

DMB

JAN 17 1984

Docket No. 040-02061

Kerr McGee Corporation  
ATTN: W. S. Shelley, Vice President  
Nuclear Licensing and  
Regulation  
Kerr McGee Center  
Oklahoma City, OK 73125

Gentlemen:

Thank you for your letter of January 5, 1984, describing the progress of your investigation into possible biases in the analysis for airborne lead-212.

We have reviewed the matter of transient equilibrium between lead-212 and bismuth-212 on the filter and agree that a bias (high) of about 9.5% exists under the sampling and counting delay times you describe. Of course the bias would be somewhat less if both the sampling and counting delay times were significantly decreased. We also note that compliance with 10 CFR 20 release limits requires that the weighted fraction of all isotopes present be considered. Lead-212 is the dominant thoron daughter but others may be present at a few percent of the limit, depending on equilibrium conditions.

We have no comment at this time regarding the counting system bias you described, but will review the matter during the current inspection. As Mr. Schumacher indicated in his telephone call to Mr. Ivan Denny on January 16, 1984, we plan to review your investigation and examine the G4000 counter before it is repaired on January 23, 1984.

Sincerely,

*C. J. Paperiello*  
C. J. Paperiello, Chief  
Emergency Preparedness and  
Radiological Safety Branch

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cc w/encl:  
I. Denny, Manager  
Special Projects  
W. Harris, Project Manager  
W. T. Crow, UFLB  
W. A. Nixon, UFLB  
P. B. Bollwerk, Office of  
General Counsel  
DMB/Document Control Desk (RIDS)  
Anne Rapkin, Office of the  
Illinois Attorney General

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|         |               |            |
|---------|---------------|------------|
| OFFICE  | RIII/DRMSP    | RIII       |
| SURNAME | Schumacher/mf | Paperiello |
| DATE    | 1/16/84       | 1/17/84    |

*Schumacher*



**KERR-McGEE CORPORATION**

KERR-McGEE CENTER • OKLAHOMA CITY, OKLAHOMA 73125

ENVIRONMENT AND HEALTH MANAGEMENT DIVISION

January 5, 1984

CERTIFIED MAIL  
RETURN RECEIPT REQUESTED

| PRINCIPAL STAFF |            |                 |
|-----------------|------------|-----------------|
| RA              | <i>was</i> | DPPP            |
| D/RA            |            | DE              |
| A/RA            |            | DRMSP           |
| RC              |            | DRMA            |
| PAO             |            | SCS             |
| SGA             |            | ML              |
| ENF             |            | File <i>was</i> |

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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

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C.J. Paperiello  
January 5, 1984  
Page Two

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

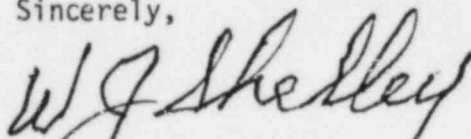
A third approach used to confirm system bias involved analyzing responses to three sources of varying alpha energy emissions. The three sources were Am-241 (5.49 MeV -- 85 percent and 5.44 MeV -- 13 percent), Th-230 (4.68 MeV -- 76 percent and 4.62 MeV -- 24 percent) and Th-230 modified (approximately 3.9 MeV). (The Th-230 source was modified by placing mylar (0.85 mg/cm<sup>2</sup>) 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, Vice President  
Nuclear Licensing & Regulation

WJS:SCM/br

Attachments: (5) As Stated

ATTACHMENT 1  
ALPHA COUNTING INSTRUMENTATION

| <u>Counting System</u>          | <u>Description</u>  | <u>Efficiency</u> | <u>Background</u> |
|---------------------------------|---|-------------------|-------------------|
| 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 $\mu\text{g}/\text{cm}^2$ . | $\sim 0.24$ c/d   | $\sim 1.0$ 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 $<100$ $\mu\text{g}/\text{cm}^2$ .   | $\sim 0.31$ c/d   | $\sim 0.2$ cpm    |
| Eberline RD-14 with MS-2 Scaler | Manual Zn(S) Alpha Detection System with a 4-inch detector. (No window)   | $\sim 0.38$ c/d   | $\sim 1.4$ cpm    |

ATTACHMENT 2  
ALPHA COUNTING SYSTEM COMPARISON

| Sample Number | Run Number | Date     | Pb-212 Activity on Sample (dpm) <sup>1</sup> |             |              | G-4000 % Bias <sup>2</sup> |
|---------------|------------|----------|--|-------------|--------------|----------------------------|
|               |            |          | (1)<br>G-4000                                | (2)<br>FC-2 | (3)<br>RD-14 |                            |
| 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                       |

<sup>1</sup> 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).

