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RO INVESTIGATION REPORT NO. 74-09

DIRECTORATE OF REGULATORY OPERATIONS

REGION III

SUMMARY REPORT OF EVALUATION OF BIOMEDICAL ASPECTS OF THE KERR-McGEE PERSONNEL CONTAMINATION INCIDENT REPORTED NOVEMBER 7, 1974

Appendix N

Summary Report

To: Mr. James Allen
U.S. Nuclear Regulatory Commission
Region III

From: Niel Wald, M.D., Medical Consultant

Date: 6 February 1975

Subject: Summary Report of Evaluation of Biomedical Aspects of the Kerr-McGee Personnel Contamination Incident Reported November 7, 1974

This is a report of the investigation of the biomedical aspects of an exposure incident at the Kerr-McGee plutonium facility in Cimarron, Oklahoma which was carried out in accordance with your telephone instructions of 10:30 AM, 8 November 1974. Individual A was the employee directly involved, but evaluations were also made for Individual B, her roommate, who was also a Kerr-McGee employee, and Individual C, a friend and former employee of the facility.

Pertinent Details of the Incident:

R.O. Investigation Report No. 74-09 provides a summary of the facts in this incident.

Medical Consultant Investigation:

In view of the unusual contamination history of the preceding several days, beginning on 5 November 74; the preliminary gross bioassay results which suggested a possible intake of 100 microcuries or more of mobile plutonium-239; and Individual A's reported unwillingness to return to work, collect excreta, or accept DTPA therapy without some guidance regarding her health status, arrangements were made to travel to Oklahoma City on 8 November 1974. Attempts to talk with the company medical consultant via telephone prior to departure in mid-afternoon were not successful. On arrival in Oklahoma City at 10:30 PM discussions were held with the AEC Regulatory Operations (R.O.) investigating team concerning the current status of their work. An interview was arranged with Individual A at 9:00 AM the next morning. At midnight the company medical consultant was reached by telephone. He had not yet seen the individual involved in the incident and was planning to arrive in Oklahoma City from Albuquerque at about 11:30 AM on 9 November. He gave approval to the planned meeting with Individual A, agreed to meet with me following his arrival, and asked me to inform Individual A that he would be available to her thereafter.

At 9:30 AM on 9 November Individual A was interviewed. At her request the legislative assistant to the Oil, Chemical and Atomic Workers Union, and Individual C, who accompanied her, remained in the room as did a member of the R.O. team who accompanied me. Individual A appeared tense and anxious, frequently seeking support and reassurance from Individual C and the Union staff member.

Pertinent historical information included a history of bronchial pneumonia and asthma from about 6 months to 15 years of age while living in Corpus Christi area of Texas. Treatment with gamma globulin seemed to be helpful. Then the asthma gradually disappeared but milder episodes of hay fever persisted. An old left nasal fracture resulted in unilateral chronically impaired breathing.

More recently, about October 1973, Individual A had a lung infection for which diagnostic chest x-rays were performed. She recovered by summer. About October 1974 a lung infection recurred lasting about 2 to 4 weeks, with diagnostic chest x-rays performed about 2 weeks ago. She was under the treatment of a physician in Oklahoma City. An additional observation was of hypertension for which he had given her some relaxant medication. This was discontinued on November 5th because of some side effects interfering with her work. She showed me a container with several types of capsules and pills including one she identified as Tylenol no. 3 (an analgesic containing acetaminophen, 300 mg. and codeine phosphate, 30 mg.). She was a cigarette smoker, using about a pack a day.

Individual A appeared intelligent and had completed 2 years of college training aimed at medical technology when she stopped for marriage and 3 children. Following dissolution of the marriage she moved to Oklahoma City about 3 years ago and began working at Kerr-McGee as a technician.

