (RMS-15).

= 0.06 for the Fuel Handling Basement Exhaust Monitor (RMS-20).

= 0.01 for the E&RC Building Hood Exhaust Monitor (RMS-22).

= 0.81 for C.V. releases via R-11 and R-12 [This indicates 0.81 of 10CFR20 limits for Containment releases and is also monitored by R-14. 0.91 = 0.81 + 0.10 (Normal Plant Releases)]

e. Determine the maximum monitor setpoint (CPM) for total body (S_t) and skin (S_s).

(Maximum total body setpoint in μCi/cc) (monitor efficiency) +

$$Bkg + 3.3\sqrt{\frac{Bkg}{2\tau}} \qquad (3.1\text{-}14)$$

(Maximum skin setpoint in μCi/cc) (monitor efficiency) + Bkg +

$$3.3 \sqrt{\frac{Bkg}{2\tau}} \qquad (3.1\text{-}15)$$

Monitor efficiency = Obtained from the applicable effluent monitor efficiency curve located in the Plant Operating Manual, Volume 15, Curve Book. Use the radioactivity concentration (μCi/cc) to find (CPM).

Bkg = The monitor background.

$3.3 \sqrt{\frac{Bkg}{2\tau}}$ = Statistical variance on the background (Bkg) count rate (CPM) at a 99.95% confidence level at a RC time constant τ (minutes). This factor is included to prevent inadvertent high/trip alarms due to random counts on the monitor.

f. Determine the actual gaseous monitor setpoint:

The setpoints that were determined based on the dose rate limits to the total body (S_t) and to the skin (S_s) are compared and the lesser value is used as the actual setpoint.

3.2 COMPLIANCE WITH 10CFR20 (GASEOUS)

3.2.1 Noble Gases

The gaseous effluent monitors setpoints are utilized to show compliance with 10CFR20 for noble gases. However, because they are based upon a conservative mix of radionuclides, the possibility exists that the setpoints could be exceeded and yet 10CFR20 limits may actually be met. Therefore, the following methodology has been provided in the event that if the alarm trip setpoints are exceeded, a determination may be made as to whether the actual releases have exceeded 10CFR20.

The dose rate in unrestricted areas resulting from noble gas effluents is limited to 500 mrem/year to the total body and 3000 mrem/year to the skin. Based upon NUREG 0133, the following are used to show compliance with 10CFR20.

$$\sum_i K_i [(\overline{X/Q})_v \dot{Q}_{iv} + (\overline{X/Q})_e \dot{Q}_{ie}] \leq 500 \text{ mrem/yr} \quad (3.2\text{-}1)$$

$$\sum_i (L_i + 1.1 M_i) [(\overline{X/Q}) \dot{Q}_{iv} + (\overline{X/Q}) \dot{Q}_{ie}] \leq 3000 \text{ mrem/yr} \quad (3.2\text{-}2)$$

where:

$(\overline{X/Q})_v$ = Annual average relative dilution for plant vent releases at the site boundary, sec/m^3.

= From Table A-1 for ground level releases.

= From Table A-10 for elevated mode releases only with upper wind speed of $\leq$ 9 mph.

$(\overline{X/Q})_e$ = Annual average relative dilution for condenser vacuum pump vent releases at the site boundary, sec/m^3.

= From Table A-1 for ground level releases.

K_i	=	The total body dose factor due to gamma emissions for noble gas radionuclide "i," mrem/year per $\mu Ci/m^3$.
L_i	=	The skin dose factor due to beta emissions for noble gas radionuclide "i," mrem/year per $\mu Ci/m^3$.
M_i	=	The air dose factor due to gamma emissions for noble gas radionuclide "i," mrad/year per $\mu Ci/m^3$.
1.1	=	The ratio of the tissue to air absorption coefficients over the energy range of the photon of interest, mrem/mrad (reference NUREG 0133, October 1978).
$\dot{Q}_{ie}$	=	The release rate of noble gas radionuclide "i" in gaseous effluents from the condenser vacuum pump vent, fuel handling basement exhaust, and the environmental and radiation control building hood exhaust, $\mu Ci/sec$.
$\dot{Q}_{iv}$	=	The release rate of noble gas radionuclide "i" in gaseous effluents from the plant vent $\mu Ci/sec$.

