Lehmacher

KERR-McGEE CORPORATION

KERR-McGEE CENTER • OKLAHOMA CITY, OKLAHOMA 73125

ENVIRONMENT AND HEALTH MANAGEMENT DIVISION

PRINCIPAL STAFF			
RA		DPRP	
D/RA		DE	
A/RA		DRMSP	✓ orig+1
RC		DRMA	
PAO		SCS	
SGA		ML	
ENF		File	

January 5, 1984

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

C.J. Paperiello, Chief
Emergency Preparedness and
Radiological Safety Branch
U.S. Nuclear Regulatory Commission
Region III
799 Roosevelt Road
Glen Ellyn, Illinois 60137

Dear Dr. Paperiello:

Kerr-McGee has determined the airborne Pb-212 concentrations reported for the West Chicago Facility are high by 32.5 percent. As discussed below, there is a 23 percent bias in the results due to an unknown (at this time) cause associated with the gas proportional counting system used to analyze the air sample filters and a 9.5 percent bias due to the transient equilibrium that exists with Pb-212 and Bi-212. In view of this determination, the Pb-212 concentrations reported to date should be multiplied by 0.7 to correct for the bias. Pending repair of the system, concentrations reported in the future will reflect this correction factor.

The bias in the West Chicago Facility G-4000 automatic gas proportional counting system has been confirmed by several approaches. While the environmental air sample Pb-212 results reported for the Facility were determined using the G-4000, there are two additional systems available at the site for determining alpha levels of air samples. Attachment 1 describes the three counting systems and shows typical counting efficiencies obtained with a Th-230 alpha source (Eberline S/N S-2049 -- NBS Traceable). Six air sample filters (two-inch diameter glass fiber -- Gelman A/E) were analyzed in triplicate on each of the three systems. As shown in Attachment 2, the calculated Pb-212 activity for filters analyzed with the G-4000 system ranged from 16 to 27 percent higher than the calculated activity for the same filters analyzed with the other two systems. The average bias was 23 percent with a standard deviation of 3.4 percent.

A second comparison was made by analyzing a Pb-212 containing sample both on the West Chicago Facility G-4000 system and on a G-4000 system at the Gamma Products office in Chicago. (Gamma Products is the manufacturer of the G-4000 systems.) These analyses, shown in Attachment 3, indicated the system at

JAN 9 1984

West Chicago is showing a bias. Consequently, Gamma Products has agreed to repair the instrument.

A third approach used to confirm system bias involved analyzing responses to three sources of varying alpha energy emissions. The three sources were Am-241 (5.49 MeV -- 85 percent and 5.44 MeV -- 13 percent), Th-230 (4.68 MeV -- 76 percent and 4.62 MeV -- 24 percent) and Th-230 modified (approximately 3.9 MeV). (The Th-230 source was modified by placing mylar (0.85 mg/cm^2) over it to attenuate the alpha energy.) The results of analyses of these sources are shown in Attachment 4, along with an alpha spectrum analysis of the sources. The fraction of events appearing in the alpha channel and in the beta channel are shown and demonstrate that as the alpha energy increases, the number of alphas appearing in the alpha channel increases. This condition would not occur with a properly operating system.

It is clear from these procedures that the G-4000 system is biased and that the bias has resulted in over-reporting of Pb-212 activity for the air samples. Kerr-McGee has arranged to have the system repaired by Gamma Products on January 23, 1984. In the event NRC desires to inspect or perform tests on the system before repairs are undertaken, please call me so that these arrangements can be made quickly.

The bias due to the transient equilibrium status between Pb-212 and Bi-212 is discussed in Attachment 5. As shown, at the time of counting of the air samples at the West Chicago Facility -- approximately 7 hours after collection -- the Pb-212 activity is 90.5 percent of the Bi-212 activity. However, the Bi-212 alpha emitter has been counted and equated to the Pb-212 activity. This has resulted in over-stating the Pb-212 concentrations by 9.5 percent.

Collectively, the Pb-212 results reported to NRC to date are therefore 32.5 percent high. The results should be corrected by multiplying by 0.7 to account for the bias due to the counting system and the transient equilibrium between Pb-212 and Bi-212.

