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A REVIEW OF URANIUM EXCRETION AND CLINICAL URINALYSIS DATA IN ACCIDENTAL EXPOSURE CASES

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ABSTRACT

This report reviews urinalysis results obtained following four incidents in which thirteen workers were exposed to high concentrations of airborne uranium. The compounds involved were U_3O_8, UF_6, and uranium ore concentrates. Urine samples collected following these exposures were always analyzed for uranium, and in some cases, for specific gravity, pH, protein, sugar, white blood cells, red blood cells, and casts. Although urinary uranium concentrations exceeded 1 mg U/l, no evidence was found to indicate kidney damage as a result of these exposures.

INTRODUCTION

Information presented in this report shows that no abnormal clinical effects were found in urine samples from uranium workers involved in exposure incidents which produced urinary uranium concentrations up to 2.85 mg U/liter. These results may be of no surprise to anyone reading the Proceedings of the first uranium symposium.[1] Several speakers at that gathering noted that such levels would not be expected to produce evidence of kidney damage. However, participants did note that more data were needed before conclusions were possible and that such data should be reported. Over twenty years ago, it was observed that sites which handled uranium had no cases of severe uranium poisoning and mild cases were practically unknown.[2] Based on our experience, that observation remains valid.

Information regarding thirteen workers involved in four different exposure situations is given here. The uranium compounds involved were U_3O_8, UF_6, and uranium concentrates. Most of these concentrates were sodium or ammonium diuranates. Some concentrates had been roasted and were mixtures of uranium oxides.

All exposures occurred at the Feed Materials Production Center, Cincinnati, Ohio. This plant is owned by the Energy Research and Development Administration and is operated by the National Lead Company of Ohio. All personnel submit urine samples on a schedule which is based on the potential for exposure to airborne uranium. Laboratory urinalysis includes a determination of uranium, specific gravity, pH, sugar, protein, and a microscopic exam of sediment for white blood cells, red blood cells, and casts. Special sample collections are made following suspected exposure incidents. Abnormal findings of protein, red blood cells, and casts are regarded as the principal indexes of renal injury by uranium. Urinary findings regarded as abnormal are: More than 10 white blood cells per high power field; more than 5 red blood cells per high power field; more than the rare occurrence of hyaline, pus, and fine granular casts, or any coarse casts, or any casts containing red blood cells.

EXPOSURES TO URANIUM CONCENTRATES

A series of exposures occurred in refinery operations during efforts to clear a screw conveyor which became blocked with damp concentrates. These concentrates are contained in 55-gallon drums, some of which are badly deteriorated or rusted. Drums with obvious holes are handled separately but occasionally a drum with small holes will escape detection and be dumped into a transfer system designed for dry material only. In a screw conveyor, the damp material may be packed tightly, requiring dismantling of the conveyor to expose the blockage. Dry feed packed behind the damp material was the major source of airborne uranium during work on the conveyor. Subsequent equipment changes have almost eliminated plugging of the transfer system.

In Tables 1-4, data are given for four workers who were involved in concentrate exposures. In early 1972, all four experienced similar exposures during a period when there was an increased frequency of conveyor jamming. One of the four, employee D, was also involved in a mid-year exposure incident. His exposure to airborne concentrate produced the highest concentration of urinary uranium given in this report, 2.85 mg U/l.

Employee A. At the time of this concentrate exposure, employee A was 45 years old and had been employed as a uranium worker for nineteen years. According to work records and the urinalyses results, his exposure to high concentrations of airborne uranium lasted about one month. On nine days throughout this period a urine sample was collected prior to the start of his work shift. The maximum uranium concentration found was 1.5 mg U/l. Two of these nine samples were also analyzed for protein and several other clinical values. No abnormalities were found in these samples or in samples collected later in the year. Urinalysis results are given in Table 1.

Employee B. The ore concentrate exposures experienced by employees A and B were similar. Employee B was 63 years old at the time of these exposures and he retired late in the following year.

Urine samples were collected on 12 days during the exposure period which lasted about one month. The highest concentration of

uranium found was 1.4 mg U/l, in a sample voided at the end of a shift. One sample was analyzed for clinical values. No abnormalities were found in this sample or in subsequent samples collected during the year. Urinalysis data for employee B are given in Table 2.

