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THIRD QUARTERLY PROGRESS REPORT ON THE THEORETICAL SAFETY EVALUATION OF CONSUMER PRODUCTS FROM PROJECT GASBUGGY

D. G. Jacobs, P. S. Rohwer, and K. E. Cowser

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D. G. Jacobs, P. S. Rohwer, and K. E. Cowser

Abstract

Dose equivalent calculations for the hypothetical use of gas from the Gasbuggy well within the San Juan Basin have been extended to include a source term with continuously decreasing concentrations of radionuclides. As a result of gas withdrawal from the cavity, most of the hypothetical dose would be associated with the use of gas during the first year of production.

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[redacted]

Effect of a Continuously Decreasing Concentration of Radionuclides At the Wellhead on the Dose to Hypothetical Users of Gasbuggy Gas

In the hypothetical utilization of gas from a well that has been stimulated by underground nuclear detonations, there are a number of factors which affect the concentration of radionuclides available for the exposure of domestic consumers. These factors were outlined in our previous progress report[1] and include:

1. concentration of radionuclide at the wellhead,
2. pipeline dilution,
3. quantity of gas consumed,
4. fraction of combustion products vented inside the home,
5. home dilution, and
6. home occupancy.

These factors can be combined into a general equation to depict the trend of radiation exposures with time.

For a first approximation, we shall assume that gas is removed from the well at a constant rate and that the bottom-hole pressure is maintained by the influx of an equivalent amount of gas into the cavity. If the gases within the cavity are well-mixed, the concentration of radionuclides in the gas removed from the wellhead would be:

$$C_p = C_o e^{-wt/V_o} e^{-\lambda t} \qquad (1)$$

where

C_o is the initial concentration of radionuclide in the cavity gas at the time production starts (μCi/SCF),

w is the rate of withdrawal of gas from the stimulated well (SCF/day),

t is the time elapsed from the start of production (days),

V_o is the initial volume of gas in the cavity (SCF), and

λ is the radioactive decay constant (days^{-1}).

For radionuclides with half-lives on the order of a few days, their concentration in gas from the wellhead could be significantly reduced by allowing a few months shut-in time for radioactive decay. For long-lived radionuclides, that is, those with half-lives on the order of a

few years, radioactive decay would not significantly reduce their activity levels during a shut-in period of a few months, but the concentrations could be reduced by releasing them in flaring operations at the wellhead. With the simplified assumption of complete mixing and maintenance of downhole pressure, flaring operation would reduce the concentrations of radionuclides in the gas removed at the wellhead as indicated in Table 1.

Table 1. Effects of Flaring on the Concentration of Long-Lived Radionuclides Assuming Perfect Mixing in the Cavity

Cavity Volumes Flared	C_p/C_o
0	1.000
1	0.368
2	0.135
3	0.050
4	0.018
5	0.007

Before the gas could be utilized by domestic users with farm taps in the triangle*, it would be diluted by flow through pipelines used for collection and distribution. Further dilution would occur in the homes due to turnover of air. Also, the fraction of combustion products vented into the homes and the occupancy factors would have to be considered. A generalized equation for the concentration of a radionuclide in the home can be written

$$C_H = \frac{fC_o e^{-wt/V_o} e^{-\lambda t}}{\frac{R}{w} \cdot \frac{A}{U}} , \qquad (2)$$

where

f is the fraction of combustion products released indoors,

*Triangle is used here in reference to the El Paso Natural Gas Company's collection and distribution system in the San Juan Basin, including the Ignacio and Blanco processing plants.

R is the average rate of flow in the gas line from all wells at the point of use (SCF/day),

U is the rate of use of gas (SCF/day),

A is the rate of air turnover in the house (SCF/day), and the other symbols are defined as above.

Most of these parameters, of course, would not be constant but would vary with time. For example, utilization of gas for heating would be seasonal and would be dependent on weather conditions; also, the rate of air turnover in a given house would depend on the ventilation. Equation (2) would give the concentration of a radionuclide in a home for the conditions specified. Intake of radioactivity would be further influenced by the breathing rate and by the occupancy factor.

Dose equivalents have been calculated for the hypothetical use situation described in our previous report as Residence "A" and Residence "C." These hypothetical situations considered a wellhead production rate of 1 M^2cf/day for the Gasbuggy well, a pipeline dilution factor of 50, and gas use corresponding to 6000-degree days of heating per year. Measured values for the initial concentrations of ^3H and ^{85}Kr of 650 and 100 pCi/cc were used as was the estimated initial volume of gas in the cavity, 132 M^2cf (ref. 2). Further assumptions were that gas would be produced and used continuously, that all combustion products would be vented into the home, and that someone would be present in the home continuously. The exposure modes considered were inhalation and skin absorption of ^3H and submersion in ^{85}Kr. Equation (2) was used to describe the concentrations of the ^{85}Kr and ^3H with time.

In Table 2 are listed the hypothetical annual dose equivalents for the conditions assumed in the calculations. The biological half-life of ^3H is quite short so that when intake ceases the additional dose due to the ^3H retained in the body ceases shortly thereafter. For ^{85}Kr the dose results from submersion in contaminated air so that little or no dose would be received after the source of radioactivity is depleted.