Individual A stated that she was concerned by the plutonium contamination findings and the repeated decontamination procedures which began on 5 November. She also felt that the company's response to the incident by having legal counsel take a deposition from her more promptly than they provided what she considered knowledgeable medical counsel was not helpful. By the morning of November 8th, therefore, she decided not to report to work until she had received such knowledgeable guidance concerning her health status. She was informed of the company medical consultant's expected arrival and agreed to meet with him in the early afternoon.

Discussions were then held with the Kerr-McGee medical consultant and their Coordinator of Radiation Health and Safety in the course of which arrangements were confirmed for whole body and chest counting as well as additional bioassay sampling to be carried out at Los Alamos Scientific Laboratory for Individuals A anc C. Individual B was then interviewed by the Kerr-McGee medical consultant and me. In view of her concerns about the contamination of the apartment she shared with Individual A it was decided to included her in the in-vivo counting arrangement. Individuals A and C then returned along with several members of the Oil, Chemical and

Atomic Workers Union. Following general discussion aimed at clarifying the health issues involved and the appropriate diagnostic procedures, the Kerr-McGee medical consultant arranged for appropriate clinical laboratory and x-ray examinations at a local hospital that afternoon. It was also planned by him to administer one dose of DTPA to Individual A at that time. He had indicated that this was to have been given on November 8th at a clinic near the plant but Individual A had not reported for work that day.

Following departure of Individuals A, B and C and their associates, discussion was held with the Kerr-McGee medical consultant concerning the Kerr-McGee program for responding to personnel exposure incidents. He had indicated to the company that the relative isolation of the plant and the nature of the work there justified an in-vivo counting facility in the vicinity to provide quick resolution of problems like this one. However, he noted that it took many years even to develop the capability to do bioassay analyses at a nearby research center of the company. Regarding medical care, he indicated that the physician who operates a clinic in the plant's vicinity served adequately as a source of primary medical care, supported by the consultant's availability to provide technical aid when needed. The local physician was to have taken the AEC-sponsored short course in Medical Management of Radiation Accidents. The Kerr-McGee medical consultant was unable to explain why the local physician was not involved in our discussions with Individuals A, B and C or with each other. He indicated that his delay in seeing Individual A was due to her not having reported to work on November 8th as requested.

Biomedical Evaluations:

My further participation in the biomedical investigation and evaluation of results included continuing discussions with the Kerr-McGee medical consultant; the leader of the Health Division at Los Alamos Scientific Laboratory, and associated radiochemistry personnel; and personnel of Regulatory Operations staff.

Individual A:

In this individual, the evaluation of the magnitude of exposure and of any resultant body burden involved examinations of five sets of data. These are: A., the information obtained by monitoring the home and work environment of the individual (Appendices A and B), B., the results of urine and fecal excretion bioassays (Appendix I), C., the results of the in-vivo internal radioactivity measurements (Appendices C and D), D., the measurements obtained from radiochemical analyses of tissues and organs obtained at autopsy (Attachment A to this report), and E., the isotopic ratios of various samples (Appendix L and Attachment A).

A. Environmental Measurements:

Beginning with the first contamination episode involving Individual A on the evening of November 5th, 1974, smears and air samples from her work room did not indicate airborne activity. Her automobile showed only slight contamination of some switches at a maximum of .07 dps.

In her apartment the air concentration on November 7th was 2.4×10^{-12} microcuries per milliliter, just slightly above the level of 2×10^{-12} microcuries per milliliter which is permitted by AEC regulations for average airborne plutonium concentrations in occupied restricted areas for 40 hours in any period of 7 consecutive days. No more than 0.0003 grams of plutonium were identified in the contamination of the Individuals or their apartment.

B. Bioassay Data:

1. Urine - Individual A showed no urinary plutonium above background on 12 bioassays performed between August, 1972 and May, 1974. Following a possible small inhalation exposure on 31 July 1974, the urinary bioassays showed a gradual increase in activity, reaching a peak of 5.0 dpm/700ml. on the 25th of August and subsiding to baseline levels in samples of September 12th and October 8th.