Employee C. As in the two previous cases, employee C began to show high concentrations of urinary uranium in January, 1972. As a result, employee C was transferred to the refinery extraction area on February 8 where dry materials are not handled and where there is a low potential for exposure to airborne uranium. Following the transfer, his urinary uranium concentration remained elevated for over three more weeks. About thirty urine samples were collected during this period and three were analyzed for clinical values. No abnormal results were found in these three samples or in three subsequent samples collected during the year.

Although all urine samples contained less than 1.0 mg U/l, this case is considered of interest because of the length of time that concentrations above 0.1 mg U/l were observed. Urinalysis results for employee C are given in Table 3.

Employee D. In addition to exposures received during January and February of 1972, employee D was also involved in an exposure incident on June 22. In this incident, a second conveyor plugged, showering concentrate over equipment on several floors and over an outside bucket conveyor. Employee D did a major part of the clean-up and apparently had a significant intake despite the use of respiratory protection.

His first sample was voided about 16 hours following the end of the shift on which the exposure occurred. The sample contained 2.85 mg U/l. A sample voided the following day contained 0.22 mg U/l. No evidence of kidney damage was found in either sample or in any other sample during the year. Urinalysis data for employee D are reported in Table 4.

EXPOSURE TO U_3O_8

Accidental exposure to large amounts of U_3O_8 are not common because this compound is not involved in routine large-scale production operations. Some residues from furnacing, metal remelt, and metal cutting are principally U_3O_8 and the drumming or dumping of these materials has presented only minor exposure problems. In the U_3O_8 exposure case reviewed below, the maximum concentration of uranium in urine was not high (0.160 mg U/l) but the concentration was elevated for several months, indicating that a significant exposure had occurred.

Employee E. At the time of this exposure, employee E was 53 years old, had been a uranium worker for 12 years, and was working as a saw operator. His job was to remove 1400-lb uranium ingots from graphite molds and transfer the ingots to a radial saw where the ingot top end was cropped and sampled. A layer of U_3O_8, formed during the remelt, usually covered the top of the ingot and mold. Separation of the ingot from the mold was done in a ventilated enclosure and the cutting was done under a stream of coolant which effectively controlled the resulting fume.

A routine periodic voiding by employee E contained 0.11 mg U/l, significantly higher than the concentration of 0.01 - 0.02 mg U/l associated with his job. Follow-up samples were also high. However, according to the employee, he had not been involved in any unusual exposure incidents. His work record showed that no unusual jobs had been performed and his foreman was unaware of any unusual exposure conditions at the employee's routine job. Other saw operators in the same area had normal uranium-in-urine values. No significant exposure conditions were disclosed by air sampling. Although the exposure was not explained, it was concluded that U_3O_8 was involved since it was the only compound encountered in the tasks performed by employee E.

Although the urinary uranium levels were not as high as had been observed in some other accidental exposure cases, there was reason to suspect that higher values occurred prior to the employee's first high result. Experience with other accidental exposures to U_3O_8 showed that in the first day following exposure, uranium concentrations were high and decreased with a half-time of 6 - 8 hours. If the elevated urinalysis results observed for employee E were due to an acute exposure, it was likely that initial concentrations exceeded 1 mg U/l. Because of the uncertain nature of the exposure, numerous start-of-shift voidings were collected. In addition, occasional overnight collections were made.

Data plotted in Figure 1 show that during a 50-day period urine results occasionally exceeded 0.1 mg U/l. During this 50-day period, eleven urine voidings were analyzed for clinical values. No abnormal values attributable to uranium were found in these samples or in approximately 200 additional samples analyzed during the two-year period following the initial high result.

Urinalysis data compiled during the 15 weeks following the initial result are given in Table 5. Included in the table are results for the routine voiding collected prior to the period of interest.

EXPOSURES TO UF_6

Most exposures to UF_6 occurred during attempts to control leaks in transfer lines between UF_6 cylinders and the process equipment in which reduction to UF_4 took place. With one notable exception, exposures were brief and appeared slight to the personnel involved. In the eight exposures described below, there was no evidence that urinary uranium concentrations as high as 1.8 mg U/l caused kidney damage.

No evidence of kidney damage was found in seven other cases of UF_6 exposure in which the estimated amounts of inhaled uranium varied from 5 mg to 12 mg.[3] The maximum concentration of urinary uranium observed in these seven previously-reported cases was 3 mg U/l.

