Attachment 2

Offsite Dose Assessment Manual

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For assessment of

Gaseous and Liquid

Effluents

at

COOPER NUCLEAR STATION

Brownville, Nebraska

August, 1983

OFFSITE DOSE ASSESSMENT MANUAL
FOR GASEOUS AND LIQUID EFFLUENTS

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1.0 Introduction

This Manual describes acceptable methods of calculating radioactivity concentrations in the environment and the potentially resultant personal dose equivalent commitment offsite* that are associated with LWR liquid and gaseous effluents. The radioactivity concentrations and dose estimates are used to demonstrate compliance with Environmental Technical Specifications required by 10 CFR 50.36.a. The methodology stated in this Manual is acceptable for use in demonstrating operational compliance with 10 CFR 20.106, 10 CFR 50 Appendix I, and 40 CFR 190.10(a). Only the dose attributable to the Station is considered in demonstrating compliance with 40 CFR 190 since no other nuclear facility exists within 50 miles of the Station.

Calculations are made to assess the air dose from radioactive noble gases near ground level at the offsite location that could be occupied by a person where the maximum air dose is expected. The maximum dose commitment to the person offsite potentially experiencing the maximum exposure to all other radioactive material measured in gaseous and liquid effluents released from the Station is also calculated. Alternatively, the dose commitment from effluents other than radioactive noble gases may be calculated to correspond with residence at an occupiable location where airborne exposures are unlikely to underestimate those experienced by the maximally exposed person.

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* Offsite is defined in the Technical Specifications Definitions.

2.0 Liquid Effluent

2.1 Radioactivity In Liquid Waste

The concentration of radionuclides in liquid waste is determined by sampling and analysis in accord with Table 4.21.B.1 of the Technical Specifications. Alternatively, pre-release analysis of the radioactivity concentration in liquid waste required by Specification 4.21.B.1.a may be done by gross β-Υ counting provided an unrestricted area MPC for unidentified emitters, 1×10^{-7} μCi/ml, is applied where the discharge canal meets the river. When a radionuclide concentration is below the LLD for the analysis, it is not reported as being present in the sample.

2.2 Aqueous Concentration

Radioactive material in liquid effluent is diluted successively by water flowing in the discharge canal and in the river. The diluted concentration of radionuclide i in a receiving stream is estimated with the equation

$$C_{zi} = C_i \frac{F_1}{F_2}$$

where

C_i = concentration of radionuclide i in liquid radwaste released (μCi/ml)

C_{zi} = concentration of radionuclide i in the receiving stream (μCi/ml)

F_1 = release rate of liquid radwaste (ml/sec)*

F_2 = dilution flow of receiving stream of water (ml/sec)*

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*F_1, F_2, and F_c may have any convenient units of flow (i.e., volume/time) provided the units of all are identical.

For the purpose of calculating the radioactivity concentration in water at the unrestricted area boundary (Section 2.4), the flow in the discharge canal, F_c, is assigned to F_2.

In the river immediately beyond the discharge canal and the restricted area boundary, the effective dilution is

$$F_2 = F_c * M$$

where F_c = discharge canal flow (ml/sec)

M = factor of additional mixing in the river

A near field mixing ratio from the canal into the near field of the river, $M = 5$, is assigned when estimating maximum potential individual doses involving exposure by eating fish or drinking water taken from the river.

In the event water is drawn from the river downstream of the Station, F_2 represents the portion of the river flow into which the liquid effluent from the Station is effectively mixed.

2.3 Method of Establishing Alarm Setpoints

The liquid waste effluent monitor and the service water monitor are connected to alarms which provide automatic indication when 10 CFR Part 20, Appendix B, Table 2, Column 2 concentrations are expected to be exceeded offsite. With prompt action to reduce radioactive releases following an alarm, the liquid release limit of 10 CFR Part 20.106 and the limits provided by 10 CFR Part 50, Appendix I, Section IV are unlikely to be exceeded after the alarm.

The alarm setpoint for the liquid effluent radiation monitor is derived from the concentration limit provided in 10 CFR Part 20, Appendix B, Table 2, Column 2 applied where the discharge canal flows into the river. The alarm setpoint does not consider dilution, dispersion, or decay of radioactive material in the river. The radiation monitoring and isolation points are located in each line through which radioactive waste effluent is eventually discharged into the discharge canal.

The alarm setpoint calculation for each liquid effluent monitor is based upon measurement according to Table 4.21.B.4 of radioactivity in a batch of liquid to be released or in the continuous aqueous discharge. Alternatively, the alarm setpoint may be based upon gross β-γ activity analysis of the liquid waste provided the unrestricted area MPC for unidentified emitters, 1×10^{-7} µCi/ml, is observed.

In any case, a monitor may be set to alarm or trip at a lower activity concentration than the calculated setpoint.

2.3.1 Setpoint for a Batch Release

A sample of each batch of liquid radwaste is analyzed for I-131 and principal gamma emitters, or for total activity concentration prior to release. The ratio, $FMPC_b$, of the activity concentration in the tank to the unrestricted area MPC (10 CFR Part 20, Appendix B, Table 2, Column 2) is calculated with the equation

$$FMPC_{bp} = \sum_i \frac{C_{bpi}}{MPC_i} \quad \text{identified}$$

where $FMPC_{bp}$ = fraction of unrestricted area MPC in batch derived from activity measured prior to release.

C_{bpi} = concentration of radionuclide i (including I-131 and principal gamma emitters) in batch sample taken prior to release (μCi/ml).

When $FMPC_{bp}$ is derived from analyses identifying iodine and principal gamma emitters only, the value $FMPC_{bp}$ may be adjusted to account for radionuclides measured in the monthly and quarterly composite sample, but not measured prior to release. This adjustment, derived from measurements during past calendar quarters, is calculated with the equation

$$FMPC_b = FMPC_{bp} \div E_b$$

$$\text{where } E_b = \frac{\text{Previous quarterly average of the fraction of MPC in the discharge canal due to I-131 and primary gamma emitters}}{\text{previous quarterly average of the fraction of MPC in the discharge canal due to all radionuclides in batch releases.}}$$

A reference value of E_b, derived from representative past measurements may be used routinely.

Whether radioiodine and primary gamma emitters are identified prior to a batch release or not, the liquid radwaste effluent line radiation monitor alarm setpoint is determined with the equation

$$S = \frac{A}{FMPC_b} \cdot \frac{F_{S2}}{F_{S1}} \cdot g$$

where S = radiation monitor alarm setpoint (cpm)

A = counting rate (cpm/ml) or activity concentration (μCi/ml) of sample in laboratory**

g = ratio of effluent radiation monitor counting rate to laboratory counting rate or activity concentration in a given batch of liquid (cpm per cpm/ml or cpm per μCi/ml)

F_{S1} = maximum flow in the batch release line (gal/min)*

F_{S2} = minimum flow in the discharge canal (gal/min)*

Note that $A \div FMPC_b$ represents the counting rate of a solution having the same radionuclide distribution as the sample and having the maximum permissible concentration of that mixture.

Gross βγ analysis alone may be used to determine the radioactivity in a batch prior to release. In that event, the fraction of the unrestricted area MPC in the batch is:

$$FMPC_{bp} = \frac{C_{bp}}{1 \times 10^{-7}}$$

where C_{bp} = gross or total radioactivity concentration in batch sample taken prior to release (μCi/ml)

1×10^{-7} = unrestricted area maximum permissible concentration of unidentified radionuclides (μCi/ml)

* Any suitable but identical units of flow (volume/time).

** A equals $\sum_i C_{bpi}$ if isotopic analysis was performed or C_{bp} if gross activity analysis was performed.

The value of $FMPC_{bp}$ computed with this expression is substituted in the preceeding equation to calculate the setpoint.

2.3.2 Setpoint for a Continuous Release

Continuous aqueous radioactive discharges are sampled and analyzed according to the schedule in Table 4.21.B.1. The ratio $FMPC_c$, of the activity concentration in each of the continuous release streams of the unrestricted area MPC is calculated with the equations.

$$FMPC_{cw} = \sum_i \frac{C_{cwi}}{MPC_i} \quad \text{identified}$$

where $FMPC_{cw}$ = fraction of unrestricted area MPC in continuous release based upon activity measured in weekly composite

C_{cwi} = concentration of radionuclide i (including I-131 and principal gamma emitters) in weekly composite sample (μCi/ml)

When $FMPC_c$ is derived from analyses of I-131 and principal gamma emitters, it may be adjusted to account for radionuclides measured in the monthly and quarterly composite sample but not measured prior to release.

Adjustment for radionuclides measured in monthly and quarterly composite samples but not in weekly composite samples is given by the equation

$$FMPC_c = FMPC_{cw} \div E_c$$

quarterly average fraction of MPC in the discharge canal due to I-131 and primary gamma emitters measured in weekly

where E_c = composite samples of continuous releases during previous quarter quarterly average fraction of MPC in the discharge canal due to all radionuclides in samples of continuous releases during previous quarter.

A reference value of E_c, derived from representative past measurements, may be used routinely, instead.

The alarm setpoint of the radiation monitor on the discharge line is determined with the equation

$$S = \frac{A}{FMPC_c} * \frac{F_{S2}}{F_{S1}} * g$$

where A = counting rate (cpm/ml) or activity concentration (μCi/ml) of weekly composite sample in the laboratory.

Terms g, F_{S1}, and F_{S2} are defined the same as in the setpoint equation for a batch release.

Gross β-γ analysis alone may be used to determine the radioactivity in a liquid radioactive discharge. In that event, the fraction of the unrestricted area MPC in a sample of the release is:

$$FMPC_c = \frac{C_c}{1 \times 10^{-7}}$$

where C_c = gross or total radioactivity concentration in continuous aqueous release (μCi/ml)

1×10^{-7} = unrestricted area maximum permissible concentration of unidentified radionuclides (μCi/ml)

The value of $FMPC_c$ computed with this expression is substituted in the preceeding equation to calculate the setpoint.

In the event a long-term trend is evident in setpoints derived from the weekly sample and a setpoint value can be derived from the aggregate of the weekly samples which appears to have less variability and to better represent the effluent, then the setpoint based on the combined, long-term data may be used.

