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HUMBOLDT BAY STACK EMISSION LIMIT, DOCKET NO. 50-133

The presently authorized stack emission limit for release of noble gases from the PG&E reactor facility at Humboldt Bay during routine operations was established and made a part of the technical specifications at the time the operating license was issued on August 28, 1962, as follows:

> "The annual average stack emission rate for noble and activated gases shall not exceed 0.05 curies per second; the instantaneous stack emission rate shall not exceed 0.5 curies per second.
>
> "If the annual average stack emission rate is exceeded for more than a week, the power level shall be reduced or other necessary steps shall be taken to reduce the emission to the annual average rate."

The gaseous wastes are discharged to the atmosphere through a stack 250 feet in height which has an automatically controlled damper to maintain a stack flow of approximately 12,000 cfm. The principal sources of gaseous wastes are the air ejector off-gas system, and the gland seal condenser and condenser mechanical vacuum pump exhaust system. Reactor and refueling building ventilation system and equipment vents are also exhausted to the stack.

Monitors are provided on the air ejector off gas system, the stack, emergency condenser vents, and at various locations in the reactor and refueling building. In addition, the technical specifications require at least 30 off-site environmental monitoring stations equipped with two 10 mr stray radiation chambers and with a film pack for determining the integrated gamma dose rate in the environs.

The air ejector off-gas monitor system is set to alarm if the off-gas activity reaches a level that would correspond to a stack release rate of 0.05 curies per second and to initiate closure of the off-gas isolation valve if the activity reaches a level that would correspond to a stack release rate of 0.5 curies per second and remain at this value for 10 minutes. The calibration

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shall be checked at least once each month during power operation. The stack gas monitor is set to alarm at a release rate of 0.05 curies per second. The calibration of this system shall be checked at least once each month. The design features of these monitoring systems are described in the technical specifications.

The stack emission rate of 0.05 curies per second is a calculated value representing the mixture of noble and activation gases that could be continuously released from the Humboldt Bay stack without exceeding 10 CFR 20 exposure limits at any habitable off-site location. This calculated value is based upon the following factors:

1. The MPC value for the mixture of gases.
   The composition of this mixture, which was described by GE, was based upon the fission yields, decay schemes and energies of the nuclides involved and took into account the delay time before release from the stack. At this period of time (March 1962) Appendix B of Part 20 did not contain MPC values for the shorter lived Xenon and Krypton nuclides included in the mixture. However, GE derived an MPC value for the mixture of 7.4×10^{-8} μc/cc that was weighted in accordance with the percentages of the nuclides present and their respective energies. This value was used by the staff in deriving the stack emission rate. (During the past year, 1965, MPC's were established in Part 20 for all of the noble gases and it is interesting to note that a weighted MPC for the Humboldt Bay mixture using the presently established Part 20 values for the individual nuclides would be 3×10^{-8} μc/cc).

2. The annual average atmospheric dilution.
   This was derived from meteorological data submitted by PG&E and included data from Arcata and Eureka. It took into account the effective height of the stack for various wind speeds, and the location of the stack with respect to Humboldt Hill. The calculation used the usual Sutton equation:

$$\chi/Q = 2/\pi \bar{u} \; C_y C_z \, x^{2-n}$$

   The analysis was performed as described below, and showed that the maximum annual value of χ/Q at any point in the environment is 1.36×10^{-6}.

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A. Atmospheric stability was determined from radiosonde measurements made at a wartime base in Arcata, approximately 10 miles north from the site. There were 402 observations made at 7:00 am and 294 observations made at 7:00 pm over a period of approximately a year and a half. Thus some seasons counted more than others. This data was combined with wind direction observations made at Eureka 4 times a day to develop lapse and inversion wind roses for 16 directions.

B. The data provided indicated a total frequency of calm of 24.4%. This was arbitrarily distributed so that 1/3 of it was given to the 3 sectors from which winds could travel toward Humboldt Hill. PG&E assumed a 60%-40% split of this time for inversions and lapse conditions, making the frequency for these sectors 4.88% inversion, and 3.3% lapse. The staff assigned the wind velocity range 0-4 mph to this calm category, since this seemed appropriate for the type of data at hand.

C. Although the above data is sketchy, the staff was able by relying on experience and information obtained at other sites, to make the reasonable assumptions required to develop the tables presented here and in paragraph D below.

Parameter	Inversions		Unstable	
n	0.5		0.2	
Direction	Speed (mph)	Frequency % in 67½°	Speed (mph)	Frequency % in 67½°
N	8.0	2.90	10	10.3
NNW	8.4	1.33	10	5.67
NW	3.4	1.44	10	7.05
Calm	2.5	4.88	2.8	3.3
TOTAL	4.0	10.55	9.0	26.32

D. Utilizing data from other sites concerning the distribution of wind speeds, a line was drawn on log probability paper with the slope obtained from other sites and the average speed obtained from the table above. The speeds obtained from this graph were then used to calculate corresponding effective stack heights, using the usual

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Bryant-Davidson equation, with a stack exhaust velocity of 100 feet/sec. In this way, one obtains the following table of wind speeds, frequencies (converted to a 45 degree sector), and effective stack heights (expressed in meters above mean sea level).