Employee F. This employee was 39 years old at the time of this exposure and had been a uranium worker for 11 years. His exposure occurred as he attempted to halt a small leak of UF_6 in a transfer line. Although respiratory equipment was available, he did not use it because the leak appeared slight and he concluded respiratory equipment was not needed. The peak concentration of uranium in urine was 1.2 mg U/l and occurred 2.1 hours after the

exposure. During an eight-day period following the incident, 21 urine samples were analyzed for uranium. Six of these samples were analyzed for clinical values and no evidence of kidney damage was found. Urinalysis data for employee F is given in Table 6.

In the ten days following the final date in Table 6, difficulties with the UF_6 operations caused employee F additional exposures. In this 10-day period 46 urine voidings were collected and analyzed for uranium. Eleven voidings had uranium concentrations greater than 0.1 mg U/l, with a peak of 0.7 mg U/l. None of these voidings was analyzed for clinical values but a routine sample analyzed about three months later showed no evidence of kidney damage.

Employee G. An accidental release of 3800 pounds of uranium as UF_6 occurred when employee G inadvertently removed a valve from a heated 10-ton UF_6 cylinder.[4] He was immediately engulfed in a cloud containing hydrolyzed UF_6 (UO_2F_2) and hydrofluoric acid. He was hospitalized for observation because of a suspicion that pulmonary edema might develop due to the inhaled hydrofluoric acid. He was hospitalized for six days and returned to work nine days after the exposure, bothered only by mild, occasional chest tightness. At the time of the accident he was 57 years old and had been a uranium worker for 14 years. Seven years after the incident he retired in good health at age 65.

While employee G was hospitalized, all urine voidings were collected and returned to the plant for analysis. The first voiding, at 2.5 hours after the incident, contained 1.8 mg U/l. Clinical findings were negative. A total of 6 samples voided during hospitalization were analyzed at our plant for protein and all results were negative. Total uranium excreted was 3.36 mg at 25.5 hours after exposure and 3.65 mg at 211.6 hours when the continuous collection was halted.

Figure 2 is a graph of the urinary uranium results obtained on voidings up to 72.3 hours after exposure. Table 7 contains laboratory data for samples voided in the first 50.7 hours, plus a sample voided when the employee returned to work.

Employees H-M. Tables 8-13 contain urinalysis data for six other employees who were involved in the same UF_6 release with employee G. These six men received their exposures during efforts to stop the cylinder leak. Five had urinary uranium concentrations above 1 mg U/l. The sixth, a foreman, had a peak concentration of 0.76 mg U/l but the elevated concentrations continued over a four-day period, probably because of reexposure during clean-up operations.

In this incident, a total of 280 employees submitted over 1000 urine samples, most of which were analyzed for uranium as well as protein, sugar, pH, white and red blood cells, and casts. Over 65 samples had a uranium concentration above 0.1 mg U/l. Six samples contained more than 1 mg U/l. The maximum concentration found was 1.9 mg U/l. There were no findings which indicated kidney damage resulting from uranium intake. A sample voided by employee L one hour after his exposure ceased contained 15 mg % protein. Other values were normal. All clinical values were normal in a second sample voided about one hour later and in all

subsequent samples. The single positive protein result cannot be interpreted as an indication of renal damage.

DISCUSSION

FREEMAN: Did you make urinary fluoride analyses on the uranium orthinium accident cases?

BOBACK: As far as I know, fluoride analyses were not made in these accident cases. There were some analyses done years back, about 1955 or 1956. As I recall, the results were sketchy, and that is probably why it was not continued.

REFERENCES

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4. M. W. Boback and R. C. Heatherton, Bioassay Aspects of A UF_6 Fume Release, in Proceedings of the 12th Annual Bioassay and Analytical Chemistry Meeting, Gatlinburg, Tennessee, October 13-14, 1966, USAEC Report CONF-661018, pp. 147-159, June 6, 1967.