2.4 Radioactivity Concentration in Water at the Unrestricted Area Boundary

Technical Specification 4.21.B.1.b requires that measured radioactivity concentrations in liquid releases be evaluated to verify that the activity concentration complied with Specification 3.21.B.1.a. Demonstration of compliance with Specification 3.21.B.2.a as specified in Specification 4.21.B.2.a is deemed to verify compliance with Specification 3.21.B.1.a.

Otherwise, the quarterly average radionuclide concentration in the discharge canal, expressed as a fraction of MPC, shall be computed quarterly from the following six components:

1) the average fraction of MPC of the nuclides measured by analyses prior to each batch release

2) the average fraction of MPC of the nuclides measured by the monthly composite analyses of the batch releases (H-3, alpha emitters)

3) the average fraction of MPC of the nuclides measured by the quarterly composite analysis of the batch releases (Sr-89, Sr-90, and Fe-55)

4) the average fraction of MPC of the nuclides measured by the weekly composite analyses of the continuous releases

5) the average fraction of MPC of the nuclides measured by the monthly composite analyses of the continuous releases (H-3 and alpha emitters)

6) the average fraction of MPC of the nuclides measured by the quarterly composite analysis of the continuous releases (Sr-89, Sr-90, and Fe-55)

This may be expressed by the following equation:

$$\overline{FMPC} = \frac{1}{t} \times \sum_{p} FMPC_{bp} \cdot t_{bp} + \sum_{m} FMPC_{bm} \cdot t_{bm} + \sum_{q} FMPC_{bq} \cdot t_{bq}$$
$$+ \sum_{w} FMPC_{cw} \cdot t_{cw} + \sum_{m} FMPC_{cm} \cdot t_{cm} + \sum_{q} FMPC_{cq} \cdot t_{cq}$$

where t is the number of hours in the averaging period (a quarter in this case, 2190 hours)

t_{bp} is the duration of the p-th batch release (hours)

t_{bm} is the sum of the durations of the batch releases which are included in the m-th monthly batch composite analysis (hours)

t_{bq} is the sum of the durations of the durations of the batch releases which are included in the q-th quarterly composite analysis (hours)

t_{cw} is the duration of the continuous release for the w-th weekly composite analysis (hours)

t_{cm} is the duration of the continuous release for the m-th monthly composite analysis (hours)

t_{cq} is the duration of the continuous release for the q-th quarterly analysis (hours)

FMPC is the fraction of unrestricted area MPC at the end of the discharge canal. Modifying subscripts are:

b, batch release

c, continuous release

p, the batch analysis index

w, the weekly composite analysis index

m, the monthly composite analysis index

q, the quarterly composite analysis index

The data used to compute FMPC are measured by the radioactive liquid sampling and analysis program described in Technical Specifications Table 4.21.B.1.

2.5 Accumulated Personal Maximum Dose

Technical Specification 4.21.B.2.a requires the dose or dose commitment to a member of the public due to radioactive material released in liquid effluent to be calculated on a cumulative basis at least once every 31 days. The requirement is satisfied by computing the accumulated dose

commitment to the most exposed organ and to the total body of a hypothetical person exposed by eating fish and drinking water taken from the river offsite near the discharge canal.

The accumulated dose commitment is computed at least once every 31 days, but may be computed as analyses becomes available. The dose will be calculated as a function of age group and pathway for appropriate body organs in accordance with Regulatory Guide 1.109, Revision 1, utilizing the LADTAPII computer code.

In the event LADTAPII is not operable for calculating the dose commitment the computation may be made in the following way:

$$D_{ank} = 3.785 \times 10^{-3} \sum_{e} \sum_{i} A_{eani} \, C_{ik_j} \cdot \Delta t_j \left(\frac{F_1}{F_2}\right)_j$$

$$D_{an} = \sum_{k} D_{ank}$$

where ΔD_{ank} = the dose commitment (mrem) to organ n of age group a due to the isotopes identified in analysis k, where the analyses are those required by Table 4.21.B.1 of the Technical Specifications. Thus the contribution to the dose from gamma emitters become available on a batch basis for batch releases and on a weekly basis for continuous releases. Similarly the contributions from H-3 are available on a monthly basis and the contributions from Sr-89 and Sr-90 become available on a quarterly basis.

D_{an} = the dose commitment attributed to releases represented by all analyses k to organ n, including total body, of the maximally exposed person in age group a (mrem).

A_{eani} = transfer factor relating a unit release of radionuclide i (Ci) in a unit stream flow (gal/min) to dose commitment to organ n, or total body, of an exposed person in age group a via environmental pathway e

$$\left(\frac{\frac{mrem}{Ci}}{gal/min}\right)$$

C_{ik} = the concentration of radionuclide i in the undiluted liquid waste to be discharged (μCi/ml), i.e., in the sample k

Δt_j = elapsed time in increment j during which radionuclide i is being discharged at concentration C_{ik}, i.e., an increment of time during the release represented by sample k (minutes)

(F_1/F_2) = the quotient of the release flow, F_1, and the dilution flow, F_2, during increment j when the release is represented by sample k

Pathway-to-dose transfer factors, A_{eani}, for use in calculating the dose commitment arising from radioactive material released in aqueous effluents, are tabulated in Appendix A. Appropriate ones of the tables representing applicable environmental pathways of exposure and most exposed age group(s) are selected and used in calculating the dose commitment. The pathway(s) and thus age group(s) selected may vary by season. For instance, when fishing near the Station during the winter is nonexistent, evaluation of the fish pathway is not required.

The age group most exposed via eating fish is expected to be the adult and the age group most exposed via drinking water from the Missouri River is expected to be the infant. Normally, only these need to be evaluated for compliance with Specification 4.21.B.2.a.

Variables F_1 and F_2 are defined in Section 2.3. In the river offsite near the discharge canal, $F_2 = 5F_c$.

2.6 Projected Personal Maximum Dose

Technical Specification 4.21.B.2.b requires the maximum total body and organ doses to a person offsite due to radioactive material released in liquid effluent to be projected over a quarter at least one time during every 31 days if radioactive liquid radwaste is released and the radwaste system is not operated.

This requirement is satisfied by calculating the projected dose commitment to a hypothetical person exposed by eating fish and drinking water taken from the river offsite near the discharge canal. The potential dose commitments to organs and to the total body are computed separately.

The quarterly dose commitment to a maximally exposed hypothetical person is projected by computing the accumulated doses to the total body and

most exposed organ during the most recent three months and assuming the result represents the projected doses during the current quarter. Doses will be calculated in accordance with Section 2.5.

As an alternative, the quarterly dose commitment to the total body and most exposed organ may be projected by using the equation

$$P_{an} = \frac{91}{X} D_{an}$$

where P_{an} = projected dose commitment (mrem) to organ n (including total body of age group a during the current quarter

91 = number of days in a quarter

X = number of days to date in current quarter

D_{an} = dose commitment during the quarter-to-date (mrem)

3.0 Gaseous Effluent

3.1 Introduction

The Station discharges gaseous effluent through a stack (Elevated Release Point) and discharges ventilation air from the radwaste, augmented radwaste, turbine, and reactor buildings through the respective building vents. These gaseous effluent streams, radioactivity monitoring points, and effluent discharge points are shown schematically in Figure 3-1. Gaseous release point locations and elevations at Cooper Station are described in Table 3-1. Gaseous discharges from the Elevated Release Point (EPR) are treated as an elevated release while discharges via building vents are assumed to be ground-level releases or split-wake releases.

Gaseous release point locations and elevations at the Station are described in Table 3-1.

3.2 Radioactivity in Gaseous Effluent

For the purpose of estimating offsite radionuclide concentrations and radiation doses, measured radionuclide concentrations in gaseous effluent and in ventilation air exhausted from the Station are relied upon. Table 4.21.C.1 in the Technical Specifications identifies the radioactive gaseous effluent measurements. When a radionuclide concentration is below the LLD for the analysis, it is not reported as being present in the sample.

Noble Gases. The distribution of noble gas radionuclides in a gaseous effluent is determined in one of the following ways.

1. Preferrably, the radionuclide distribution is obtained by gamma spectrum analysis of effluent gas samples in accordance with Specification 4.21.C.1. Results of analyses of one or more samples may be averaged to obtain a representative spectrum.

2. In the event a representative radioactive noble gas distribution is unobtainable from samples taken during the period of interest, it may be derived from previous measurements or may be based upon a computed spectrum appearing in Table 3-2.

3. Alternatively, the total activity concentration of radioactive noble gases may be assumed to be krypton - 88.

The total quantity of radioactive noble gas discharged during an interval of time is determined by integrating the rate measurement of each effluent noble gas monitor. This may be done by the effluent monitoring system or the measured activity discharged via a gaseous effluent stream may be calculated with the equation

$$Q = 2.8 \times 10^4 \frac{N}{g} \cdot F$$

where Q = total radioactive noble gas release via a gaseous effluent stream during a given time interval (μCi)

N = net counts accumulated during the time interval

g = effluent noble gas monitor counting rate response $\left(\frac{\text{cpm}}{\mu\text{Ci/cm}^3}\right)$

F = gaseous effluent stream discharge rate (cfm)

2.8×10^4 = conversion constant (cm^3/ft^3)

3.3 Main Condenser Air Ejector Noble Gas Monitor Alarm Setpoint

A noble gas activity monitor is provided to measure gross gamma activity in gases at the main condenser air ejector. The monitor includes an alarm that is set to report when the gamma radiation level in gas discharged by the main condenser air ejector indicates the gross radioactivity discharge rate exceeds 1 Ci/sec.

The alarm setpoint is determined with the relation

$$S = 10^6 \frac{g}{F}$$

or the more general form of the equation:

$$S = 1 \text{ Ci/sec} * g * \frac{1}{F}$$

where S = main condenser air ejector noble gas monitor alarm setpoint (mR/hr)

F = air ejector discharge rate (cfm)

g = noble gas monitor calibration or counting rate response for gamma radiation $\frac{\text{mR/hr}}{\text{Ci/sec/cfm}}$

An alarm setpoint based upon a discharge rate limit less than 1 Ci/sec may be adopted.

