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RADON CONCENTRATION AND WORKING LEVEL IN THE EXPLORATORY STUDIES FACILITY (ESF)

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I. ABSTRACT

Radon-222 (^{222}Rn) and ^{222}Rn progeny WL monitoring in the Exploratory Studies Facility (ESF) was initiated to support regulatory compliance. Measurements were taken over two periods, in Test Alcove #1 of the ESF, about 60 m from the tunnel entrance.

For both periods, ^{222}Rn concentration was less than 10 % of the Derived Air Concentration (DAC) set forth in DOE Order 5480.11. Thus, these assessments were sufficient to demonstrate regulatory compliance. Based on these findings, quarterly ^{222}Rn and ^{222}Rn progeny monitoring was initiated.

Two systems each were employed for ^{222}Rn and ^{222}Rn progeny measurement. No significant differences were observed between the respective systems.

An interesting finding was that at the time the measurements were taken, barometric pressure appeared to be the predominant factor controlling ^{222}Rn concentration in the ESF. This was true even during periods of ventilation shutdown.

II. INTRODUCTION

This report provides an assessment of ^{222}Rn and ^{222}Rn progeny levels in the Exploratory Studies Facility (ESF), and a comparison of the measurement systems employed. Results are discussed with regard to regulatory compliance and in relation to variables that influence radon emanation from the walls of the ESF.

Radon-222 decays to a series of short-lived, chemically reactive progeny. For ^{222}Rn dosimetry, the 'short-lived progeny'[1,2] are defined as ^{218}Po, ^{214}Pb, ^{214}Bi and ^{214}Po. To calculate the dose to the lung from the inhalation of ^{222}Rn progeny, the concept of potential alpha energy concentration (PAEC) was developed[1].

The unit of PAEC is the Working Level (WL), which is defined as any combination of the short-lived ^{222}Rn progeny in 1 liter of air that will result in the emission of 1.3×10^5 MeV of potential alpha energy. This is the amount of kinetic alpha energy released from the complete decay of 100 pCi of ^{222}Rn, contained in a liter of air. The unit of ^{222}Rn exposure is the Working Level Month (WLM), which is defined as the exposure to an average of 1 WL for a working month of 170 h[2].

The relationship between ^{222}Rn concentration (pCi l^{-1}) and WL is:

$$WL = ER \times \left(\frac{Rn}{100}\right) \quad (1)$$

Where ER is the equilibrium ratio between ^{222}Rn and the short-lived ^{222}Rn progeny.

Title 10 CFR 835; Occupational Radiation Protection[3], the U.S. Department of Energy (DOE) Radiological Control Manual (RCM)[4], the DOE Site-specific RCM[5], and DOE Order 5480.11; 'Radiation Protection for Occupational Workers'[6] define the regulatory basis for ^{222}Rn and ^{222}Rn progeny monitoring in the ESF.

An evaluation of potential ^{222}Rn exposures in the ESF must be performed to comply with the exposure and dose limits of 10 CFR 835 and the RCMs. In addition to meeting minimum requirements, steps must be taken to ensure radiological exposures are kept As Low As is Reasonably Achievable (ALARA).

For ALARA, the DOE RCM specifies a control level of 10 % of the derived air concentration (DAC) for ^{222}Rn of 3×10^{-8} μCi ml^{-1} set forth in DOE Order 5480.11, or assuming secular equilibrium, 30 mWL for ^{222}Rn progeny.

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III. WORK DESCRIPTION

Field work was conducted by Civilian Radioactive Waste Management Systems Management and Operations (M&O) personnel over two periods; 04/04/94 to 04/19/94, and 06/20/94 through 07/28/94. Measurements were taken in Test Alcove #1 of the ESF, about 60 m from the tunnel entrance. For the first period, ^{222}Rn concentration was monitored continuously for 2 weeks, using a Pylon trace-level ^{222}Rn detector.

Working level was assessed by two methods; instantaneous measurements and long-term averages. Instantaneous measurements were calculated from grab samples, using the modified Tsivoglou[7,8] method. Long-term averages were measured with the E-RPISU electret system.

For the second period, ^{222}Rn concentration was measured with the Pylon, and the E-PERM electret system. The E-PERM system provided average ^{222}Rn concentration for a specified interval. Radon progeny levels were assessed in the same manner as before.

IV. RESULTS

The first continuous ^{222}Rn data set revealed diurnal cycles, and an apparent long-term cycle with a period of from three to four days. Both types of cycles appeared correlated with changes in barometric pressure, as measured at an elevation equivalent to the ESF.

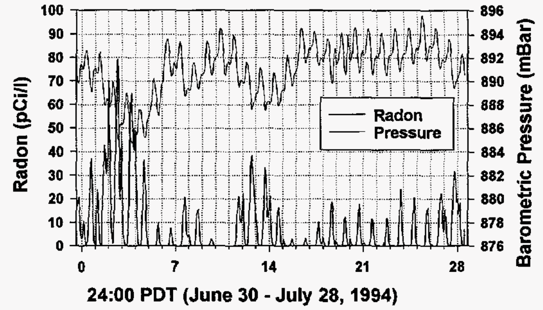
The relationship between ^{222}Rn concentration and barometric pressure was clearer in the second data set. There was a marked inverse correlation, both diurnally, and with pressure cycles occurring over periods of several days (Figure 1).