The determination of limiting location for implementation of 10CFR20 for noble gases is a function of the radionuclide mix, release rate, and the meteorology. For the most limiting location, the radionuclide mix will be based on sample analysis of the effluent gases.

The X/Q value utilized in the equations for implementation of 10CFR20 is based upon the maximum long-term annual average $(\overline{X/Q})$ in the unrestricted area. Table 3.2-2 presents the distances from HBR to the nearest area for each of the 16 sectors as well as to the nearest residence, vegetable garden, cow, goat, and beef animal. Long-term annual average $(\overline{X/Q})$ values for the HBR release points to the special locations in Table 3.2-2 are presented in Appendix A. A description of their derivation is also provided in this appendix.

Q_{iv} = Release rate of radionuclide "i" from the plant vent, μCi/sec.

Q_{ic} = Release rate of radionuclide "i" from the condenser vacuum pump vent, μCi/sec.

$(\overline{X/Q})_v$ = Annual average relative dilution for plant vent releases at the site boundary, sec/m^3.

$(\overline{X/Q})_e$ = Annual average relative dilution for condenser vacuum pump vent releases at the site boundary, sec/m^3.

P_{i_I} = The dose parameter for Iodine-131, Iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days for the inhalation pathway only in the most restrictive sector in mrem/yr per μCi/m^3. The dose factor is based on the most restrictive group (child) and most restrictive organ at the SITE BOUNDARY (see Table 3.3-4).

where:

In the calculation to show compliance with 10CFR20, only the inhalation is considered. A description of the methodology used in calculating the Pi values is presented in Appendix B. Compliance with 10CFR20 is achieved if the dose rate via inhalation pathway to a child is $\leq$ 1500 mrem/year.

TABLE 3.2-4

P_i VALUES FOR A CHILD FOR THE H.B. ROBINSON UNIT NO. 2*

Nuclide	Pi Bone	Pi Liver	Pi T. Body	Pi Thyroid	Pi Kidney	Pi Lung	Pi GI-LLI
H-3	ND	1.12E3	1.12E3	1.12E3	1.12E3	1.12E3	1.12E3
Cr-51	ND	ND	1.54E2	8.55E1	2.43E1	1.70E4	1.08E3
Mn-54	ND	4.29E4	9.51E3	ND	1.00E4	1.58E6	2.29E4
Fe-55	4.74E4	2.52E4	7.77E4	ND	ND	1.11E5	2.87E3
Fe-59	2.07E4	3.34E4	1.67E4	ND	ND	1.27E6	7.07E4
Co-58	ND	1.77E3	3.16E3	ND	ND	1.11E6	3.44E4
Co-60	ND	1.31E4	2.26E4	ND	ND	7.07E6	9.62E4
Ni-63	8.21E5	4.63E4	2.80E4	ND	ND	2.75E5	6.33E3
Zn-65	4.26E4	1.13E5	7.03E4	ND	7.14E4	9.95E5	1.63E4
Rb-86	ND	1.98E5	1.14E5	ND	ND	ND	7.99E3
Sr-89	5.99E5	ND	1.72E4	ND	ND	2.16E6	1.67E5
Sr-90	1.01E8	ND	6.44E6	ND	ND	1.48E7	3.43E5
Y-91	9.14E5	ND	2.44E4	ND	ND	2.63E6	1.84E5
Zr-95	1.90E5	4.18E4	3.70E4	ND	5.96E4	2.23E6	6.11E4
Nb-95	2.35E4	9.18E3	6.55E3	ND	8.62E3	6.14E5	3.70E4
Ru-103	2.79E3	ND	1.07E3	ND	7.03E3	6.62E5	4.48E4
Ru-106	1.36E5	ND	1.69E4	ND	1.84E5	1.43E7	4.29E5
Ag110m	1.69E4	1.14E4	9.14E3	ND	2.12E4	5.48E6	1.00E5
Te-125m	6.73E3	2.33E3	9.14E2	1.92E3	ND	4.77E5	3.38E4
Te-127m	2.49E4	8.55E3	3.02E3	6.07E3	6.36E4	1.48E6	7.14E4
Te-129m	1.92E4	6.85E3	3.04E3	6.33E3	5.03E4	1.76E6	1.82E5
I-131	4.81E4	4.81E4	2.73E4	1.62E7	7.88E4	ND	2.84E3
Cs-134	6.51E5	1.01E6	2.25E5	ND	3.30E5	1.21E5	3.85E3
Cs-136	6.51E4	1.71E5	1.16E5	ND	9.55E4	1.45E4	4.18E3
Cs-137	9.07E5	8.25E5	1.28E5	ND	2.82E5	1.04E5	3.62E3
Ba-140	7.40E4	6.48E1	4.33E3	ND	2.11E1	1.74E6	1.02E5
Ce-141	3.92E4	1.95E4	2.90E3	ND	8.55E3	5.44E5	5.66E4
Ce-144	6.77E6	2.12E6	3.61E5	ND	1.17E6	1.20E7	3.89E5
Pr-143	1.85E4	5.55E3	9.14E2	ND	3.00E3	4.33E5	9.73E4
Nd-147	1.80E4	8.73E3	6.81E2	ND	4.81E3	3.28E5	8.21E4