3.4 Effluent Noble Gas Monitor Alarm Setpoint

Technical Specification 4.21.C.1.b requires an alarm setpoint to be determined for each radioactive noble gas effluent monitor. Each setpoint is derived to cause the alarm to report when the dose equivalent rate Offsite due to radioactive noble gas in gaseous effluent exceeds a limit in Specification 3.21.C.1.a. Alternatively, a setpoint may be derived on the basis of the 10 CFR Part 20, Appendix B, Table II, column 2 limit for the radioactive noble gas mixture in air near ground-level Offsite. Each noble gas activity monitor included in Table 3.21.A.2 except the main condenser air ejector off gas monitor is set to initiate alarm at or below the derived setpoint.

For the purpose of deriving a setpoint, the distribution of noble gas radionuclides in an effluent stream is determined as described in Section 3.2.

Setpoint Based on Dose Rate. The alarm setpoint of a radioactive noble gas effluent monitor may be calculated on the basis of whole body dose equivalent rate offsite. A setpoint of a monitor of an elevated release, e.g., from the stack, may be calculated with the equation.

$$S = 1.06 \frac{h}{f} \frac{\sum_i C_i}{\sum_i C_i \cdot DF_i^s}$$

The setpoint of a monitor of a ground-level or split-wake release, e.g., from the turbine building vent or the AOG building, may be calculated with the equation

$$S = 1.06 \frac{h}{f \frac{X}{Q}} \frac{\sum_i C_i}{\sum_i C_i \cdot DF_i^v}$$

where S = the alarm setpoint (cpm) or (mR/hr)

h = monitor response to activity concentration of effluent being monitored,

$$\frac{cpm}{\mu Ci/cm3} \quad \text{or} \quad \frac{mR/hr}{\mu Ci/cm3}$$

C_i = relative concentration of noble gas radionuclide i in effluent at the point of monitoring (μCi/cm3)

X/Q = atmospheric dispersion from point of ground-level or split-wake release to the location of potential exposure (sec/m3)

DF_i^s = factor converting elevated release rate of radionuclide i to total body dose equivalent rate at the location of potential exposure

$$\frac{mrem}{yr \cdot \frac{\mu Ci}{sec}}$$

DF_i^v = factor converting ground-level of split-wake release of radionuclide i to the total body dose equivalent rate at the location of potential exposure

$$\frac{mrem}{yr \cdot \frac{\mu Ci}{m3}}$$

f = flow of gaseous effluent stream, i.e., flow past the monitor (ft^3/min)

Each monitoring channel has a unique response, h, which is determined by the instrument calibration.

The concentration of each noble gas radionculide i in a gaseous effluent is determined as discussed in Section 3.2.

The atmospheric dispersion and the dose conversion factor, DF_i^s, depends upon local conditions. For the purpose of calculating radioactive noble gas effluent monitor alarm setpoints appropriate for Cooper Station, the locations of maximum potential offsite exposure and the reference atmospheric dispersion factors applicable to the derivation of setpoints are:

Discharge Point	Discharge Height	Receptor Location Sector	Receptor Location Distance(m)	Atm. Dispersion (sec/m3)
Vent	Ground-Level or Split-Wake	NNW	1,300	3.4×10^{-6}
ERP	Elevated	WSW	1,800	8.0×10^{-8}

The applicable dose conversion factors, DF_i^s and DF_i^v, for deriving setpoints are in Table 3-3.

Setpoint Based on Concentration. The alarm setpoint of an effluent noble gas monitor may be calculated on the basis of the 10 CFR part 20, Appendix B, Table II, Column 1 concentration limit for radioactive noble gases. The equation used to calculate a setpoint on this basis is:

$$S = \frac{MPC \times h}{4.7 \times 10^{-4} \times f \times \frac{X}{Q}}$$

where S = alarm counting rate setpoint (cpm) or (mR/hr)

h = effluent noble gas monitor counting rate response $\left(\frac{cpm}{\mu Ci/cm3}\right)$ or calibration $\left(\frac{mR/hr}{\mu Ci/cm3}\right)$ for noble gas

f = discharge rate of gaseous effluent (ft^3/min)

X/Q = atmospheric dispersion from release point to unrestricted area ($\mu Ci/cm3$ per $\mu Ci/sec$)

4.7×10^{-4} = conversion constant

$$\left(\frac{1\ m3}{35.31\ ft^3} \times \frac{1\ min}{60\ sec}\right)$$

MPC = unrestricted area maximum permissible concentration for the effluent noble gas mixture, i.e., 10 CFR Part 20, Appendix B, Table 2, Column 1 limit for a mixture ($\mu Ci/cm3$)

The MPC of noble gas is then calculated from the distribution with the equation

$$MPC = \sum_i C_i \div \sum_i \frac{C_i}{MPC_i}$$

where C_i = relative concentration of noble gas radionuclide i in gaseous release ($\mu Ci/cm3$)

MPC_i = 10 CFR Part 20, Appendix, B, Table 2, Column 1 value

Note that this is simply the aggregate of the concentrations of radionuclides i in a sample divided by the sum of fractions of MPC constituted by radionuclides i in the same sample.

In the event the distribution of radioactive noble gases is based on the distributions in Table 3-2, the values of MPC are

MPC = 1.7 x 10^{-7} µCi/cm3 for noble gases released via the ERP

MPC = 1.6 x 10^{-7} µCi/cm3 for noble gases released via a vent

Alternatively, the total activity concentration of the noble gases may be used with the MPC value of Kr-88 (2 x 10^{-8} µCi/cm3) for the purpose of conservatively determining an activity concentration of noble gases that will be less than the 10 CFR 20, Appendix B, Table 2, Column 1 limit. If this approach is used, the value of MPC is simply 2 x 10^{-8} µCi/cm3.

The value of atmospheric dispersion used to derive a setpoint based on concentration is the reference atmospheric dispersion value from the discharge point to the location of maximum potential exposure offsite. The applicable reference values are:

Discharge Point	Discharge Height	Receptor Location		Atm. Dispersion (sec/m3)
		Sector	Distance(m)	
Vent	Ground-Level or Split-Wake	NNW	1,300	3.4 x 10^{-6}
ERP	Elevated	WSW	1,800	8.0 x 10^{-8}

3.5 Noble Gas Gamma Radiation Dose Accumulated in Air

Technical Specification 4.21.C.2.a requires the calculation on a cumulative basis of air dose due to gamma radiation from radioactive noble gas released in gaseous effluents. Specification 3.21.C.2.a requires that the offsite air dose during any calendar quarter not exceed 5 mrad from noble gas gamma radiation.

The distribution of radioactive noble gases in gaseous releases and the quantity discharged during an interval of interest are determined as described in Section 3.2.

The gamma radiation dose to air offsite as a consequence of noble gas released from the station will be calculated in accordance with Regulatory Guide 1.109, Revision 1, utilizing USNRC Computer Code GASPAR.

In the event GASPAR is not operable for calculating the gamma radiation dose to air offsite as a consequence of noble gas released from the station, it may be calculated with the equation

$$D = \sum_i \left(Q_{cs_i} \cdot A\Upsilon_{cs_i} \right) + \sum_i \left(Q_{cv_i} \cdot \left(\frac{X}{Q}\right)_{cv} \cdot A\Upsilon_{v_i} \right)$$

where D = noble gas gamma dose to air (mrad)

Q_{cs_i} = $\sum \Delta Q_{cs_i}$ = cumulative release of noble gas nuclide i from stack (μCi).

$A\Upsilon_{cs_i}$ = factor converting unit noble gas stack release to ground level air dose from overhead plume gamma radiation (mrad/μCi).

$A\Upsilon_{v_i}$ = factor converting time integrated, ground level concentration of noble gas to air dose from gamma radiation $\left(\frac{\text{mrad}}{\mu\text{Ci}\ \frac{\text{sec}}{\text{m}^3}}\right)$

Q_{cv_i} = $\sum \Delta Qcv_i$ = cumulative release of noble gas nuclide i from building vents (μCi).

$\left(\frac{X}{Q}\right)_{cv}$ = long term average atmospheric dispersion factor for a ground level or split wake release (sec/m^3).

Specification 4.21.C.2.a is satisfied by calculating the noble gas gamma radiation dose to air at the offsite location identified in Figure 3-2 and on the basis of reference* atmospheric dispersion assuming continuous gaseous release. At that location, the reference atmospheric dispersion factor for a vent (ground-level) release is $\frac{X}{Q} = 3.4 \times 10^{-6}$ sec/m^3 at the NNW site boundary. Appropriate values of AT_{cs_i} and AT_{v_i} for use in calculating air doses at that location are listed in Table 3-4.

3.6 Noble Gas Beta Radiation Dose Accumulated in Air

Technical Specification 3.21.C.2 requires that the offsite air dose during any calendar quarter not exceed 10 mrad from noble gas beta radiation. Specification 4.21.C.2.a requires the air dose to be calculated on a cumulative basis.

The radioactive noble gas distribution and activity discharged are determined as described in § 3.4 herein.

The beta radiation dose to air offsite as a consequence of noble gas released from the station will be calculated in accordance with Regulatory Guide 1.109, Revision 1, utilizing USNRC Computer Code GASPAR.

* Onsite meteorological data for the period July 1, 1976, to June 30, 1977, which was used in the Cooper Station Demonstration of Compliance with 10 CFR 50, Appendix I, revision 1, January, 1978.

In the event GASPAR is not operable for calculating the beta radiation dose to air offsite as a consequence of noble gas released from the station, it may be calculated with the equation

$$D = \sum_i \left[Q_{cs_i} \left(\frac{X}{Q}\right)_{cs} + Q_{cv_i} \left(\frac{X}{Q}\right)_{cv} \right] * A\beta_i$$

Where D = noble gas beta dose to air (mrad)

$\left(\frac{X}{Q}\right)_{cs}$ = long-term average atmospheric dispersion factor for stack releases (sec/m^3)

$A\beta_i$ = factor converting time integrated ground level concentration of noble gas radionuclide i to air dose from beta radiation $\left(\frac{mrad}{(\mu Ci\ sec)/m^3}\right)$

Specification 4.21.C.2.a is satisfied by calculating the noble gas beta radiation dose to air offsite at the location identified in Figure 3-2 and on the basis of reference atmospheric dispersion assuming continuous gaseous discharge. At that location, the reference atmospheric dispersion factors are:

$\left(\frac{X}{Q}\right)_s = 1.2 \times 10^{-8}$ sec/m^3 at the NNW site boundary

$\left(\frac{X}{Q}\right)_v = 3.4 \times 10^{-6}$ sec/m^3

Beta radiation-to-air dose conversion factors, $A\beta_i$, for noble gas radionuclides are listed in Table 3-4.

