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**DETERMINING ACCEPTABLE STACK CONCENTRATIONS
FOR GASEOUS WASTES RELEASED TO THE ATMOSPHERE**

November 7, 1967

D. J. Brown
Environmental Safety-Nuclear Materials Section
Research and Engineering Department
Chemical Processing Division

Contract AT(45-1)-2130
ATLANTIC RICHFIELD HANFORD COMPANY

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November 7, 1967

To: L. R. Michels

From: D. J. Brown

Subject: DETERMINING ACCEPTABLE STACK CONCENTRATIONS FOR
GASEOUS WASTES RELEASED TO THE ATMOSPHERE

The following information is provided to assist you with your engineering evaluation of the gaseous wastes released to the atmosphere via stacks and roof vents in the 200 Areas for inclusion in the Hanford Low Level Waste Management Reevaluation Study report.

The criteria, established by the AEC for the release of the chemical and radiochemical gaseous wastes of concern in your report, are published in AECM 0524. For your convenience I have listed these as follows:

Critical Organ	Contributing Isotope	Restricted Areas	Permissible Dose Rates - rem per year *	
			Individuals and Small Population Groups near Facilities	Large Population Groups
Thyroid	Iodine-131	30	1.5	0.5
Whole Body	Krypton-85	5	0.5	0.17
Bone	Plutonium-239	30	1.5	0.5
Bone	Strontium-90	30	1.5	0.5
Lungs	NO ₂	5 ppm	5 ppm	5 ppm

*Permissible dosages are not additive. NO₂ concentrations are ceiling threshold values in parts per million. There should be no exposure at or above the listed NO₂ concentrations however short the time period.

The basic release rate guides established by the AEC for the various radio-nuclides emitted from stacks and roof vents in the 200 Areas is found in AECM 0510. These are as follows:

- The guide for total release of iodine-131 from all 200 Area facilities is 500 curies per calendar quarter.
- The guides for effluent release from each stack in the 200 Areas are:

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<u>Radionuclide</u>	<u>Release Guide (Curies per Week)</u>	
	<u>200-Foot Stack</u>	<u>Short Stack or Vent</u>
Strontium-90	1	1×10^{-1}
Iodine-131	30	3
Plutonium-239	1×10^{-2}	1×10^{-3}
Uranium (Natural)	4×10^{-2}	4×10^{-3}
Total of others except H-3, C-14, and Noble Gases	20	2

It is the AEC-RL policy to strive to keep releases at or below 10 percent of these guides.

The rationale for establishing AEC-RL policy at or below 10 percent of the guide values in AECM 0510 was developed by the Environmental Health Department of Battelle Northwest Laboratory. This rationale is stated as follows:

"Several different radionuclides and several different modes of exposure (e.g., drinking water, milk, breathing air, etc.) can contribute to the total annual dose of an individual. However, experience has shown that for any single mode of exposure, only one or two radionuclides usually contribute most of the exposure to a particular critical organ. If only 10 percent of the permissible dose is allowed to come from any one nuclide via one mode, then it is highly improbable that the combined dose to any critical organ from all available nuclides via whatever modes will reach the limits specified in the basic standards AECM 0524."

Using iodine-131 as an example, we can see the analogy in the establishment of the release guide limit at 3 curies per week for a 200-foot stack (10 percent of the published value). Environmental monitoring results, obtained from the region surrounding the Hanford Project area during the past 20 years, have shown that a release of one curie of iodine-131 per week out the 200-foot stack at the Purex Plant will give rise to an iodine-131 concentration in the local milk supply of 3 pCi/l. An iodine-131 concentration of 100 pCi/l in milk, if consumed at a normal rate for one year, would result in a yearly dose to a child's thyroid of 1.5 rems. This is the maximum allowable yearly dose an individual living near a nuclear facility can receive according to AECM 0524. Applying the rationale that only 10 percent of the permissible dose be allowed to come from any one source, the iodine-131 concentration in the local milk would have to be controlled to 10 pCi/cc, which equates to a release rate of 3.3 curies per week for the 200-foot stack at the Purex plant.

The release rate limits, as specified by the Atlantic Richfield Hanford Company in ARH-220, for all gaseous wastes released to the atmosphere in the 200 Areas, are ten percent of those guide values listed in AECM 0510.