References:

1. NUREG 0133, Section 5.2.1.1 (Calculation of P_i (Inhalation)).
2. Regulatory Guide 1.109 Table E-5, Table E-9 (Breathing Rate Constant and Inhalation dose factors).

*Units are mrem/yr per $\mu Ci/m^3$.

3.3 COMPLIANCE WITH 10CFR50 (GASEOUS)

3.3.1 Noble Gases

3.3.1.1 Cumulation of Doses

Based upon NUREG 0133, the air dose in the unrestricted area due to noble gases released in gaseous effluents can be determined by the following equations:

$$D_\gamma = 3.17 \times 10^{-8} \sum_i M_i \left[(\overline{X/Q})_v \, \overline{Q}_{iv} + (\overline{X/q})_v \, \overline{q}_{iv} + (\overline{X/Q})_e \, \overline{Q}_{ie} \right] \quad (3.3\text{-}1)$$

$$D_\beta = 3.17 \times 10^{-8} \sum_i N_i \left[(\overline{X/Q})_v \, \overline{Q}_{iv} + (\overline{X/q})_v \, \overline{q}_{iv} + (\overline{X/Q})_e \, \overline{Q}_{ie} \right] \quad (3.3\text{-}2)$$

where:

D_γ = The air dose from gamma radiation, mrad.

D_β = The air dose from beta radiation, mrad.

M_i = The air dose factor due to gamma emissions for each identified noble gas radionuclide "i," mrad/ year per $\mu Ci/m^3$.

N_i = The air dose factor due to beta emissions for each identified noble gas radionuclide "i," mrad/year per $\mu Ci/m^3$.

$(\overline{X/Q})_v$ = The annual average dilution for areas at or beyond the unrestricted area boundary for long-term plant vent releases (> 500 hrs/year), sec/m^3.

= From Table A-1 for ground level releases.

= From Table A-10 for elevated mode releases to be used only with upper wind speeds $\leq$ 9 mph.

$(\overline{X/q})_v$ = The dilution for areas at or beyond the unrestricted area boundary for short-term vent releases ($\leq$ 500 hours/year), sec/m^3.

= From Table A-7 for ground level releases.

= From Table A-16 for mixed mode releases.

$(\overline{X/Q})_e$ = Annual average relative dilution for condenser vacuum pump vent releases at the site boundary, (> 500 hours/year), sec/m^3.