3.7 Dose Due to Iodine and Particulates in Gaseous Effluents*

Technical Specification 3.21.C.3 requires that radioiodine, and radioactive material in particulate form having half-lives greater than eight days in gaseous effluents released to the area offsite cause no more than 7.5 mrem to any organ of a member of the public during a calendar quarter. Specification 4.21.C.3.b requires the dose to be calculated at least once every 31 days.

Radionuclides other than noble gases or tritium in gaseous effluents that are measured by the sampling and analysis program described in Technical Specification Table 4.21.C.1 are used as the release term in dose calculations. Airborne releases are discharged either via the stack (ERP) as an elevated release or via building vents and treated as a ground level or split-wake release. For each of these release combinations, samples are analyzed weekly, monthly, quarterly, or for a specific release according to Table 4.21.C.1.

Each sample provides a measure of the concentration of specific radionuclides, C_i, in gaseous effluent discharged at flow, F_a, during a time increment Δt. Thus, each release is quantified according to the relation

$$\Delta Q_{ijk} = C_{ik} \, Fa_j \, \Delta t_j$$

$$Q_{ik} = \sum_j C_{ik} \, Fa_j \, \Delta t_j$$

* The dose to any organ of a person arising from radioactive iodine-131, iodine-133, and radioactive material in particulate form having half-lives greater than eight days. Noble gases not considered.

where Q_{ik} = the quantity of radionuclide i released in a given effluent stream based on analysis k (Ci)

C_{ik} = concentration of radionuclide i in gaseous effluent identified by analysis k (Ci/m^3) or ($\mu Ci/cm^3$)

F_{aj} = effluent stream discharge rate during time increment Δt_j (m^3/sec)

Δt_j = elapsed time in increment j during which radionuclide i at concentration C_{ik} is being discharged (sec)

3.7.1 A person may be exposed directly to an airborne concentration of radioactive material discharged in effluent and indirectly via pathways involving deposition of radioactive material onto the ground. Dose estimates account for the separate exposure pathways. The dose commitment to a person offsite associated with a gaseous release, Q_{ik}, of radioactive material other than noble gas will be calculated in accordance with Regulatory Guide 1.109, Revision 1, utilizing USNRC Computer Code GASPAR.

In the event GASPAR is not operable for calculating the dose commitment to a person offsite associated with a gaseous release, Q_{ik}, of radioactive material other than noble gas may be calculated with one of the appropriate following equations

release via the stack:

$$D_{ansk} = Q_{iks}\left[\sum_i TA_{ani}\left(\frac{Xd}{Q}\right)\sum_{cs} + \sum_e\sum_i TG_{eani}\left(\frac{D}{Q}\right)_{bse}\right]$$

release via a vent:

$$D_{anvk} = Q_{ikv}\left[\sum_i TA_{ani}\ \frac{Xd}{Q}_{bv} + \sum_e\sum_i TG_{eani}\left(\frac{D}{Q}\right)_{cve}\right]$$

where D_{ansk} = the dose commitment (mrem) to organ n of a person in age group a due to radionuclides identified in analysis k of an elevated (ERP) release where the analysis is one required by Technical Specification Table 4.21.C.1.

D_{anvk} = the dose commitment from a vent release (mrem)

TA_{ani} = factor converting airborne concentration of radionuclide i to dose commitment to organ n of a person in age group a

$$\left(\frac{\text{mrem}}{(\text{Ci sec})/\text{m}^3}\right)$$

TG_{eani} = factor converting ground deposition of radionuclide i to dose commitment to organ n of a person in age group a exposed via environmental pathway e (mrem/Ci/m^2)

(D/Q) = relative deposition factor (m^{-2})

(Xd/Q) = depleted atmospheric dispersion factor ($\mu\text{Ci/m}^3$ per μCi/sec)

The analysis index k may represent eithe.

p, analysis of a grab sample

w, a weekly composite analysis

m, a monthly composite analysis

q, a quarterly composite analysis

The dose commitment accumulated by a person offsite is computed at least every 31 days, but may be calculated as analytical results of effluent measurements, performed according to Table 4.21.C.1 in the Technical Specifications, become available.

The dose is accumulated in the following way.

The dose accumulated as a result of stack discharge is

$$D_{ans} = \sum_{w} D_{answ} + \sum_{m} D_{ansm} + \sum_{q} D_{ansq}$$

and the dose accumulated as a result of a vent discharge is

$$D_{anv} = \sum_{w} D_{anvw} + \sum_{m} D_{anvm} + \sum_{q} D_{anvq}$$

Doses committed during the same time period due to discharges from the stack and vents are additive, thus

$$D_{an} = D_{ans} + \sum_{v} D_{anv}$$

where D_{an} = the dose commitment accumulated during the quarter to date as a result of all measured radioactive gaseous discharges except noble gases and tritium to any organ n, including total body, of a person offsite in age group a (mrem)

When the dose to a person from iodine and particulates discharged in gaseous effluent is calculated as required by Specification 4.21.C.3.b, appropriate environmental pathways of exposure will be evaluated. The pathway(s) and/or age group(s) selected may vary by season. Appropriate pathway-to-dose transfer factors, A_{eani}, are selected from Appendix A for use in calculating the dose.

The dose to a receptor at the location identified in Figure 3-2, 1.1 miles west of the Station is calculated on the basis of continuous gaseous release and reference meteorological conditions. The reference atmospheric dispersion and deposition factors at that location to be used for assessing compliance with Specification 4.21.C.3.a are:

$$\left(\frac{Xd}{Q}\right)_s = 8.1 \times 10^{-8} \text{ sec/m}^3 \qquad \left(\frac{D}{Q}\right)_s = 4.6 \times 10^{-10} \text{ m}^{-1}$$

$$\left(\frac{Xd}{Q}\right)_v = 4.4 \times 10^{-7} \text{ sec/m}^3 \qquad \left(\frac{D}{Q}\right)_v = 9.5 \times 10^{-10} \text{ m}^{-1}$$

The receptor is assumed to drink milk produced by the milch animal which experiences the maximum $\frac{D}{Q}$. Maximum values of the relative deposition factors where a real milch animal is located, 3.7 miles northwest of the Station, are:

$$\left(\frac{D}{Q}\right)_s = 1.2 \times 10^{-10} \text{ m}^{-1}$$

$$\left(\frac{D}{Q}\right)_v = 3.7 \times 10^{-10} \text{ m}^{-1}$$

40 CFR Part 190. When the dose due to gaseous effluent is calculated for the purpose of evaluating compliance with 40 CFR Part 190 (reference Section 4.2), the dose contributed by tritium is included in the evaluation and is calculated in the following way.

Since tritium in water vapor is absorbed directly by vegetation, the tritium concentration in growing vegetation is proportional to the airborne concentration rather than to relative deposition as in the case of particulates. Thus the dose commitment from airborne tritium via vegetation (fruit and vegetables), air-grass-cow-milk, or air-grass-cow-meat pathways is calculated with the appropriate one(s) of the equations:

for a stack release

$$D_{ansk} = \left(\frac{X}{Q}\right)_s \sum_i Q_{iks} \sum_p TA_{anip}$$

for a vent release

$$D_{ankv} = \left(\frac{X}{Q}\right)_v \sum_i Q_{ikv} \sum_p TA_{anip}$$

3.8 Dose to a Person from Noble Gases

Technical Specification 4.21.D.1 requires the calculation of dose to a member of the public for the purpose of assessing compliance with provisions of 40 CFR Part 190.10(a). That assessment includes the calculation of the gamma dose to the total body and the beta plus gamma dose to the skin of the person due to radioactive noble gases in gaseous effluents.

3.8.1 Gamma Dose to Total Body

The gamma radiation dose to the whole body of a member of the public as a consequence of noble gas released from the station will be

calculated in accordance with Regulatory Guide 1.109, Revision 1, utilizing USNRC Computer Code GASPAR.

In the event GASPAR is not operable for calculating the gamma radiation dose to the whole body of a member of the public as a consequence of noble gas released from the Station it is calculated with the equation:

$$D_\gamma = \sum_i \left(Q_{csi} * P\gamma_{cs_i} + Q_{cv_i} \left(\frac{X}{Q}\right)_{cv} * P\gamma_{v_i} \right)$$

where D = noble gas gamma dose to total body (mrem)

$P\gamma_{cs_i}$ = factor converting unit noble gas nuclide i in stack release to total body dose at ground level received from the overhead plume (mrem/μCi)

$P\gamma_{v_i}$ = factor converting time integrated, ground level concentration of noble gas nuclide i to air dose from gamma radiation

$$\left(\frac{\text{mrem}}{\mu\text{Ci} \ \frac{\text{sec}}{\text{m}^3}} \right)$$

When the total body dose due to gamma radiation from noble gas is evaluated as required by Technical Specification 4.21.D.1, the dose to the nearby resident exposed most by all applicable exposure pathways combined is computed. Alternatively, the nearby resident exposed to maximal ground-level noble gas concentrations (maximum $\frac{X}{Q}$) may be selected as the receptor. The location of the latter residence is identified in Figure 3-2. Values by $P\gamma cs_i$ and $P\gamma v_i$ applicable at the location of the residence 1.1 miles west of the station appear in Table 3-5.

3.8.2 Dose to Skin

The beta radiation dose to the skin of a member of the public due to beta radiation from noble gas released from the station will be calculated in accordance with Regulatory Guide 1.109, Revision 1, utilizing USNRC Computer Code GASPAR.