Release guide values for NO_2 and krypton-85 are not published in AECM 0510. For the purpose of your study these values were calculated by utilizing available field data and an extrapolation method devised by C. E. Elderkin, Fallout Research Unit, Battelle Northwest Laboratory, which relates concentrations of gaseous wastes in a stack to concentrations in the atmosphere at ground level as a function of release rate, stack height, distance from stack,

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exposure time and atmospheric stability. The appropriate release guide to use for krypton-85 is 40,000 curies per week. This guide is for the 200-foot stack at the Purex plant, which is the only point at which this gas is released to the atmosphere. The guide for NO₂ will have to be calculated for each release point because of the many variables involved. This can be done by utilizing the graphical method provided in the attached appendix. An explanation as to its operation and use is provided with the graphs in the appendix.

In the outline of the gaseous wastes section of the Hanford Low Level Waste Management Reevaluation Study requested by R. J. Sloat, there is a section on present status of iodine-131, krypton-85 and NO₂ in the atmosphere at ground level. Two tables were prepared for inclusion in your report which show ground level concentrations of these gaseous wastes at distances of one, five, and ten miles downwind from the major release points in the 200 Areas. The concentrations were calculated from the graphs in the attached appendix.

Table I (attached) presents NO₂ concentrations at the ground surface downwind from the three major release points in the 200 Areas (namely, the 291-A stack at Purex, the AR-PV stack at the 244-AR Vault, and the 224-U X-14 stack at the UO₂ plant. Because there is no allowable exposure time for NO₂ above 5 ppm, no consideration was given to climatic conditions other than prevailing wind directions in locating the general sector where the greatest number of gaseous waste puffs would be likely to hit the ground during the year. These data show that 41 percent of the time the wind blows from the northwest and west-northwest.

The data for the two radionuclides, iodine-131 and krypton-85, are presented in Table II, attached. Only the 200-foot Purex stack was considered here, because this stack is the only one releasing these two radionuclides in concentrations of concern at the present time.

To relate the radionuclide concentration values which appear in Table II to equivalent dose rates, the following relationships are provided:

<u>Air Concentrations</u> <u>(Continuous Yearly Exposure)</u>	<u>Yearly Dose</u>	<u>Allowable Yearly Dose to</u> <u>Individuals and Small</u> <u>Population Groups near</u> <u>Nuclear Facilities</u>
3×10^{-8} uCi ⁸⁵ Kr/ml	0.05 rem	0.5 rem
1×10^{-11} uCi ¹³¹ I/ml	0.15 rem	1.5 rem

Because it is highly unlikely that an individual would position himself on the centerline of maximum concentration in the plume downwind of a release point for an entire year, consideration should be given to the climatic factors which control the direction of movement of the gaseous waste. Approximately 41 percent of the time the wind blows from the northwest and west-northwest directions toward the Tri-Cities and the Columbia Basin Irrigation Project land to the east. If an individual could position himself at the point of maximum concentration, he would receive a dose of 0.08 rem from iodine-131 and 0.1 rem from krypton-85.

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TABLE I

**NO₂ CONCENTRATIONS IN THE ATMOSPHERE AT GROUND LEVEL
DOWNWIND FROM PRINCIPLE RELEASE POINTS IN THE 200 AREAS**

Percent of Time NO ₂ Concentrations are Below Listed Values	Distance from Release Point								
	1 Mile			3 Miles			10 Miles		
	291-A * Stack	AR-PV ** Stack	UO ₃ *** Stack	291-A Stack	AR-PV Stack	UO ₃ Stack	291-A Stack	AR-PV Stack	UO ₃ Stack
99	130 ppm	12 ppm	20 ppm	30 ppm	3 ppm	5 ppm	4 ppm	<1 ppm	<1 ppm
95	100	10	15	17	1	2	1	<1	<1
90	60	6	9	12	1	1	1	<1	<1

- * 200-foot Purex stack, release rate 960 pounds per hour.
 ** 150-foot 224-AR Tank Vault stack, release rate 70 pounds per hour.
 *** 80-foot 224-U stack, release rate 111 pounds per hour.