= From Table A-1 for ground level releases;

q_{iv} = The average release of noble gas radionuclide "i" in gaseous releases for short-term plant releases ($\leq$ 500 hours/year), μCi;

$\overline{Q}_{ie}$ = The average release of noble gas radionuclide "i" in gaseous releases for long-term condenser vacuum pump vent releases (> 500 hours/year), μCi;

$\overline{Q}_{iv}$ = The average release of noble gas radionuclide "i" in gaseous effluents for long-term vent releases (> 500 hours/year), μCi;

3.17×10^{-8} = The inverse of the number of seconds in a year $(sec/year)^{-1}$.

At HBR the limiting location is 0.26 miles SSE. Based upon the tables presented in Appendix A, substitution of the short-term X/Q value into Equation 3.3-1 yields lower dose value than the long-term X/Q values been used. In order to be conservative, for purposes of this document only, long-term annual

For the calendar year:

$$D_\gamma \leq 10 \text{ mrad} \quad (3.3\text{-}5)$$

$$D_\beta \leq 20 \text{ mrad} \quad (3.3\text{-}6)$$

The quarterly limits given above represent one-half of the annual design objectives of Section II.B.1 of Appendix I of 10CFR50. If any of the limits of Equations 3.3-3 through 3.3-6 are exceeded, a special report pursuant to Technical Specification 6.9.4.a must be filed with the NRC. This report complies with Section IV.A of Appendix I of 10CFR50.

3.3.1.2 Projection of Doses

Doses resulting from the release of gaseous effluents will be projected once per 31 days. These projections will include a safety margin based upon expected operational conditions which will take into consideration both planned and unplanned releases.

Projected dose will be calculated as follows:

$$PD = \frac{31\,(DA + DB)}{(TE)} + M \quad (3.3\text{-}7)$$

where:

PD = Projected doses in mrem.

DA = Dose accumulated during current quarter in mrem.

DB = Projected dose from this release.

TE = Time elapsed in quarter in days.

M = Safety margin in mrem.

3.17×10^{-8} = The inverse of the number of seconds in a year, $(\text{sec/year})^{-1}$.

$(\overline{X/Q})_v$ = Annual average relative concentration for plant vent releases (> 500 hrs/yr) sec/m^3.

= From Table A-1 for ground level releases.

= From Table A-10 for elevated mode releases only to be used with wind speeds $\leq$ 9 mph.

$(\overline{X/Q})_e$ = Annual average dilution for condenser vacuum pump vent releases (> 500 hours/yr) sec/m^3.

= From Table A-1 for ground level releases.

$(\overline{D/Q})_v$ = Annual average deposition factor for plant vent releases (> 500 hrs/yr) m^{-2}.

= From Table A-3 for ground level releases.

= From Table A-12 for elevated mode releases only to be used with upper wind speeds $\leq$ 9 mph.

$(D/q)_v$ = Relative deposition factor for short-term plant vent releases ($\leq$ 500 hrs/yr), m^{-2}.

= From Table A-9 for ground level releases.

= From Table A-18 for elevated mode releases only to be used with upper wind speeds $\leq$ 9 mph.

$(D/Q)_e$ = Annual average relative deposition factor for condenser vacuum pump vent releases (> 500 hrs/ yr), m^{-2}.

= From Table A-3 for ground level releases.

For the calendar quarter:

$$D_\tau \leq 7.5 \text{ mrem} \quad (3.3\text{-}9)$$

For the calendar year:

$$D_\tau \leq 15 \text{ mrem} \quad (3.3\text{-}10)$$

The quarterly limits given above represent one-half the annual design objectives of Section II.C of Appendix I of 10CFR50. If any of the limits of Equations 3.3-9 or 3.3-10 are exceeded, a special report pursuant to Technical Specification 6.9.4.a must be filed with the NRC. This report complies with Section IV.A of Appendix I of 10CFR50.

3.3.2.2 Projection of Doses

Doses resulting from release of radioiodines and particulate effluents will be projected once per 31 days. These projections will include a safety margin based upon expected operational conditions which will take into consideration both planned and unplanned releases.

Projected dose will be calculated as follows:

$$PD = \frac{31\ (DA + DB)}{(TE)} + M \quad (3.3\text{-}11)$$

where:

PD = Projected doses in mrem.