It can be shown that the ^{222}Rn data best fit a log-normal distribution. As such, the data were natural log-transformed prior to performing a statistical analysis.

The ventilation system was turned off in the ESF on weekends, and for longer periods on two separate occasions, yet the analysis showed ventilation status was only weakly correlated with ^{222}Rn concentration (Pearson Correlation Coefficient (PCC) = -0.242). In contrast, the correlation between barometric pressure and ^{222}Rn concentration was much stronger (PCC = -0.656).

A stepwise model selection of transformed radon concentration vs barometric pressure and ventilation status confirmed that barometric pressure was the most

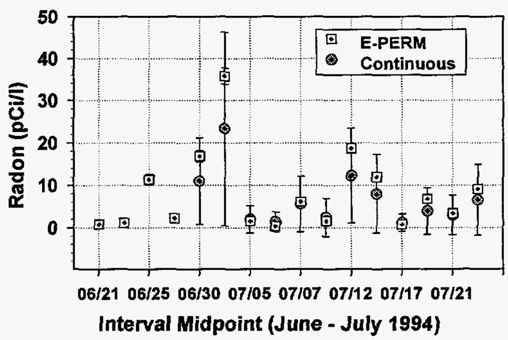
Figure 1. Continuous Radon (Pylon) vs Barometric Pressure (July, 1994)



influential of the two variables (Cp = 1.505, p = 0.0001).

For the second period, E-PERM ^{222}Rn concentration was consistent with averaged continuous ^{222}Rn over the same intervals. For all intervals, E-PERM ^{222}Rn concentration was within 1 arithmetic standard deviation of averaged continuous data (Figure 2).

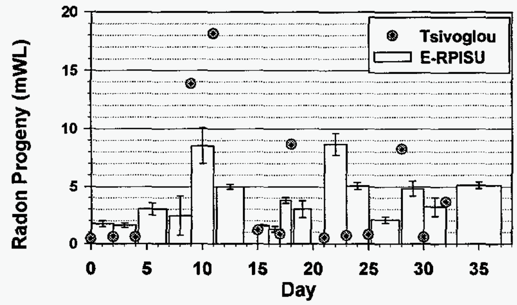
Figure 2. Average Radon Concentration in the ESF: (Continuous vs E-PERM)



For both periods, WL for all collection intervals was less than 10 % of the DAC set forth in DOE Order 5480.11. Thus, these assessments were sufficient to demonstrate regulatory compliance. The observed differences between E-RPISU and Tsivoglou WL is best explained by pronounced diurnal fluctuations in ^{222}Rn concentration (Figure 3).

A comparison of E-PERM ^{222}Rn concentration and E-RPISU ^{222}Rn progeny levels yielded an ER of about 0.1. The low ER value in the ESF is probably due to the high air exchange rate in the Test Alcove.

Figure 3. Working Level in the ESF: Tsivoglou vs. E-RPISU Methods



V. CONCLUSIONS

Quarterly ^{222}Rn and ^{222}Rn progeny WL monitoring was initiated to support regulatory compliance. Periodic measurements have confirmed that the ESF is in compliance with pertinent requirements. Quarterly monitoring is sufficient to detect changes likely to result from ESF construction activities.

As construction progresses, it may be necessary to increase the number of monitoring locations to obtain statistically valid, representative samples. Specific sampling strategies for future measurements will be based on the status of construction at that time, as well as the uranium and thorium content of the rock matrix composing the tunnel walls.

An interesting finding was that barometric pressure appears to be the predominant factor controlling ^{222}Rn concentration in the ESF. This was true even during periods of ventilation shutdown. A probable mechanism is that barometric pressure influences ^{222}Rn flux into the ESF from the tunnel walls. The influence of barometric pressure changes on ^{222}Rn concentration may decrease at points deeper in the mountain, but will likely remain significant near the surface.

VI. REFERENCES

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PROGRAMMATIC AND POLICY REVIEW OF TECHNICAL PAPER ENTITLED "RADON CONCENTRATION AND WORKING LEVEL IN THE EXPLORATORY STUDIES FACILITY (ESF)" BY JOHN H. STIVER AND CHAO-HSIUNG TUNG (SCPB: N/A)

The Yucca Mountain Site Characterization Office (YMSCO) has completed its review of the subject draft paper and finds it to be acceptable from a programmatic and policy standpoint. YMSCO hereby approves of its publication. The Document Review Sheet is enclosed. Also enclosed is a hard copy of the E-mail message reporting comments from the DOE Nevada Operations Office, Technical Information Office review.

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TRIP SUMMARY

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Organization:	Lawrence Livermore National Laboratory
Date:	June 1, 1995
Trip Dates:	May 13, 1995 - May 25, 1995
Destination:	Vienna, Austria

Trip Purpose:

To participate as a consultant on a working group to prepare a draft IAEA safety series report "Occupational Radiation Protection."

Report Abstract:

Traveler participated on a working group to develop a first draft of a document to be issued as an IAEA Safety Series Report on radiation protection. A report outline was prepared and some initial sections drafted. Additional effort will be required over the coming months to complete the draft and a second working group meeting may be scheduled.

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