Sincerely,

W J Shelley

W.J. Shelley, Vice President
Nuclear Licensing & Regulation

WJS:SCM/br

Attachments: (5) As Stated

ATTACHMENT 1

ALPHA COUNTING INSTRUMENTATION

Counting System	Description	Efficiency	Background
Gamma Products G4000	Automatic Gas Proportional System using pulse height analysis to differentiate between alpha and beta events. The system has a 2-inch diameter detector with a window thickness of 80 $\mu g/cm^2$.	~ 0.24 c/d	~ 1.0 cpm
Eberline FC-2 with MS-2 Scaler	Manual Gas Proportional System. The system has a 2-inch diameter detector with a window thickness of <100 $\mu g/cm^2$.	~ 0.31 c/d	~ 0.2 cpm
Eberline RD-14 with MS-2 Scaler	Manual Zn(S) Alpha Detection System with a 4-inch detector. (No window)	~ 0.38 c/d	~ 1.4 cpm

ATTACHMENT 2

ALPHA COUNTING SYSTEM COMPARISON

Sample Number	Run Number	Date	Pb-212 Activity on Sample (dpm)[1] (1) G-4000	(2) FC-2	(3) RD-14	G-4000 % Bias[2]
1	1	12/10/83	41816	31565	32910	22.9
	2		42478	31258	32554	24.9
	3		42489	31235	32905	24.5
2	1	12/14/83	56977	42001	40973	27.2
	2		57553	41810	41387	27.7
	3		56560	41375	40773	27.4
3	1	12/15/83	45870	34176	34364	25.3
	2		45392	34127	35057	23.8
	3		45268	34338	34788	23.6
4	1	12/16/83	43761	34571	33493	22.2
	2		43659	34731	33409	22.0
	3		43800	34364	33463	22.6
5	1	12/19/83	51770	42597	42652	17.7
	2		50741	42398	42742	16.1
	3		50624	42190	42860	16.0
6	1	12/20/83	37683	28647	28403	24.3
	2		37474	28411	28710	23.8
	3		37350	28289	28620	23.8

[1] Samples containing Pb-212 activity were obtained by placing two-inch diameter Gelman Type A/E filters into a Pylon Type 190 Thoron Daughter Standard (S/N D-100).

[2] The G-4000 system bias is the percent difference between the average Pb-212 activities determined using the FC-2 and RD-14, and the Pb-212 activity using the G-4000 system divided by the activity determined by the G-4000 system. Mathematically this is shown as:

$$\frac{[\text{Col.(1)} - (\frac{\text{Col.(2)} + \text{Col.(3)}}{2})]}{\text{Col.(1)}}$$

ATTACHMENT 3

ALPHA COUNTING SYSTEM COMPARISON

KERR-McGEE AND GAMMA PRODUCTS G-4000 SYSTEMS

Date	Run Number	Pb-212 Activity on Sample (dpm)[1] KM G-4000	GP G-4000	KM FC-2	KM RD-14
12/21/83	1	49464	39525	37054	36431
	2		37481		

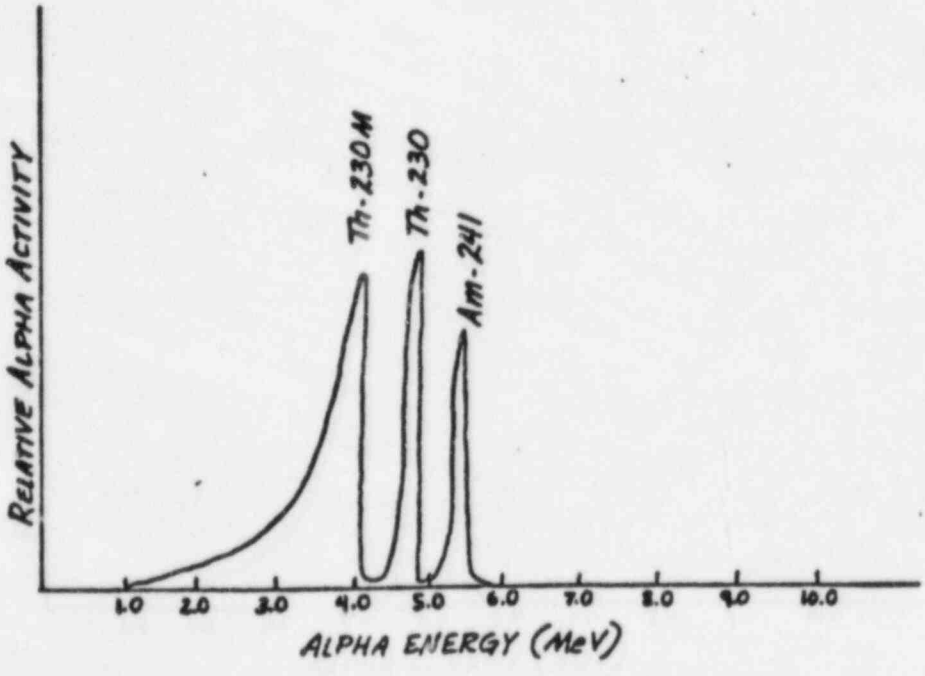
[1] Sample containing Pb-212 activity was obtained by placing a two-inch diameter Gelman Type A/E Filter into a Pylon Type Thoron Daughter Standard (S/N D-100).