DA = Dose accumulated during current quarter in mrem.

DB = Projected dose from this release.

TE = Time elapsed in quarter in days.

M = Safety margin in mrem.

Exposure Pathway and/or Sample	Sample Point	Sample Point Description, Distance, and Direction	Sampling and Collection Frequency	Analysis[1] Frequency	Analysis[1]
2. Direct Radiation (continued)	13.	Corner pine tree where dirt road splits 1.0 mile W.	Continuous measurement with readout at least once per quarter (TLDs)	Quarterly	Gamma Dose[5]
	14.	Power pole by Highway 151 on front of Pine Ridge Church 0.9 mile WNW.			
	15.	Pine tree down dirt road off Highway 151 directly adjacent to ash pond on CP&L property 1.0 miles NW.			
	16.	Southeast fence at Darlington County I.C. Turbine Plant 1.0 mile NNW.			
	17.	Small pine tree, right side of road, 1.0 mile down Discharge Canal road at Old Unit One Weir 1.1 miles N.			
	18.	Left side of train trestle over Black Creek 0.7 mile SE.			
	19.	Third power pole on Road #S-16-23 from intersection with 1.0 mile E.			
	20.	Power Pole #47 at right side of Road #S-16-39 going north 1.3 miles ENE.			
	21.	Power pole in the yard of A. Atkinson at Atkinson's boat landing 1.4 miles NE.			
	22.	Shady Rest at light pole near the dock 1.9 miles NNE.			
	23.	Power Pole #41E-5 on Road #41E-5 on Road #S-16-39 1.2 miles ESE.			
	24.	151 north past peach farm, first paved Road #S-13-711 left. Fifth pole left side of road. Yellow marking 5.0 miles NW.			

.ble 4.0-1 (continued)

Exposure Pathway and/or Sample	Sample Point	Sample Point Description, Distance, and Direction	Sampling and Collection Frequency	Analysis[1] Frequency	Analysis[1]
2. Direct Radiation (continued)	25.	Road #S-13-346 off 151 North. Cross railroad tracks and proceed 3/8 mile. Walk down right fence line into the woods towards pond. Badge on right pine tree ~ 18 yards directly in front of fence marked "No Trespassing" 4.6 miles NNW.	Continuous measurement with readout at least once per quarter (TLDs)	Quarterly	Gamma Dose[5]
	26.	Power pole #32J-6 across old yellow house on Road #S-13-346 5.0 miles N.			
	27.	Road #S-13-763, ~ 1.3 miles from intersection 5.0 miles NNE.			
	28.	Power Pole #30-4-A near dumpster on road #S-13-39 4.8 miles NE.			
	29.	Transmission pole nearest Road #S-16-20 ~ 1/2 mile south of lookout tower 4.1 mile ENE.			
	30.	Located on Road #S-16-20, power pole in front yard of Johnson Fence and Awning 4.6 miles E.			
	31.	Lakeshore Drive, Pole #1122 right side of road. Yellow marking 4.6 miles ESE.			
	32.	Straight down the end of Kalber Drive, 12 feet up the transmission tower. Yellow marking 4.5 miles SE.			
	33.	Power Pole #25-4, left side of Road #S-16-493 near Harley Segar's driveway 4.6 miles SSE.			
	34.	Transmission pole nearest Road #S-16-772 4.6 miles S.			