The next two samples, I-22 and I-23, collected between October 15th and October 31st at home, showed levels 4 orders of magnitude above baseline. Sample I-24, collected at work in the same time period and left in Individual A's locker, was less than 1 dpm. Then I-25 and I-27, collected in the next week at home, were again 4 to 5 orders of magnitude higher. The remaining urine samples showed a return to fractional dpm values in a steadily descending order.

2. Feces - The samples collected shortly after the exposure incident of July 31st showed no difference in plutonium activity from that collected in the previous year. The remaining samples were collected beginning on November 6th in the course of the investigation of the recent contamination incident. Beginning at plutonium levels about 7 orders of magnitude above background, they showed a rapid fall with time over the following 7 days before Individual A's death.

C. In-Vivo Count Data:

In-vivo counting was carried out on Individual A on the 11th and 12th of November, 1974 at Los Alamos Scientific Laboratory. Their results are presented in Appendix C of the investigation report. Americium was detected equally in both sides of the chest, while plutonium was below the detection limit. Extrapolation from the americium level, using the isotopic distribution of a nasal smear as being representative of the inhaled material, resulted in estimation of 6 nCi of plutonium and .34 nCi of americium.

D. Post-Mortum Tissue Analyses:

Following the death of Individual A on 13 November 1974, an autopsy was performed. Tissues were removed to Los Alamos Scientific Laboratory for radiochemical analysis. The results of the tissue analyses, as summarized in the Los Alamos Scientific Laboratory report on Table 4.1 and Table 4.2, and their Appendix A summarizing all of the tissue data are appended as Attachment A to this report. It will be noted that the

fecal sample collected within the large intestine showed very similar activities to those obtained from pre-mortum fecal samples on November 12th and 13th. It should also be noted that the lung parenchyman contained at least 5 times as much activity as did the tracheo-bronchial lymph nodes.

The estimated organ burdens for plutonium are 3.6 nCi in liver, 5 nCi in lung, and less than 0.2 nCi in the bone. Since these are the major areas of plutonium deposition in the body, the Los Alamos Scientific Laboratory report concluded that the total plutonium body burden was under 10 nCi or less than 25 percent of the maximum permissible body burden for occupational exposure (40 nCi). The low value in the bone, and the relatively low value in the tracheo-bronchial lymph nodes compared to that in the lungs, suggested to Los Alamos Scientific Laboratory personnel that the major portion of the plutonium exposure was of recent origin, probably less than 30 days prior to death. The Los Alamos Scientific Laboratory report pointed out that because of the small sample size analyzed thus far and the resulting extrapolation uncertainties, the results must be used cautiously.

E. Isotopic Ratios:

Isotopic ratios were calculated from the results of the radiochemical analyses of environmental samples, excreta and post-mortum tissue samples. Ratios examined were those of plutonium-239 (plutonium-239/240 in HSL analyses) to plutonium-238; and plutonium-239 to americium-241.

The plutonium-239 to 238 ratio ranged from 5.9 to 10.0 with a mean of 7.9. There were no systematic deviations from the mean either by type of sample analyzed or by laboratory performing the analysis.

In general, the plutonium to americium ratios showed a greater range. Environmental samples, nasal smear and fecal samples had an average ratio of 16 with a range from 11 to 26. Samples collected at autopsy showed ratios of 16 for intestinal feces, 32 for liver and 19 for lung.

Isotopic ratios could be determined in two of the urine samples, I-25 and I-27, both of which had high activity levels. The ratios were 5.7 and 6.0.

Discussion and Conclusions:

1. The environmental levels do not suggest a high likelihood of the acquisition of a internal body burden of plutonium exceeding the occupational permissible limit by orders of magnitude, as the initial urine and fecal counts associated with this incident (I-26, I-27) suggested.

2. The results of in-vivo counting and tissue analysis are in reasonably good agreement as to magnitude of internal contamination, i.e. less than 10 nCi or 25 percent of the occupational "permissible body burden".