ATTACHMENT 4

G-4000 ALPHA ENERGY DEPENDENCE

Source	Approximate Alpha Energy (MeV)	Alpha Channel	Beta Channel
Am-241	5.5	0.80	0.20
Th-230	4.7	0.76	0.24
Th-230M	3.9	0.69	0.31

ALPHA SPECTRAL ANALYSIS OF SOURCES



ATTACHMENT 5

TRANSIENT EQUILIBRIUM CONSIDERATION*

The Pb-212 activity on a filter is determined by counting a sample by gross alpha analysis. Pb-212 is a beta emitter; however, two of its daughter products (Bi-212 and Po-212) emit 6.1 and 8.8 Mev alphas, respectively. The Bi-212 alpha is emitted 36% of the time and the Po-212 64% of the time, resulting in the emission of essentially one alpha for each Pb-212 beta. Pb-212 has a 10.64 hour half-life and Bi-212 has a 60.5 minute half-life.

Where the half-life of the daughter (Bi-212) is smaller than the parent (Pb-212), the daughter activity, assuming the parent is initially pure and free of daughter activity, starts at zero, rises to a maximum and then seems to decay with the same half-life as the parent. The Pb-212 and Bi-212 are then said to be in a state of transient equilibrium.

The following equation expresses the activity of Bi-212:

$$A_{Bi\text{-}212} = \left[\frac{\lambda_{Bi\text{-}212} \cdot A_{Pb\text{-}212}^{\circ}}{\lambda_{Bi\text{-}212} - \lambda_{Pb\text{-}212}}\left[\left(e^{-\lambda_{Pb\text{-}212}t}\right) - \left(e^{-\lambda_{Bi\text{-}212}t}\right)\right]\right] + \left[A_{Bi\text{-}212}^{\circ}\left(e^{-\lambda_{Bi\text{-}212}t}\right)\right]$$

Since the samples are normally analyzed at approximately seven hours after collection (t = 7 hours) then $e^{-\lambda_{Bi\text{-}212}t} = 0$.

---

* Reference: Gerhart Friedlander et al. "Nuclear and Radiochemistry" John Wiley & Sons, New York, 1981.

The equation expressing Bi-212 activity then becomes:

$$A_{Bi\text{-}212} = \frac{\lambda_{Bi\text{-}212} \cdot A^{\circ}_{Pb\text{-}212}}{\lambda_{Bi\text{-}212} - \lambda_{Pb\text{-}212}} \left(e^{-\lambda_{Pb\text{-}212} t}\right)$$

The Pb-212 activity on the filter at time of counting is equal to $A_{Pb\text{-}212}$ and can be substituted into the above equation for the term $A^{\circ}_{Pb\text{-}212}(e^{-\lambda_{Pb\,212} t})$. The equation then becomes:

$$A_{Bi\text{-}212} = \frac{\lambda_{Bi\text{-}212} \cdot A_{Pb\text{-}212}}{\lambda_{Bi\text{-}212} - \lambda_{Pb\text{-}212}} \qquad OR$$

$$A_{Bi\text{-}212} = \frac{(0.6861)\, A_{Pb\text{-}212}}{(0.6861 - 0.0651)} = 1.1049\ A_{Pb\text{-}212}$$

$$A_{Pb\text{-}212} = 0.9051\ A_{Bi\text{-}212}$$

As can be seen from the above the Pb-212 activity is 90.5% of the Bi-212 activity. Since our analysis is by alpha and actually reflects the Bi-212 activity the Pb-212 activity will be 9.5% lower. This correction will be included in Pb-212 calculations.