TABLE II

**IODINE-131 AND KRYPTON-85 CONCENTRATIONS IN THE ATMOSPHERE
AT GROUND LEVEL DOWNWIND FROM THE 291-A STACK**

Percent of Time Concentrations are Below Listed Values	Distance from Release Point					
	1 Mile		3 Miles		10 Miles	
	I-131 *	Kr-85 *	I-131	Kr-85	I-131	Kr-85
99	7 x 10 ⁻¹⁰	8 x 10 ⁻⁶	7 x 10 ⁻¹¹	8 x 10 ⁻⁷	6 x 10 ⁻¹²	7 x 10 ⁻⁸
95	3 x 10 ⁻¹⁰	3 x 10 ⁻⁶	3 x 10 ⁻¹¹	4 x 10 ⁻⁷	2 x 10 ⁻¹²	2 x 10 ⁻⁸
90	1 x 10 ⁻¹⁰	2 x 10 ⁻⁶	2 x 10 ⁻¹¹	2 x 10 ⁻⁷	2 x 10 ⁻¹²	2 x 10 ⁻⁸
50	2 x 10 ⁻¹¹	2 x 10 ⁻⁷	8 x 10 ⁻¹²	1 x 10 ⁻⁷	8 x 10 ⁻¹³	1 x 10 ⁻⁸

* Iodine-131 and krypton-85 values are given in uCi/ml.

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APPENDIX

METHOD FOR EXTRAPOLATING STACK CONCENTRATIONS OF GASEOUS WASTES TO
ATMOSPHERIC CONCENTRATIONS AT GROUND LEVEL

The five graphs included in this Appendix provide a method for extrapolating stack concentrations of gaseous wastes to atmospheric concentrations at ground level. The stepwise procedure given below provides the information for using the attached graphs.

1. Determine the "effective stack height" in feet.
 - a. "Effective stack height" is defined as the height of a stack above ground level where there are no major obstructions within a radius of 200 feet. Where major obstructions are situated within a 200-foot radius of a stack, the effective height shall be measured from the top of the highest obstruction.
2. Determine the release rate of the gaseous waste in grams per second.
3. Determine the flow rate of the air exhausted from the stack in cubic meters per second.
4. Choose the appropriate percent of time you want the maximum air concentration to be at or below the value to be calculated. The graphs included with this Appendix (Figures 1 through 4) are for 50, 90, 95, and 99 percent.
5. Select the distance from the stack you are interested in determining the ground level air concentration.
6. Determine the X_a/Q value from either Figure 1, 2, 3 or 4.
 - a. The X_a/Q value is constant for each effective height out to those distances indicated on the sloping curve. Beyond these points of intersection, the X_a/Q value is dependent on distance only.
 - b. If the gaseous waste is NO_2 , multiply the X_a/Q value by 70.
7. Enter the graph in Figure 5 on the X_a/Q scale with the value obtained at Step 6 or 6-a.
8. Move up, normal to the X_a/Q scale, until intersecting the appropriate flow rate.
 - a. For X_a/Q values less than 1×10^{-4} , the graph in Figure 5 need not be used. Multiply the X_a/Q value obtained at Step 6 or Step 6-a by the release rate directly. This product will be the air concentration at ground level in units of grams per cubic meter.
9. Proceed to the left, parallel with the X_a/Q scale, until intersecting the release rate value determined at Step 2.
10. From this point of intersection, move to the left, parallel to the release rate scale, and read off the air concentration in either ppm for NO_2 or grams per cubic meter for any other gaseous waste.

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FIGURE I.
MAXIMUM AIR CONCENTRATION AT OR BELOW CALCULATED VALUES
50% OF TIME

FIGURE 2.
MAXIMUM AIR CONCENTRATION AT OR BELOW CALCULATED VALUES
90% OF TIME

FIGURE 3.

MAXIMUM AIR CONCENTRATION AT OR BELOW CALCULATED VALUES
95% OF TIME

FIGURE 4.

MAXIMUM AIR CONCENTRATION AT OR BELOW CALCULATED VALUES
99% OF TIME

FIGURE 5.
MAXIMUM AIR CONCENTRATIONS AT GROUND LEVEL

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