<sup>2</sup> 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

| <u>Date</u> | <u>Run<br/>Number</u> | <u>Pb-212 Activity on Sample (dpm)<sup>1</sup></u> |                      |                    |                     |
|-------------|-----------------------|--|----------------------|--------------------|---------------------|
|             |                       | <u>KM<br/>G-4000</u>                               | <u>GP<br/>G-4000</u> | <u>KM<br/>FC-2</u> | <u>KM<br/>RD-14</u> |
| 12/21/83    | 1                     | 49464  | 39525                | 37054              | 36431               |
|             | 2                     |  | 37481                |                    |                     |

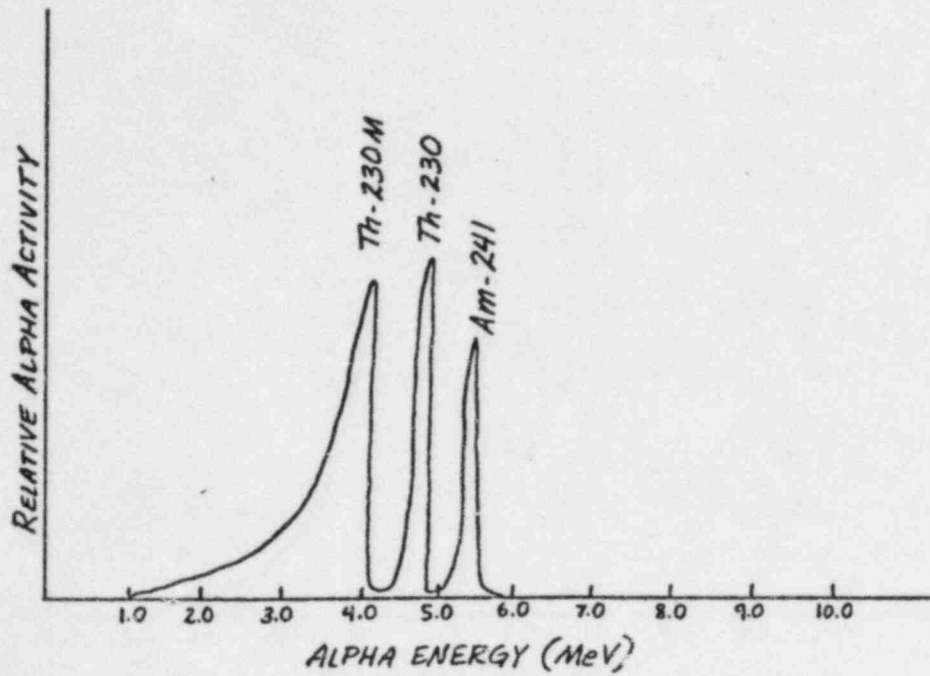
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<sup>1</sup> Sample containing Pb-212 activity was obtained by placing a two-inch diameter Gelman Type A/E Filter into a Pylon Type Thoron Daughter Standard (S/N D-100).

ATTACHMENT 4  
G-4000 ALPHA ENERGY DEPENDENCE

| <u>Source</u> | <u>Approximate Alpha Energy (MeV)</u> | <u>Alpha Channel</u> | <u>Beta Channel</u> |
|---------------|---------------------------------------|----------------------|---------------------|
| Am-241        | 5.5                                   | 0.80                 | 0.20                |
| Th-230        | 4.7                                   | 0.76                 | 0.24                |
| Th-230M       | 3.9                                   | 0.69                 | 0.51                |

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:

$$A_{Bi-212} = \left[ \frac{\lambda_{Bi-212} \cdot A_{Pb-212}^0 \left[ (e^{-\lambda_{Pb-212} t}) - (e^{-\lambda_{Bi-212} t}) \right]}{\lambda_{Bi-212} - \lambda_{Pb-212}} \right] + \left[ A_{Bi-212}^0 (e^{-\lambda_{Bi-212} t}) \right]$$

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

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

The equation expressing Bi-212 activity then becomes:

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

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

The equation then becomes:

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

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

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

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.