In the event GASPAR is not operable for calculating the beta radiation dose to the skin of a member of the public due to beta radiation from noble gas released from the Station may be calculated with the equation

$$D_\beta = \sum_i \left(Q_{cs_i} \left(\frac{X}{Q}\right)_{cs} + Q_{cv_i} \left(\frac{X}{Q}\right)_{cv} \right) * S\beta_i$$

where $D\beta$ = noble gas beta dose to skin (mrem)

$S\beta_i$ = factor converting time integrated ground level concentration of noble gas radionuclide i to skin dose from beta radiation

$$\left(\frac{\text{mrem}}{(\mu\text{Ci sec})/\text{m}^3} \right)$$

Values of $S\beta_i$ for noble gases are included in Table 3-5.

When the skin dose due to noble gas beta radiation is evaluated as required by Specification 4.21.D.1, the receptor selected is the nearby resident exposed most via all applicable exposure pathways together. Alternatively, the nearby resident exposed to maximal ground-level concentrations (maximum $\frac{X}{Q}$) may be selected as the receptor. The location of the latter resident is identified in Figure 3-2.

The total dose to the skin from noble gases is approximately equal to the beta radiation dose to the skin plus the gamma radiation dose to the total body.

3.9 Projected Air Doses Due to Gaseous Effluent

Technical Specification 4.21.C.4.a requires air doses due to radioactive material in gaseous effluent to be projected over a quarter during each month in which radioactive material is released in gaseous effluent without treatment. The purpose is to guide plant personnel in operating the Waste Gas System and the exhaust ventilation treatment systems.

The air doses are projected by calculating the air doses accumulated during the most recent three months in accordance with Sections 3.5 and 3.6 and by assuming the result represents the projected doses during the current quarter.

Alternatively, the quarterly air dose may be projected by using the equation:

$$PD_{\gamma} = \frac{91}{X} D_{\gamma}$$

or $$PD_{\beta} = \frac{91}{X} D_{\beta}$$

where PD_{γ} = projected air dose due to noble gas gamma radiation during the current quarter (mrad)

PD_{β} = projected air dose due to noble gas beta radiation during the current quarter (mrad)

91 = number of days in a quarter

X = number of days to date during current quarter

D_γ = air dose due to noble gas gamma radiation during the quarter-to-date (mrad)

D_β = air dose due to noble gas beta radiation during the quarter-to-date (mrad)

4.0 Dose Commitment From Releases Over Extended Time

4.1 Releases During A Quarter

Technical Specification 6.7.1.E.2 requires an annual assessment of radiation doses arising from liquid and gaseous effluents from the Station during each calendar quarter. The assessment includes the following calculations of doses for

1. total body and maximally exposed organ doses due to liquid effluent via drinking water and eating fish from the river as in § 2.6.

2. total body and maximally exposed organ doses due to gaseous effluents* other than noble gases and tritium as in § 3.7.

3. doses to air offsite due to noble gas γ as in § 3.5 and due to noble gas β as in § 3.6.

The dose calculations are based on liquid and gaseous effluents from the Station during each calendar quarter determined in accord with Technical Specification Tables 4.21.B.1 and 4.21.C.1.

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* radioactive iodine-131, iodine-133, and radioactive material in particulate form, having half-lives greater than eight days.

Aqueous concentration is estimated according to 2.2 on the basis of quarterly averaged stream flow or stream flow during discharge. If practical, quarterly averaged meteorological conditions concurrent with the quarterly gaseous release being evaluated are used to estimate atmospheric dispersion and deposition. Otherwise, the quarterly dose commitment due to gaseous effluent will be calculated using either reference meteorology or annual averaged meteorology during the year in which the release occurred.

The receptor of the dose is described such that the dose to any resident near the Station is unlikely to be underestimated. That is, the receptor is selected on the basis of the combination of applicable pathways of exposure to gaseous effluent identified in the annual land use census and maximum ground level $\frac{X}{Q}$ at the residence. Conditions (i.e., location, $\frac{X}{Q}$, and/or pathways) more conservative (i.e., expected to yield higher calculated doses) than appropriate for the maximally exposed individual may be assumed in the dose assessment.

Seasonal appropriateness of exposure pathways may be considered. Exposure by eating fresh vegetation or drinking milk from cows or goats fed fresh forage is an inappropriate assumption during the first or fourth calendar quarter; rather consumption of stored vegetation and stored forage is ordinarily assumed.

Similarly, the liquid effluent-river-fish-man pathway is not ordinarily assumed during the winter quarter.

Factors converting stack-released noble gas to gamma radiation dose from the overhead plume are calculated on the basis of reference meteorological data for the receptor location. Other environmental pathway-to-dose transfer factors used in the dose calculations are provided in Appendix A.

4.2 Releases During 12 Months

The regulation governing the maximum allowable dose or dose commitment to a member of the public from all uranium fuel cycle sources of radiation and radioactive material in the environment is stated in 40 CFR Part 190.10(a). It requires that the dose or dose commitment to a member of the public from all sources not exceed 75 mrem/yr to the thyroid or 25 mrem/yr to the total body or any other organ. Technical Specification 4.21.D.1 requires calculation of the dose at least once per year to assess compliance with the regulation. If conditions warrant, according to provisions of Specification 3.21.D.1, an assessment may be made for a portion of a calendar year.

Fuel cycle sources or nuclear power reactors other than the Station itself do not measurably or significantly increase the radioactivity concentration in the vicinity of the Station; therefore, only radiation and radioactivity in the environment attributable to the Station itself are considered in the assessment of compliance with 40 CFR Part 190.

The dose to a member of the public which is due to exposure to radioactive material in liquid and gaseous effluents from the station are ordinarily calculated while the dose attributable to irradiation is evaluated with environmental radiation dosimetry.

The receptor of the dose is selected on the basis of the combination of applicable pathways of exposure to gaseous effluent identified in the annual land use census and minimum atmospheric dispersion factor (maximum ground level $\frac{X}{Q}$) at his residence. The receptor is described such that the dose to any resident near the Station is not likely to be underestimated. Conditions more conservative than appropriate for the maximally exposed (real) person may be assumed in the dose assessment.

Calculated Doses. Doses to a member of the public are calculated on the basis of liquid and gaseous effluents from the station determined in accord with Technical Specifications Tables 4.21.B.1 and 4.21.C.1.

Contributions to the dose due to liquid and gaseous effluent are calculated as described by the equations for:

1. total body and maximally exposed organ doses due to liquid effluent via drinking water and eating fish from the river as in § 2.6.
2. total body dose due to noble gas γ as in § 3.8.1.
3. skin dose due to noble gas β as in § 3.8.2.

4. total body and maximally exposed organ doses due to gaseous effluents* other than noble gases as in § 3.7.

Aqueous radioactive material concentrations are estimated according to § 2.2 on the basis of annual averaged stream flow.

Atmospheric dispersion, deposition, and if calculated, exposure by irradiation from airborne emitters are based on annual averaged meteorological conditions during the year evaluated or, alternatively, on reference meteorological conditions. In the event a portion of the year is examined, average meteorology for the period examined may be used in lieu of annual averaged or reference meteorology data.

Factors converting stack-released noble gas to gamma radiation dose from the overhead plume are calculated on the basis of annual averaged meteorological data for the receptor location. Other environmental pathway-to-dose transfer factors used in the dose calculations appear in Appendix A.

Environmental Measurements. When assessing compliance with 40 CFR 190, Radiological Environmental Monitoring Program results may be used to indicate actual radioactivity levels in the environment attributable to CNS as an alternate to calculating the concentrations from radioactive effluent measurements. The measured environmental activity levels may thus be used to supplement the evaluation of doses to real persons for assessing compliance with 40 CFR 190.

* radioactive iodine, tritium, and radioactive material in particulate form having half-lives greater than eight days.

The dose to a member of the public due to irradiation (external exposure to gamma radiation) from the station and station effluents will be estimated with the aid of environmental TLD, PIC, or similar environmental dosimetry. This will be done by examining the annual dosimetry data for a statistical difference between measurements near the station and background measurements. Alternatively, irradiation attributable to station effluents may be calculated by methods referenced earlier in this section.

The person most exposed to radiation and radioactive material in effluent from Cooper Station is expected to live within ten miles of the Station. Although the Station is in a rural area, the maximum personal exposure due to airborne effluent almost certainly occurs to a resident within three or four miles of it. Since the nearest public water intake downstream of Cooper Station in the Missouri River is about 85 miles, radioactive liquid effluent contamination of potable water is not foreseen to be significant. The other liquid effluent pathway of potential significance, via fish taken from the river, would be evaluated when assessing compliance with 40 CFR 190 only in the event that a significant increase in fishing downstream in the river near the Station occurs during the previous 12 months. Fishing within about ten miles downstream of the Station is considered to be nonexistent during the first quarter and negligable during the remainder of the year. In the event the fish pathway is evaluated to assess compliance with 40 CFR 190, the fish would be taken from the river within ten miles downstream of the Station.