3. The plutonium-239 to 238 ratios of all samples are in general agreement. The plutonium-americium ratios of nasal smears, fecal samples, tissues and samples of home and work environment are also in reasonably good agreement. The fecal and urinary radioactivity levels after 7 November and the autopsy findings are compatible with the ingestion and inhalation of radioactive material a short time earlier than that date. These data suggest that the environmental contamination, the intake, the internal deposition and the fecal excretion could all have involved the same radioactive material. The fact that the Pu-Am isotopic ratios in the only two urine samples in which the analysis could be obtained are 5.7 and 6.0, could reflect a different contaminant and/or the body's greater facility for renal excretion of americium compared with plutonium.

4. Analyses of urine samples I-22, I-23, I-25 and I-27 gave results which are not in accord with the above mentioned internally consistent data. Discordant findings related to the samples include the following:

a. The high levels of activity in urine samples I-22 and 23 preceded the detection of any personal contamination of Individual A when monitored at her work place.

b. The one sample, I-24, which was apparently collected and kept at the plant has an activity level 4 orders of magnitude below the others mentioned. Such a variation in the excretion of plutonium and americium from high level to low level to high level over a few days is biologically unlikely.

c. It is biologically unlikely that the small body burden of a comparatively insoluble plutonium compound measured by in-vivo counting and in post-mortum tissue could have been so much larger 4 or 6 days earlier as to result in the high level of radioactivity seen in sample I-27.

5. Based on the above findings, it is inferred that activity found in urine samples I-22, I-23, I-25, and I-27 represents exogenous contamination and that remaining bioassay, environmental, in-vivo counting and post-mortum tissue findings are the result of a recent intake of Pu-Am material resulting in a plutonium body burden of less than 10 nCi or 25 percent of the occupational exposure limit.

Individual B:

In this individual the evaluation of the magnitude of exposure and of any resultant body burden involved examination of four sets of data. These are A., information obtained by monitoring the home environment of the individual (Appendix B), B., the results of urine and fecal excretion bioassays (Appendix J), C., the results of the in-vivo internal radioactivity measurement (Appendices C and D), and D., the isotopic ratios of various samples (Appendix L).

A. Environmental Measurements:

Contamination levels in the apartment which Individual B shared with Individual A have been included in the R.O. investigation report. Individual B's car showed no evidence of contamination.

B. Bioassay Data:

1. Urine - Individual B showed no plutonium activity in 2 samples tested in 1974 between January and July. Slight plutonium activity was detected beginning November 8th and peaking on November 9th. By November 11th and 12th the activity had fallen below detection limits, where it remained through November 20th.

2. Feces - The first fecal sample, collected at Los Alamos Scientific Laboratory on November 11th, showed a level of radioactivity 3 orders of magnitude above background. Subsequent fecal samples, beginning with that of November 12th, showed very little or no activity.

C. In-Vivo Count Data:

In-vivo counting was carried out on Individual B on the 11th and 12th of November 1974 at Los Alamos Scientific Laboratory. The results are presented in Appendix C of the investigation report. No internal contamination was found.

D. Isotopic Ratios:

Two fecal samples, J-10 and J-23, revealed isotopic ratios of plutonium to americium of 18 and 15. These are well within the range of those found in the environmental samples of the apartment and in the fecal samples of Individual A, which averaged a ratio of 16.

Discussion and Conclusions:

1. Environmental levels do not suggest a high likelihood of the acquisition of a body burden of plutonium exceeding the permissible occupational limit by orders of magnitude.

2. The results of the urine and fecal bioassays, and the isotopic ratios suggest that Individual B's contamination probably involved the same radioactive material as found in Individual A and that the ingestion and inhalation took place shortly before the first positive bioassay result.

3. In view of the negative in-vivo counting result, and the relatively low level quantity of radioactive contaminants in the urine and feces, any internal deposition would have to be of a very low order of magnitude or a few percent of the permissible occupational burden at most. Since most of the activity simply passed through the gastrointestinal tract where absorption is minimal, the body burden, if any, is so small that there is no significant health hazard from this exposure.