Stable				Unstable			
u m/sec	Freq. %	h meters	Dist. meters	u m/sec	Freq. %	h meters	Dist. meters
1.0	1.20	200	3800	2.24	2.89	117	2320
1.5	1.27	145	2700	3.36	3.15	100	1820
2.0	1.06	125	2320	4.48	2.62	94	1720
2.5	0.78	110	1900	5.60	1.93	90	1700
3.0	1.13	105	1830	6.72	2.80	88	1680
5.0	0.85	92	1700	11.2	2.10	84	1665
7.0	0.78	88	1680	15.7	1.93	82	1650

E. This table also lists the distances from the stack at which plumes traveling at the various speeds and heights would intersect Humboldt Hill (at which point the effective stack height becomes zero). The corresponding values of Cz for each speed and height were determined by the methods of Barad and Hilst (HW-21415 Rev.). The plume was spread uniformly over a 45 degree sector, weighted for the wind speed and direction frequency, and the effective value of each X/Q for that distance calculated. It is seen that the lowest inversion wind speed group causes the plume to intersect the hill at a distance of 3800 meters, and that the lowest lapse wind speed causes the plume to intersect the hill at a distance of 2320 meters. After the plume for each condition intersects the hill, it is assumed that it continues on up the hill, adding to other plumes which intersect higher up and at greater distances. Atmospheric diffusion continues at the same rate as the plume passes on up the hill (a conservative assumption, since the rough terrain might increase the rate of diffusion). The cumulative effective of all the plumes at a distance of 3800 meters was calculated, and the value of X/Q so obtained is 1.28×10^{-6} sec/m^3. A second cumulative calculation was made in which it was found that at a distance of 2700 meters, the value of X/Q ~~is is~~ 1.56 $\times 10^{-6}$ sec/m^3. Similary, at a distance of 2320 meters the value obtained was 1.37×10^{-6} sec/m^3. On this basis, the maximum value of X/Q at any point on Humboldt Hill was taken to be 1.56×10^{-6} sec/m^3, occurring at a distance of 2700 meters.

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3. Calculation of dose based on concentration.
Dividing the MPC value for the mixture (7.4×10^{-8}) by the X/Q obtained above, one arrives at the stack limit, which, using the exact numbers given here, is 47,500 uc/sec. This value was rounded to 50,000 uc/sec for the license limit.

4. Shine dose from the plume.

A. As a check on the above method of calculation, which is based on concentrations, and involves the conservative assumption that all the plumes are effectively infinite in extent (on the order of 500 meters across), the following calculation was made before the stack limit was licensed. In this calculation, the geometry of the plume was considered, along with the special distribution of the radioactivity. Radiation from point sources at all points in the plume was allowed to impinge on a receptor after account was taken for air attenuation for each source to receptor distance, and the total effect was obtained by a numerical integration over all space. This work was originally done by R. L. Waterfield in 1953 and published in Document XDC-54-4-12(Unclassified) as part of the ANP Program. The basic equations involved are as follows:

$$\text{Dose} = \int_0^{\infty} (S_e\, e^{-ur}/r^2)\, dr$$

$$\text{where } S_e = (2\, Q/\pi\, u\, Cy\, Cz\, x^{2-n})\, e^{-h^2/Cz^2 x^{2-n}}$$

and Q = total curies released during the exposure time.

The other parameters are as described above in the concentration calculation.

B. This equation thus takes into account the gaussian distribution of the radioactivity in the plume (and therefore the size of the plume). Although buildup due to scattering was not included in the model, this was compensated for by decreasing the amount of attenuation in the air to obtain approximately the same effect. The final results are presented in the form of a graph in the referenced report. When this graph is used to calculate dose, one needs only the size of the plume as it passes over the point of interest, and the appropriate wind speed and conversion factors. The dose is a slowly-changing function of plume size for the conditions being considered at this site.

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The equation is:

Dose = K Q F I/U

where F is the frequency of the wind speed, direction and stability

K is the dose corrosion factor,

I is the cloud integral described above,

U is the wind speed,

and Q is the total curies released during the exposure time considered.

C. Because the dose rate is relatively insensitive to change in cloud size a constant value of Cz (calculated as above for the maximum plume height) was used for all wind speeds and stack heights. The value used for inversions was 0.027, and that for lapse conditions was 0.22. After the plume centerline intersected the hill (for each wind speed and effective stack height as calculated above), it was assumed to continue on up the slope at a height of 15 meters above the surface. The peak dose was found at a distance of 2100 meters, with most of it contributed by the inversion conditions.

D. Utilizing the same MPC value as used above in the concentration calculation, the shine dose from an emission rate of 50,000 uc/sec found to be 72 mr/year, which is a factor of 7 less than permitted by Part 20. We concluded that this provided sufficient additional support to the previously calculated emission limit that it could be authorized.

5. In the past year, Part 20 has been extended to cover all the noble fission gases, and the MPC of the mixture at hand was found to be approximately 3×10^{-8}uc/cc. On this basis, the shine dose (considering the finite cloud size) for the licensed emission rate is 176 mr/year.

6. PG&E has recently submitted detailed on-site meteorological measurements which have been reviewed by the writer. It has been found that the distribution of velocity and stability conditions with direction which was assumed based on the initial meager data shows an amazing agreement with the on-site data. We therefore conclude that the the original estimates of atmospheric diffusion for this site are as accurate as can be obtained from data of this type, and that further effort along this line is not needed.

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7. We feel that only a long-term diffusion test, such as the period of high stack emission rates, would give diffusion estimates which are more reliable than those calculated above. The environmental monitoring measurements obtained during this time have been analyzed by the writer, and will be the subject of another memo. The results of this analysis show that if the plant were operated at the presently licensed stack emission limit for an entire year, the maximum off-site exposure on Humboldt Hill would be approximately 300 millirem, as compared with the calculated value of 176 millirem obtained in the gamma shine calculation above. It is seen that continuous operation at the licensed level would leave only a small "margin of safety" in meeting the requirements of Part 20.

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