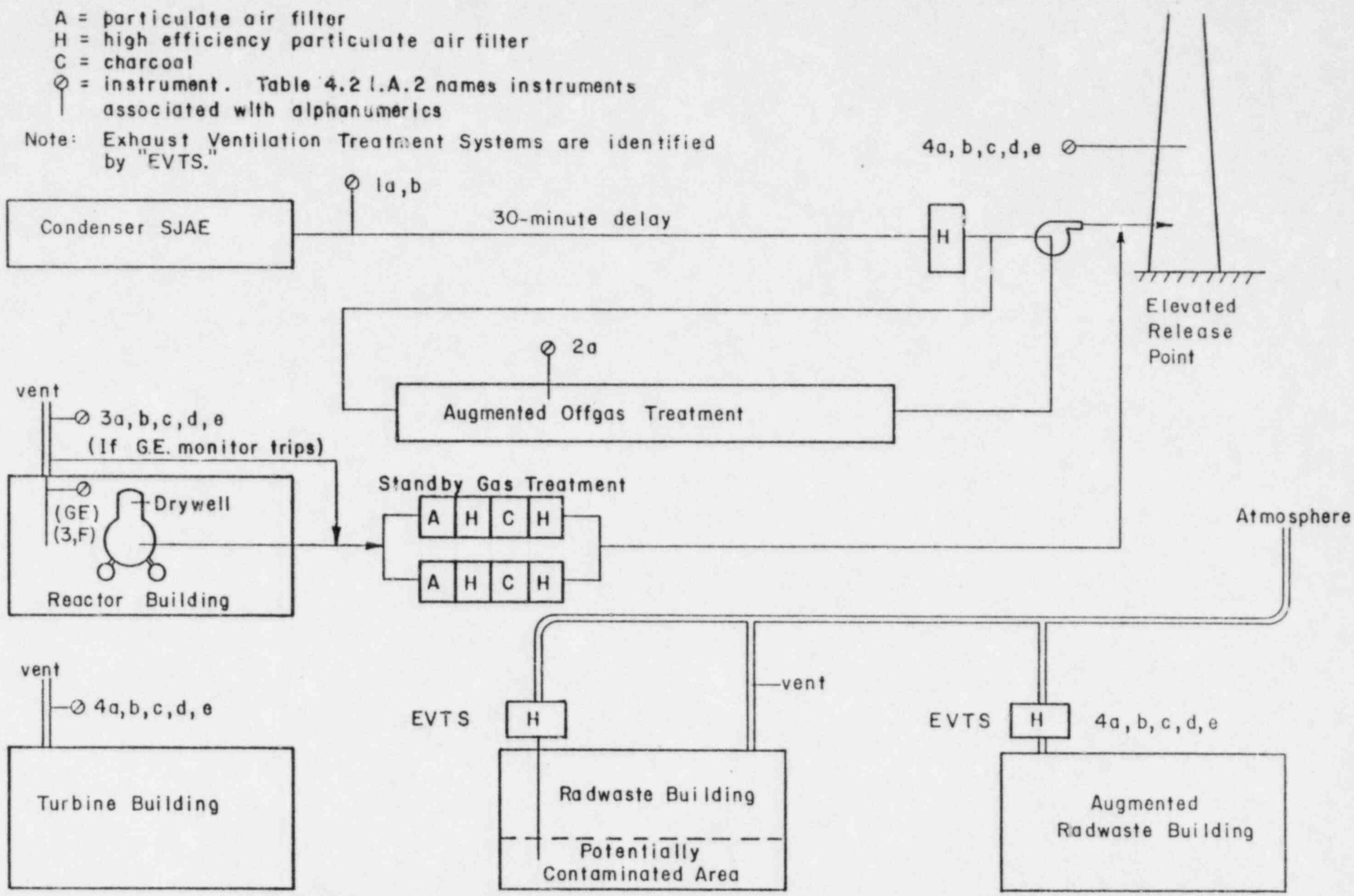

Figure 3-1 Gaseous Effluent Streams, Treatment and Monitoring Equipment, and Discharge Points.

Figure 3-2

Offsite Locations at which Radiological Doses are Calculated

APPENDIX A

PATHWAY-DOSE TRANSFER FACTORS

Environmental pathway transfer factors, usage factors, and dose commitment factors appropriate for each exposure pathway, age, and organ are combined into integrated environmental concentration-to-dose factors for each radionuclide. This appendix includes tables of values of the transfer factors calculated in accord with equations and values recommended in Regulatory Guide 1.109, Revision 0, except as noted below.* Appropriate transfer factors from Appendix A are used in performing dose assessment calculations prescribed in the ODAM. The transfer factors have been tabulated for individual pathways. If a single, composite transfer factor is desired, it can be obtained by summing the factors for appropriate pathways for a given organ and age group of interest.

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* Quantities used in calculating pathway to dose transfer factors which differ from values recommended in Regulatory Guide 1.109, Revision 0, are these:

1. factor for converting inhaled Fe-59 to adult liver dose
2. bioaccumulation factor for tellurium in fish and shellfish
3. stable element transfer factor for Pa in meat.

APPENDIX B

REFERENCE METEOROLOGICAL DATA

Reference meteorological measurements were at Cooper Station during the period from July 1, 1976, through June 30, 1977. The summary data and the computer code, PUFF, were used to generate tables of reference values of X/Q, depleted X/Q, and D/Q herein.

Table 3-1

Atmospheric Gaseous Release Points at the
Cooper Nuclear Generating Station

Structure	Reactor Building	Turbine Building	Radwaste Building	Augmented Radwaste Building	Elevated Release Point
Number of Ducts	1	2	2	1	1
Duct Size (inches)	96" x 48"	48" x 96"	24" x 96"	22" x 35"	14" I.D.
Height of Vent (feet above roof)	15	1.3	Horizontal Discharge at roof top	Horizontal Discharge at roof top	325 (above grade)
Flow Rate (cfm)	73405	101420 (both ducts)	40570 Potentially Contaminated 10000 Radwaste Building	16500	3000
Flow Velocity (fps)	3.82	26.4	42.3	50.9	46.7
Exhaust Temp. (^{o}F) - Winter	70	70	70	70	60
Exhaust Temp. (^{o}F) - Summer	90	90	90	90	90
Release Mode	Partial Elevated	Ground Level	Ground Level	Ground Level	Elevated

Table 3-2

Computed Release of Radioactive Noble Gases
In Gaseous Effluent From Cooper Nuclear Station

Nuclide	Stack Release (Ci/yr)	Stack Release Fraction	Plant Vents Release (Ci/yr)	Plant Vents Release Fraction
Kr-83m	3.60E+01	8.38E-03	0	0
Kr-85m	6.50E+01	1.51E-02	7.10E+01	1.14E-02
Kr-85	2.00E+02	4.66E-02	0	0
Kr-87	2.13E+02	4.96E-02	1.33E+02	2.13E-02
Kr-88	2.13E+02	4.96E-02	2.33E+02	3.74E-02
Kr-89	1.00E+03	2.33E-01	0	0
Xe-133m	3.00E 00	6.99E-04	0	0
Xe-133	1.51E+02	3.52E-02	2.63E+03	4.22E-01
Xe-135m	7.20E+01	1.68E-02	6.96E+02	1.12E-01
Xe-135	2.64E+02	6.15E-02	1.06E+03	1.70E-01
Xe-137	1.20E+03	2.79E-01	0	0
Xe-138	8.77E+02	2.04E-01	1.41E+03	2.26E-01
Total	4294.	1.0	6233.	1.0

Releases (mputed by BWR-GALE for Cooper Station Base Case gaseous radwaste treatment.

The release rate (Ci/yr) is included only to show the basis of the radionuclide distribution. To estimate the concentrations of radionuclides in a sample in which only the total radioactivity has been measured, multiply the total activity concentration by the <u>fraction</u> of respective radionuclides listed above.

Table 3-3

Dose Conversion Factors f r Deriving Radioactive
Noble Gas Effluent Monitor Setpoints

Radionuclide	Factor DF_i^s for Stack Release[a] $\frac{\text{mrem}}{\text{yr}\ \frac{\mu\text{Ci}}{\text{sec}}}$	Factor DF_i^v for Ground-Level or Split-Wake Release $\frac{\text{mrem}}{\text{yr}\ \frac{\mu\text{Ci}}{\text{m3}}}$
Kr-83m	To Be Supplied	7.56 E-2
Kr-85m		1.17 E3
Kr-85		1.61 E1
Kr-87		5.92 E3
Kr-88		1.47 E4
Kr-89		1.66 E4
Kr-90		1.56 E4
Xe-131m		9.15 E1
Xe-133m		2.51 E2
Xe-133		2.94 E2
Xe-135m		3.12 E3
Xe-135		1.81 E3
Xe-137		1.42 D3
Xe-138		8.83 E3
Xe-139		5.02 E3
Ar-41		8.84 E3

[a] Based on reference meteorology; applicable at meters WSW of the ERP.

Table 3-4

Transfer Factors for Maximum Dose To A
Person Offsite Due To Radioactive Noble Gases

Radionuclide	Dose Transfer Factors		
	$A\gamma_{cs_i}$ [a]	$A\gamma_{v_i}$	$A\beta_i$
	$\frac{mrad}{\mu Ci}$	$\frac{mrad}{\mu Ci\ sec/m^3}$	$\frac{mrad}{\mu Ci\ sec/m^3}$
Kr-83m	2.6E-14	6.1E-7	9.13E-6
Kr-85m	4.0E-12	3.9E-5	6.24E-5
Kr-85	5.8E-14	5.4E-7	6.18E-5
Kr-87	1.7E-11	2.0E-4	3.26E-4
Kr-88	4.6E-11	4.8E-4	9.28E-5
Kr-89	2.2E-11	5.5E-4	3.36E-4
Kr-90	--	5.2E-4	2.48E-4
Xe-131m	1.1E-11	4.9E-6	3.52E-5
Xe-133m	8.7E-13	1.0E-5	4.69E-5
Xe-133	9.0E-13	1.1E-5	3.33E-5
Xe-135m	8.3E-12	1.1E-4	2.34E-5
Xe-135	6.3E-12	6.1E-5	7.79E-5
Xe-137	1.8E-12	4.8E-5	4.02E-4
Xe-138	2.7E-11	2.9E-4	1.51E-4
Ar-41	3.2E-11	2.9E-4	1.04E-4

[a] Dose at NNW site boundary

Table 3-5

Transfer Factors for Maximum Dose To A Person Offsite Due To Radioactive Noble Gases

Radionuclide	Dose Transfer Factors		
	$P\Upsilon_{cs_i}$ [a,b]	$P\Upsilon_{v_i}$	$S\beta_i$
	$\frac{mrem}{\mu Ci}$	$\frac{mrem}{\mu Ci\ sec/m^3}$	$\frac{mrem}{\mu Ci\ sec/m^3}$
Kr-83m	1.6E-16	2.4E-9	--
Kr-85m	2.4E-12	3.7E-5	4.6E-5
Kr-85	3.0E-14	5.1E-7	4.2E-5
Kr-87	7.9E-12	1.9E-4	3.1E-4
Kr-88	2.3E-11	4.7E-4	7.5E-5
Kr-89	6.7E-12	5.3E-4	3.2E-4
Kr-90	--	4.9E-4	2.3E-4
Xe-131m	7.7E-13	2.9E-6	1.5E-5
Xe-133m	5.9E-13	8.0E-6	3.1E-5
Xe-133	6.9E-13	9.3E-6	9.7E-6
Xe-135m	3.3E-12	9.9E-5	2.3E-5
Xe-135	3.7E-12	5.7E-5	5.9E-5
Xe-137	5.1E-13	4.5E-5	3.9E-4
Xe-138	1.2E-11	2.8E-4	1.3E-4
Ar-41	1.5E-11	2.8E-4	8.5E-5