Individual C:

In this individual the evaluation of the magnitude of exposure and of any resultant body burden involved examination of four sets of data. These are: A., the information obtained by monitoring the environment of the individual (Appendix B), B., the results of urine and fecal bioassays (Appendix K), C., the results of the in-vivo internal activitiy measurements (Appendices C and D), and D., the isotopic ratios of various samples (Appendix L).

A. Environmental Measurements:

Since Individual C had not worked at the Kerr-McGee plant since September, 1974, the probable source of contamination was the apartment of Individuals A and B. The levels of the contamination there have already been described in this report. Neither Individual C's residence nor his automobile showed any evidence of radioactivity.

B. Bioassay Data:

1. Urine - Appendix K reveals no plutonium detectable in urine samples collected intermittently from June 1971 until September 20th, 1974, after which the individual terminated his employment with Kerr-McGee. Urine samples produced on November 11th through 13th showed no increase over the past.

2. Feces - One fecal sample voided on November 11th was found by Los Alamos Scientific Laboratory to have a slight amount of plutonium and americium contamination. Subsequent samples on the 13th and 14th of November showed virtually no activity.

C. In-Vivo Count Data:

In-vivo counting was carried out on Individual C on the 11th and 12th of November, 1974 at Los Alamos Scientific Laboratory. The results are presented in Appendix C of the investigation report. No plutonium or americium activity was detected.

D. Isotopic Ratios:

A plutonium to americium ratio of 9 was reported for the one fecal sample in which such data could be obtained.

Discussions and Conclusions:

1. The environmental levels in the apartment of Individual A and B were sufficiently low and the amount of time spent there by Individual C was comparatively small so the likelihood of the acquisition of a significant body burden exceeding the permissible limit by orders of magnitude is very low.

2. The absence of detectable activity in in-vivo counts and urine bioassays suggests that no significant internal contamination occurred in

Individual C. The very poor absorption to be expected by the passage of a relatively small amount of activity through the gastrointestinal tract likewise suggests that no significant body burden accumulated in this individual.

3. The comparatively low plutonium-americium ratio from the one analyzable stool sample is of uncertain significance since it is based on the analysis of a small sample with rather low levels of activity.

General Conclusions Concerning Biomedical Management:

1. Although the medical consultant for the Kerr-McGee company is knowledgeable and experienced, having served as medical director at the site in the past, his present location in another state makes it difficult to provide useful early input into the handling of contaminated individuals. In the present instance the magnitude and significance of the incident did not become clear and recognizable to the Kerr-McGee medical consultant until well beyond the time when his early intervention could have facilitated evaluation and disposition procedures for the three individuals concerned.

2. Capability of the local physician and clinic could not be assessed since the former was not a party to the interviews made in connection with this investigation.

3. Gross bioassay information was available locally through the Kerr-McGee research center with reasonable promptness. Their capability for carrying out accurate refined chemical isotopic analyses is not certain and should be tested.

4. The lack of local availability of any means for in-vivo assessment of plutonium and americium internal contamination is a major drawback in the biological and psychological management of contaminated individuals at this facility. Reliance on the capability of the Los Alamos Scientific Laboratory is a cumbersome means for obtaining such essential information although the reliability of the results is good.

5. Results of the biomedical investigations were provided to Individuals B and C in satisfactory fashion orally and in writing by the leader of the Health Division, Los Alamos Scientific Laboratory, and orally by the Kerr-McGee medical consultant.