Table 2. Annual Dose Equivalents to Whole Body from the Hypothetical Use of Gas from the Gasbuggy Well (Pipeline Dilution Factor = 50)

Production Year	Annual Hypothetical Dose (mrem)	
	^{3}H	^{85}Kr
1	15.0	0.93
2	1.1	0.06
3	0.06	----

Limits of Detection of Radionuclides in Gas from the Gasbuggy Well and Their Hypothetical Impact on Dose

The radioactivity in gas samples withdrawn from the Gasbuggy Well have been analyzed by the Lawrence Radiation Laboratory.[2] Tritium and ^{85}Kr were detected and measured in the gas samples, but no other radionuclides were reported as being present. In attempting an evaluation of the radiological safety of the hypothetical use of Gasbuggy gas, it is important to ascertain that the concentration of other radionuclides would be low enough so that they could not contribute significantly to the total hypothetical dose. Lawrence Radiation Laboratory has provided a list of radionuclides that were analyzed for and the limits of their detectability with the analytical procedures used.[3] Some additional information, obtained by Isotopes, Incorporated, was provided by C. R. Bowman, El Paso Natural Gas Company.

It is important to keep in mind that the values listed in Table 3 are detection limits (that is, they represent the highest concentration of the radionuclide that could have escaped detection) and that the true concentrations would probably be well below these limits. The 50-year dose commitments and the external gamma dose potentials were calculated for the hypothetical use situation described in the previous section.

Of the radionuclides listed in Table 3, looking ahead to the possible nuclear stimulation of a large producing formation (involving

Table 3. Limits of Detection of Radionuclides in Gas from the Gasbuggy Well and Their Hypothetical Impact on Dose

The contribution of the daughters are considered in the total. Gas production is assumed to begin immediately following the detonation. (Pipeline Dilution Factor = 50)

Radionuclide	Detection Limit in Undiluted Gas at the Time of Analysis Extrapolated to the Time of Detonation[a] (pCi/cc)	Radioactive Half-life (days)	Critical Organ	Upper Limit of Internal Dose Commitment (50 yr) to the Critical Organ (mrem)	Upper Limit of Potential External Gamma Dose (mrem)
^{90}Sr	1.4×10^{-3}	1.0×10^{4}	Bone	5	----
^{125}Sn	1.8	9.5	GI(LLI)	0.9	2×10^{-3}
^{131}I	0.03	8.05	Thyroid	0.4	1×10^{-4}
^{14}C[b]	0.05	2×10^{14}	Fat	0.02	----
^{127}Sb	2.25	3.9	c	c	5×10^{-3}
^{129m}Te	0.001	3.3	Kidneys	2×10^{-3}	5×10^{-6}
^{125m}Te	7×10^{-4}	58	GI(LLI)	6×10^{-4}	2×10^{-6}
^{137}Cs	1.4×10^{-5}	1.1×10^{4}	Liver	1×10^{-4}	1×10^{-6}
^{125}Sb	5×10^{-5}	877	Bone	8×10^{-5}	1×10^{-6}
^{106}Ru	1.3×10^{-5}	365	GI(LLI)	7×10^{-5}	3×10^{-7}
^{103}Ru	8×10^{-5}	41	GI(LLI)	3×10^{-5}	6×10^{-8}

[a] Data from reference 3 except for ^{14}C.

[b] Data on the detection limit of ^{14}C was supplied by C. R. Bowman, El Paso Natural Gas Company.

[c] Not calculated.

thousands of nuclear stimulated wells), ^{90}Sr might contribute a significant dose commitment (after a shut-in period of a few months) if it were initially present in a concentration approaching its present detection limit. Thus, it is suggested that more sensitive analytical techniques should be used to establish a lower detection limit.

Conclusions

Dose equivalent calculations for the hypothetical use of gas from the Gasbuggy well within the San Juan Basin have been extended to include a source term with continuously decreasing concentrations of radionuclides. As a result of gas withdrawal from the cavity, most of the hypothetical dose would be associated with the use of gas during the first year of production.

Dose equivalents for other potential radioactive contaminants in the Gasbuggy gas have also been calculated employing the same hypothetical use situation. These calculations provide only estimates of the upper limits of hypothetical doses, because the true concentrations of potential contaminants must be lower than the present detection limits. On the basis of these calculations, it is suggested that a more sensitive measurement be made of the ^{90}Sr concentration in the gas.

Acknowledgment

Dose equivalent calculations were made by P. S. Rohwer for internal modes of exposure and by S. V. Kaye for external exposure.

References

1. M. J. Kelly, P. S. Rohwer, D. G. Jacobs, and C. R. Bowman, Second Quarterly Progress Report on the Theoretical Evaluation of Consumer Products from Project Gasbuggy, ORNL-TM-2513 (March 1969).

2. C. F. Smith and F. F. Momyer, Gas Quality Investigation Program Status Report for Project Gasbuggy, UCRL-71314 (Sept. 18, 1968).

3. C. F. Smith, Non-gaseous Radioisotopes Project Gasbuggy Chimney Gas, January 15, 1969, an attachment to a letter from G. H. Higgins, Lawrence Radiation Laboratory, to S. V. Kaye, Oak Ridge National Laboratory, February 24, 1969.

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