Exposure Pathway and/or Sample	Sample Point	Sample Point Description, Distance, and Direction	Sampling and Collection Frequency	Analysis[1] Frequency	Analysis[1]
4. Ingestion a. Milk	53.	Lyndale Farm 9.0 miles SW (control station)	Semimonthly when animals are on pasture; monthly @ other times	Semimonthly when animals are on pasture; monthly @ other times	Gamma Scan[4] and I-131 analysis semi-monthly when animals are on pasture; monthly @ other times
b. Fish	45.	Site varies within Lake Robinson.	Semiannually (collect comparable species at all three locations)	Each sample	Gamma Scan[4] Edible portion
	46.	Prestwood Lake 4.9 miles ESE.			
	47.	Bee Lake (Control Station)[2] 13 miles NNW or May Lake 12.5 miles NW.			
c. Food Products leafy vege-tables	58.	One location within 3 miles of site in the sector with the highest de-position rate based on the latest information or historical data (location may vary).	Annual at Harvest	Each sample	Gamma Scan[4]
	49.	One location greater than 5 miles from plant site with the least de-position rate (Control Station)[2].			
	54.	Auburndale Plantation[8] 10.1 miles E.			
d. Broad-leaf vegetation	50.	0.25 mile SSE CP&L property[9].	Monthly when available (3 different kinds of broad-leaf vegetation)	Each sample	Gamma Scan[4] I-131
	51.	0.25 NNE CP&L property[9].			
	52.	10 miles W Bethune (Control Station)[2].			

FOOTNOTES

1. The LLD for each analysis is specified in Table 3.17-3 of the HBR Technical Specifications.

2. Control stations are locations outside the influence of plant effluents.

3. Airborne particulate sample filter shall be analyzed for gross beta radioactivity 24 hours or more after sampling to allow for radon and thoron daughter decay. If gross beta activity in air particulate is greater than ten times the yearly mean of control samples, gamma isotopic analysis shall be performed on the individual samples.

4. Gamma scan means the identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents from the facility.

5. Thermoluminescent dosimeter (TLD) is considered to be one phosphor; two or more phosphors in a packet are considered as two or more dosimeters.

6. Composite sample aliquots shall be collected at time intervals that are short (5 or 6 times daily) relative to the compositing period (monthly in order to assure obtaining a representative sample).

7. Collection of drinking water samples is not required since there are no known reservoirs on Black Creek used for drinking purposes.

8. Water from Black Creek is sometimes used to irrigate food crops at Arburndale Plantation which is located 11 miles east @ 90° from the plant.

9. Sample Points 50 and 51 are the highest and the second highest D/Q values, respectively. These locations are more restrictive than site boundary locations.

APPENDIX B

DOSE PARAMETERS FOR RADIOIODINES, PARTICULATES, AND TRITIUM

This appendix contains the methodology which was used to calculate the dose parameters for radioiodines, particulates, and tritium to show compliance with 10CFR20 and Appendix I of 10CFR50 for gaseous effluents. These dose parameters, P_i and R_i, were calculated using the methodology outlined in NUREG 0133 along with Regulatory Guide 1.109, Revision 1. The following sections provide the specific methodology which was utilized in calculating the P_i and R_i values for the various exposure pathways.

B.1 Calculation of P_i

The dose parameter, P_i, contained in the radioiodine and particulates portion of Section 3.2 includes pathway transport parameters of the "i" radionuclide, the receptor's usage of the pathway media, and the dosimetry of the exposure. Pathway usage rates and the internal dosimetry are functions of the receptor's age; however, the youngest age group, the infant, will always receive the maximum dose under the exposure conditions for Technical Specification 3.9.3.1.b. For the infant exposure, separate values of P_i may be calculated for the inhalation pathway which is combined with a W parameter based on (X/Q) and the food (milk) and ground pathway which is combined with a W parameter normally based on (D/Q), except for tritium. The following sections provide in detail the methodology which was used in calculating the P_i values for inclusion into this ODCM.

B.1.1 Inhalation Pathway

The evaluation of this pathway consists of estimating the maximum dose to the most critical organ received by an infant through ihhalation by:

$$P_{i_I} = K'(BR)\ DFA_i \qquad (B.1-1)$$

II. LAND USE CENSUS CHANGES

Environmental Monitoring Sample Point 54, the Auburndale Plantation milk sample point was discontinued. The dairy closed.

III. CHANGES TO RADIOACTIVE WASTE SYSTEMS

There were no changes to the Radioactive Waste Systems during this reporting period.

IV. CHANGES TO THE PCP

There were no changes to the Process Control Program during this reporting period.