Attachment A

TABLE 4.1

SUMMARY OF TISSUE ANALYSIS RESULTS

Tissue Analyzed	Weight of Organ (g)	Weight Analyzed (g)	Activity (dis/min per gram) ^{239}Pu	^{238}Pu	^{241}Am	Isotopic Ratio (Percent of Total Activity) 239/238/241	Extrapolated Tissue Burden - $^{238-239}Pu$ dis/min	nCi
Duodenum								
Tissue	73.4[a]	7.4	N.S.[b]	N.S.	N.A.[c]			
Chyme		<0.1	122	20	0.1	86/14/0		
Intestine, Large								
Trans. Colon	113.9[a]	30.9	0.08	N.S.	0.01			
Feces		19.5	34.3	4.2	2.4	84/10/6		
Intestine, Small								
Tissue	588[a]	17.3	0.04	N.S.	N.A.			
Chyme		3.3	0.3	0.1	N.A.			
Liver	1311	19.0	5.4	0.7	0.2	86/11/3	8.0×10^3	3.6
Lung, Whole	995							
Parenchyma		17.2	10.1	1.3	0.6	84/11/5	1.1×10^4	5.0
Pleura		16.6	N.S.	N.S.	N.A.			
Lymph Nodes								
Periportal		3.3	0.2	N.S.	N.A.			
Tracheobronchial		6.7	1.8	0.3	0.1	82/14/4	1.4×10	.01
Stomach Wall	132.8	8.8	1.0	0.1	0.01	90/9/1	1.5×10^2	.06

[a] Including contents

[b] N.S. = not significant

[c] N.A. = not analyzed

LASL AEC 2nd Q.A.

TABLE 4.2

SUMMARY OF BONE ANALYSIS RESULTS

Specimen	Weight Received (g)	Weight Analyzed (g)	Activity (dis/min per gram) ^{239}Pu	Activity (dis/min per gram) ^{238}Pu	Extrapolated Skeletal Burden (nCi)
Rib	54	20	N.S.*	N.S.	--
Sternum	256	21	0.03	N.S.	0.14
Vertebra	81	33	0.01	N.S.	0.05
Femur	95	45	N.S.	N.S.	--

*N.S. = not statistically significant from background count level of 0.03 dis/min per sample aliquot.

APPENDIX A

TISSUES RECEIVED FOR PLUTONIUM ANALYSIS AND THE ANALYSIS RESULTS FOR SELECTED TISSUE SECTIONS

Tissues Received	Weight Received (g)	Weight Analyzed (g)	Activity for 10% Aliquot $^{239}Pu \pm 1$ S.D.[a]	Activity for 10% Aliquot $^{238}Pu \pm 1$ S.D.[a]
Bone, Femur	95			
Rib(2)	54			
Sternum	256			
Vertebral wedge	81			
Brain	846			
Duodenum, Tissue	73	7.4	0.0 ± 0.0	0.0 ± 0.0
Chyme		<0.1	1.2 ± 0.1	0.2 ± 0.03
Fat, Mesenteric	72			
Gonad	27			
Heart	187			
Intestine, Large				
Colon, ascending	124			
Colon, transverse	114	30.9	0.2 ± 0.03	0.02 ± 0.01
Fecal specimen		19.5	6.7 ± 0.2	0.8 ± 0.1
Colon, decending	124			
Intestine, Small, with Contents	588			
Tissue specimen		17.3	0.08 ± 0.02	0.0 ± 0.0
Chyme specimen		3.3	0.10 ± 0.02	0.02 ± 0.01
Kidney(one)	121			
Liver	1311	19.0	10.3 ± 0.2	1.3 ± 0.1
Lung, Whole	995			
Parenchyma specimen		17.2	17.4 ± 0.3	2.2 ± 0.1
Pleura specimen		16.6	0.02 ± 0.01	0.0 ± 0.0
Lymph Nodes				
Large intestine	0.01			
Mesenteric, lower	2.			
Mesenteric, upper	2.			
Periportal	3.3	3.3	0.05 ± 0.02	0.01 ± 0.01
Tracheobronchial		6.7	1.2 ± 0.1	0.2 ± 0.03
Muscle	270			
Omentum	51			
Spleen	116			
Stomach Wall	133	8.8	0.8 ± 0.1	0.1 ± 0.02
Thyroid	8.			

[a]Fecal activity for 1% aliquot.