[a] Receptor located at 1.1 miles west of Station

[b] Based on reference meteorology at Cooper Station

UNDEPLETED MEAN RELATIVE CONCENTRATION (sec/m^3)
ELEVATED RELEASE POINT - STANDARD DISTANCES
COOPER NUCLEAR STATION
NEBRASKA PUBLIC POWER DISTRICT

DISTANCE (miles)

SECTOR	.5	1.5	2.5	3.5	4.5	7.5	15.	25.	35.	45.
NNE	6.7E-09	2.3E-08	2.2E-08	1.8E-08	1.5E-08	1.9E-08	5.8E-09	4.7E-09	3.0E-09	1.8E-09
NE	6.1E-09	1.4E-08	1.4E-08	1.3E-08	1.1E-08	1.5E-08	6.9E-09	2.7E-09	2.4E-09	1.8E-09
ENE	7.0E-09	1.4E-08	1.4E-08	1.2E-08	9.3E-09	1.3E-08	2.9E-09	3.7E-09	1.5E-09	9.4E-10
E	6.5E-09	1.4E-08	1.3E-08	1.2E-08	9.5E-09	1.5E-08	4.0E-09	2.3E-09	1.3E-09	3.0E-10
ESE	5.2E-09	1.2E-08	1.0E-08	9.8E-09	7.9E-09	7.3E-09	4.1E-09	1.8E-09	1.2E-09	6.3E-10
SE	8.2E-09	1.9E-08	1.6E-08	1.4E-08	1.2E-08	1.0E-08	3.7E-09	1.6E-09	1.3E-09	6.5E-10
SSE	1.1E-08	3.2E-08	2.3E-08	2.0E-08	3.4E-08	2.6E-08	6.1E-09	2.2E-09	2.3E-09	1.2E-09
S	1.9E-08	3.4E-08	3.3E-08	2.6E-08	2.5E-08	1.6E-08	4.8E-09	2.4E-09	1.4E-09	1.1E-09
SSW	1.0E-08	4.3E-08	1.7E-08	1.7E-08	1.4E-08	9.5E-09	2.5E-09	1.2E-09	9.9E-10	5.1E-10
SW	4.4E-09	5.0E-08	1.7E-08	1.1E-08	1.1E-08	9.3E-09	3.1E-09	1.5E-09	9.4E-10	7.3E-10
WSW	4.1E-09	6.6E-08	3.2E-08	2.8E-08	1.2E-08	6.6E-09	4.1E-09	1.6E-09	1.1E-09	5.0E-10
W	5.6E-09	6.8E-08	3.8E-08	2.2E-08	1.8E-08	6.4E-09	4.1E-09	1.3E-09	8.2E-10	4.9E-10
WNW	6.1E-09	8.0E-08	5.2E-08	3.4E-08	2.1E-08	9.5E-09	3.2E-09	1.6E-09	1.0E-09	6.6E-10
NW	4.8E-09	8.8E-08	7.4E-08	5.2E-08	3.3E-08	1.4E-08	7.2E-09	3.4E-09	1.9E-09	1.3E-09
NNW	8.4E-09	2.7E-08	7.9E-08	6.9E-08	2.2E-08	2.1E-08	5.5E-09	3.1E-09	2.2E-09	1.6E-09
N	7.5E-09	3.5E-08	3.3E-08	2.5E-08	2.0E-08	1.6E-08	6.8E-09	5.2E-09	3.4E-09	1.1E-09

UNDEPLETED MEAN RELATIVE CONCENTRATION (sec/m^3)
GROUND LEVEL RELEASE POINT - STANDARD DISTANCES
COOPER NUCLEAR STATION
NEBRASKA PUBLIC POWER DISTRICT

Distance (Miles)

SECTOR	.5	1.5	2.5	3.5	4.5	7.5	15.	25.	35.	45.
NNE	3.2E-06	5.5E-07	2.2E-07	1.5E-07	8.0E-08	4.4E-08	1.2E-08	4.9E-09	3.2E-09	2.4E-09
NE	2.0E-06	3.3E-07	1.8E-07	1.2E-07	6.1E-08	3.1E-08	9.2E-09	4.1E-09	2.6E-09	1.4E-09
ENE	2.2E-06	2.9E-07	1.5E-07	8.1E-08	5.4E-08	2.0E-08	7.4E-09	3.1E-09	1.6E-09	8.0E-10
E	2.2E-06	3.1E-07	1.5E-07	7.2E-08	5.5E-08	2.3E-08	6.3E-09	3.1E-09	1.8E-09	9.6E-10
ESE	2.4E-06	3.9E-07	1.5E-07	7.8E-08	5.7E-08	2.7E-08	7.4E-09	2.6E-09	1.3E-09	8.1E-10
SE	2.4E-06	3.9E-07	1.6E-07	1.2E-07	6.1E-08	2.5E-08	6.5E-09	1.8E-09	1.0E-09	7.8E-10
SSE	3.8E-06	6.0E-07	2.6E-07	1.5E-07	9.6E-08	4.2E-08	8.7E-09	2.8E-09	1.7E-09	1.2E-09
S	4.6E-06	8.1E-07	3.7E-07	2.0E-07	1.4E-07	6.6E-08	1.8E-08	6.4E-09	3.6E-09	2.1E-09
SSW	2.6E-06	5.0E-07	2.1E-07	1.1E-07	8.4E-08	5.5E-08	5.6E-09	1.5E-09	8.2E-10	4.8E-10
SW	1.9E-06	2.6E-07	1.8E-07	8.1E-08	6.2E-08	2.0E-08	5.2E-09	1.0E-09	3.9E-10	2.5E-10
WSW	2.0E-06	2.8E-07	1.7E-07	9.0E-08	6.4E-08	1.7E-08	3.6E-09	1.3E-09	7.4E-10	5.1E-10
W	1.6E-06	3.7E-07	1.4E-07	1.0E-07	6.5E-08	1.9E-08	6.1E-09	2.4E-09	1.1E-09	6.0E-10
WNW	3.1E-06	4.9E-07	2.2E-07	1.2E-07	1.0E-07	3.7E-08	1.0E-08	4.1E-09	2.1E-09	1.2E-09
NW	4.9E-06	7.8E-07	3.4E-07	2.2E-07	1.3E-07	6.5E-08	1.9E-08	5.0E-09	2.8E-09	2.0E-09
NNW	6.1E-06	9.7E-07	4.1E-07	2.5E-07	1.7E-07	9.5E-08	2.9E-08	1.2E-08	5.8E-09	1.6E-09
N	5.2E-06	8.9E-07	3.9E-07	2.2E-07	1.6E-07	7.4E-08	2.4E-08	1.1E-08	6.1E-09	3.5E-09

DEPLETED MEAN RELATIVE CONCENTRATION (sec/m^3)
ELEVATED RELEASE POINT - STANDARD DISTANCES
COOPER NUCLEAR STATION
NEBRASKA PUBLIC POWER DISTRICT

DISTANCE (miles)

SECTOR	.5	1.5	2.5	3.5	4.5	7.5	15.	25.	35.	45.
NNE	6.6E-09	2.2E-08	2.1E-08	1.7E-08	1.5E-08	1.8E-08	5.4E-09	4.5E-09	2.8E-09	1.6E-09
NE	6.0E-09	1.4E-08	1.4E-08	1.3E-08	1.1E-08	1.5E-08	6.5E-09	2.5E-09	2.2E-09	1.7E-09
ENE	6.9E-09	1.3E-08	1.4E-08	1.1E-08	8.8E-09	1.3E-08	2.7E-09	3.5E-09	1.4E-09	8.6E-10
E	6.4E-09	1.3E-08	1.3E-08	1.1E-08	9.0E-09	1.5E-08	3.9E-09	2.2E-09	1.2E-09	2.6E-10
ESE	5.1E-09	1.1E-08	1.0E-08	9.5E-09	7.6E-09	6.9E-09	3.9E-09	1.6E-09	1.1E-09	5.6E-10
SE	8.1E-09	1.9E-08	1.6E-08	1.3E-08	1.1E-08	9.6E-09	3.4E-09	1.4E-09	1.1E-09	5.5E-10
SSE	1.1E-08	3.1E-08	2.3E-08	2.0E-08	3.3E-08	2.5E-08	5.6E-09	1.9E-09	2.0E-09	9.8E-10
S	1.9E-08	3.3E-08	3.2E-08	2.5E-08	2.4E-08	1.6E-08	4.4E-09	2.0E-09	1.1E-09	8.3E-10
SSW	1.0E-08	4.3E-08	1.7E-08	1.6E-08	1.4E-08	9.0E-09	2.3E-09	1.0E-09	8.6E-10	4.2E-10
SW	4.3E-09	4.9E-08	1.6E-08	1.1E-08	1.0E-08	9.0E-09	2.9E-09	1.4E-09	8.4E-10	6.4E-10
WSW	4.0E-09	6.6E-08	3.2E-08	1.7E-08	1.1E-08	6.3E-09	3.9E-09	1.5E-09	9.5E-10	4.2E-10
W	5.5E-09	6.8E-08	3.7E-08	2.1E-08	1.7E-08	6.0E-09	3.8E-09	1.1E-09	6.8E-10	4.0E-10
WNW	6.0E-09	7.9E-08	5.1E-08	3.3E-08	2.1E-08	9.0E-09	3.0E-09	1.4E-09	8.8E-10	5.5E-10
NW	4.7E-09	8.7E-08	7.3E-08	5.1E-08	3.2E-08	1.3E-08	6.9E-09	3.1E-09	1.7E-09	1.2E-09
NNW	8.3E-09	2.6E-08	7.8E-08	6.8E-08	2.1E-08	2.1E-08	5.1E-09	2.8E-09	2.0E-09	1.5E-09
N	7.3E-09	3.5E-08	3.2E-08	2.4E-08	1.9E-08	1.5E-08	6.3E-09	4.8E-09	3.1E-09	9.4E-10

DEPLETED MEAN RELATIVE CONCENTRATION (sec/m^3)
GROUND LEVEL RELEASE POINT - STANDARD DISTANCES
COOPER NUCLEAR STATION
NEBRASKA PUBLIC POWER DISTRICT

DISTANCE (miles)

SECTOR	.5	1.5	2.5	3.5	4.5	7.5	15.	25.	35.	45.
NNE	2.8E-06	4.5E-07	1.7E-07	1.1E-07	6.1E-08	3.2E-08	7.8E-09	2.7E-09	1.6E-09	1.1E-09
NE	1.7E-06	2.8E-07	1.4E-07	9.1E-08	4.6E-08	2.2E-08	5.7E-09	2.2E-09	1.2E-09	5.6E-10
ENE	1.9E-06	2.4E-07	1.2E-07	6.2E-08	4.0E-08	2.4E-08	4.7E-09	1.7E-09	7.7E-10	3.3E-10
E	1.9E-06	2.5E-07	1.2E-07	5.5E-08	4.1E-08	1.6E-08	3.9E-09	1.5E-09	8.3E-10	3.9E-10
ESE	2.1E-06	3.2E-07	1.2E-07	6.0E-08	4.3E-08	1.9E-08	4.6E-09	1.5E-09	6.3E-10	3.9E-10
SE	2.1E-06	3.2E-07	1.3E-07	9.0E-08	4.6E-08	1.7E-08	3.9E-09	9.5E-10	5.0E-10	3.6E-10
SSE	3.3E-06	5.0E-07	2.1E-07	1.2E-07	7.3E-08	3.0E-08	5.4E-09	1.6E-09	8.5E-10	5.2E-10
S	4.0E-06	6.7E-07	3.0E-07	1.6E-07	1.1E-07	4.8E-08	1.2E-08	3.7E-09	1.9E-09	9.4E-10
SSW	2.3E-06	4.2E-07	1.7E-07	8.1E-08	6.3E-08	3.9E-09	3.4E-09	8.4E-10	4.2E-10	2.1E-10
SW	1.7E-06	2.2E-07	1.4E-07	6.1E-08	4.5E-08	1.4E-08	3.1E-09	5.8E-10	1.8E-10	1.1E-10
WSW	1.7E-06	2.3E-07	1.4E-07	6.8E-08	4.7E-08	1.2E-08	2.1E-09	7.0E-10	3.8E-10	2.5E-10
W	1.4E-06	3.0E-07	1.1E-07	7.7E-08	4.8E-08	1.3E-08	3.7E-09	1.2E-09	5.0E-10	2.7E-10
WNW	2.7E-06	4.0E-07	1.7E-07	9.2E-08	7.6E-08	2.7E-08	6.3E-09	2.3E-09	1.0E-09	5.8E-10
NW	4.1E-06	6.5E-07	2.7E-07	1.7E-07	1.0E-07	4.7E-08	1.2E-08	2.9E-09	1.5E-09	9.3E-10
NNW	5.4E-06	8.1E-07	3.3E-07	1.9E-07	1.3E-07	6.9E-08	1.9E-08	6.5E-09	3.0E-09	7.6E-10
N	4.6E-06	7.5E-07	3.1E-07	1.7E-07	1.3E-07	5.4E-08	1.5E-08	5.9E-09	3.0E-09	1.6E-09

MEAN RELATIVE DEPOSITION (m^{-2})

ELEVATED RELEASE POINT - STANDARD DISTANCES
COOFER NUCLEAR STATION
NEBRASKA PUBLIC POWER DISTRICT

DISTANCE (miles)

SECTOR	.5	1.5	2.5	3.5	4.5	7.5	15.	25.	35.	45.
NNE	2.6E-10	3.0E-10	1.8E-10	1.3E-10	9.2E-11	5.7E-11	2.3E-11	1.3E-11	8.1E-12	5.8E-12
NE	1.9E-10	2.0E-10	1.2E-10	8.2E-11	6.1E-11	4.0E-11	1.6E-11	8.3E-12	6.0E-12	3.8E-12
ENE	1.[illegible]E-10	1.4E-10	8.7E-11	6.2E-11	4.5E-11	2.9E-11	1.1E-11	5.7E-12	3.8E-12	2.6E-12
E	9.6E-11	9.5E-11	6.4E-11	4.6E-11	3.6E-11	2.3E-11	7.6E [illegible]2	3.7E-12	2.5E-12	8.5E-13
ESE	7.7E-11	1.0E-10	6.6E-11	4.8E-11	3.8E-11	2.3E-11	1.2E-11	5.2E-12	3.5E-12	2.0E-12
SE	2.3E-10	2.3E-10	1.4E-10	1.0E-10	7.5E-11	4.0E-11	1.7E-11	7.5E-12	4.8E-12	3.3E-12
SSE	4.2E-10	4.5E-10	2.6E-10	1.7E-10	1.6E-10	7.7E-11	3.3E-11	1.6E-11	1.1E-11	7.6E-12
S	6.4E-10	5.1E-10	3.0E-10	2.0E-10	1.5E-10	7.2E-11	2.9E-11	1.6E-11	1.1E-11	6.7E-12
SSW	3.0E-10	3.4E-10	1.4E-10	9.7E-11	7.2E-11	3.5E-11	1.3E-11	6.5E-12	4.9E-12	2.6E-12
SW	7.9E-11	2.1E-10	8.4E-11	5.0E-11	4.0E-11	2.1E-11	7.4E-12	3.8E-12	2.4E-12	1.8E-12
WSW	5.7E-11	2.3E-10	1.0E-10	6.2E-11	4.3E-11	2.3E-11	8.5E-12	4.3E-12	2.7E-12	1.8E-12
W	1.0E-10	3.4E-10	1.6E-10	9.8E-11	6.9E-11	2.9E-11	1.3E-11	6.2E-12	3.4E-12	2.0E-12
WNW	1.2E-10	4.1E-10	2.1E-10	1.3E-10	8.3E-11	3.9E-11	1.4E-11	7.0E-12	4.1E-12	2.6E-12
NW	1.2E-10	3.8E-10	2.1E-10	1.3E-10	8.2E-11	4.1E-11	1.7E-11	1.0E-11	6.3E-12	3.9E-12
NNW	2.3E-10	2.6E-10	3.0E-10	2.0E-10	1.1E-10	6.0E-11	2.1E-11	1.1E-11	6.1E-12	3.9E-12
N	2.5E-10	3.7E-10	2.3E-10	1.5E-10	1.2E-10	7.1E-11	2.9E-11	1.7E-11	1.3E-11	5.2E-12

MEAN RELATIVE DEPOSITION (m^{-2})
GROUND LEVEL RELEASE POINT - STANDARD DISTANCES
COOPER NUCLEAR STATION
NEBRASKA PUBLIC POWER DISTRICT

DISTANCE (miles)

SECTOR	.5	1.5	2.5	3.5	4.5	7.5	15.	25.	35.	45.
NNE	8.0E-09	1.2E-09	5.2E-10	3.1E-10	2.0E-10	9.9E-11	3.3E-11	1.6E-11	9.6E-12	6.0E-12
NE	5.1E-09	7.6E-10	3.4E-10	2.0E-10	1.3E-10	6.9E-11	2.4E-11	1.1E-11	6.7E-12	4.1E-12
ENE	4.0E-09	6.1E-10	2.7E-10	1.6E-10	1.1E-10	4.8E-11	2.0E-11	7.6E-12	3.9E-12	2.5E-12
E	4.0E-09	6.1E-10	2.8E-10	1.6E-10	1.1E-10	5.0E-11	1.8E-11	8.0E-12	4.2E-12	2.3E-12
ESE	5.3E-09	8.2E-10	3.5E-10	2.0E-10	1.4E-10	6.7E-11	2.1E-11	9.6E-12	5.6E-12	3.8E-12
SE	6.4E-09	9.6E-10	3.9E-10	2.4E-10	1.6E-10	7.1E-11	2.5E-11	1.1E-11	6.8E-12	4.1E-12
SSE	1.0E-08	1.5E-09	6.1E-10	3.5E-10	2.3E-10	1.1E-10	3.9E-11	1.8E-11	1.1E-11	6.5E-12
S	8.7E-09	1.4E-09	5.8E-10	3.3E-10	2.3E-10	1.1E-10	4.0E-11	1.8E-11	1.0E-11	6.3E-12
SSW	3.7E-09	6.0E-10	2.6E-10	1.5E-10	1.0E-10	5.9E-11	1.5E-11	5.0E-12	3.0E012	1.8E-12
SW	2.9E-09	4.4E-10	2.2E-10	1.2E-10	8.3E-11	3.5E-11	1.1E-11	3.0E-12	1.4E-12	8.7E-13
WSW	2.8E-09	4.6E-10	2.2E-10	1.3E-10	9.0E-11	3.7E-11	1.1E-11	4.2E-12	2.2E-12	1.4E-12
W	3.6E-09	5.9E-10	2.6E-10	1.5E-10	1.0E-10	4.6E-11	1.7E-11	6.9E-12	3.8E-12	2.2E-12
WNW	5.6E-09	8.7E-10	3.8E-10	2.3E-10	1.6E-10	7.3E-11	2.5E-11	1.0E-11	6.2E-12	3.8E-12
NW	1.0E-08	1.6E-09	6.8E-10	4.1E-10	2.7E-10	1.3E-10	4.5E-11	1.8E-11	1.1E-11	6.8E-12
NNW	1.1E-08	1.6E-09	6.9E-10	4.1E-10	2.8E-10	1.4E-10	5.2E-11	2.3E-11	1.3E-11	5.2E-12
N	1.2E-08	1.9E-09	8.1E-10	4.6E-10	3.2E-10	1.5E-10	5.8E-11	2.7E-11	1.7E-11	1.0E-11