Table 1. Employee A Urinalysis Data

Date	Sp. Gravity	pH	Protein	Sugar	WBC (1)	RBC (2)	Casts	Uranium mg/l	
1/14/72		7.5	neg.	neg.	0-2	0-2	none	0.063	
1/18/72								1.500	
1/20/72	1.024	6.0	neg.	neg.	0-4	0-2	none	0.022	
1/20/72								0.150	(3)
1/27/72								0.040	
1/28/72								0.043	
1/29/72								0.200	
1/30/72								0.130	
1/31/72								0.170	
2/10/72								0.130	
2/15/72								0.025	
2/16/72								0.032	
3/ 9/72								0.068	
4/18/72								0.028	
6/23/72								0.012	
7/10/72	1.017	5.5	neg.	neg.	few	rare		0.009	
9/20/72								0.009	
10/16/72								0.003	
11/15/72								0.007	
12/15/72		7.5	neg.	neg.	rare	rare	rare	0.004	

(1) White blood cells per microscope high power field.
(2) Red blood cells per microscope high power field.
(3) End of shift sample. All other samples were voided at the start of a work shift.

Table 2. Employee B Urinalysis Data

Date	Sp. Gravity	pH	Protein	Sugar	WBC (1)	RBC (2)	Casts	Uranium mg/l
1/14/72								0.065
1/17/72								0.420 (3)
1/18/72								0.340 (3)
1/19/72								0.210
1/20/72								0.150
1/21/72								0.029
1/21/72	1.021	5.0	neg.	neg.	0-4	rare	none	1.400 (3)
1/25/72								0.046
1/26/72								0.028
1/27/72								0.011
2/ 1/72								0.110
2/14/72								0.020
2/15/72								0.100
3/12/72								0.007
4/13/72		5.0	neg.	neg.	0-4	0-2	none	0.010
6/ 9/72								0.002
7/ 3/72								0.011
7/ 7/72								0.002
9/14/72	1.020	6.0	neg.	neg.	0-3	0-3	none	0.008
10/11/72								0.021
10/13/72		5.0	neg.	neg.	rare	rare	none	0.003
11/13/72		5.0	neg.	neg.	0-3	0-2	rare	0.007
11/20/72								0.002

(1) White blood cells per microscope high power field.
(2) Red blood cells per microscope high power field.
(3) End of shift samples. All other samples were voided at the start of a work shift.

Table 3. Employee C Urinalysis Data

Date	Sp. Gravity	pH	Protein	Sugar	WBC (1)	RBC (2)	Casts	Uranium mg/l
1/18/72								0.190
1/20/72	1.026	5.0	neg.	neg.	0-2	0-4	rare	0.660 (3)
1/21/72	1.022	5.0	neg.	neg.	0-3	0-2	rare	0.470 (3)
1/22/72								0.200
1/23/72								0.260
1/24/72								0.240
1/27/72								0.210
1/28/72								0.150
1/29/72								0.200
1/30/72								0.110
1/31/72								0.280
2/ 4/72								0.240
2/ 5/72								0.200
2/ 6/72								0.110
2/ 7/72								0.170
2/ 8/72								0.055
2/ 9/72								0.160
2/11/72								0.053
2/12/72								0.210
2/13/72								0.120
2/14/72								0.020
2/15/72								0.250
2/16/72								0.260
3/ 7/72								0.065
3/ 9/72								0.100
3/10/72								0.040
4/19/72		6.0	neg.	neg.	0-2	rare	none	0.069
4/20/72								0.032
4/21/72								0.021
4/24/72	1.017	5.5	neg.	neg.	0-2	0-2	none	0.031
6/23/72								0.080
6/29/72								0.053
7/11/72								0.033
10/16/72		5.5	neg.	neg.	0-2	0-2	none	0.003
11/18/72								0.013
12/20/72		7.5	neg.	neg.	0-2	rare	rare	0.007

(1) White blood cells per microscope high power field.
(2) Red blood cells per microscope high power field.
(3) End of shift samples. All other samples were voided at the start of a work shift.

Table 4. Employee D Urinalysis Data

Date	Sp. Gravity	pH	Protein	Sugar	WBC (1)	RBC (2)	Casts	Uranium mg/l
1/ 3/72		5.0	neg.	neg.	2-6	0-4	rare	0.037
1/28/72	1.020	7.5	neg.	neg.	rare	0-2	none	0.120
1/29/72								0.054
1/30/72								0.120
1/31/72	1.020	5.5	neg.	neg.	0-2	1-5	rare	0.120
2/14/72	1.021	5.5	neg.	neg.	0-3	1-5	none	0.048
2/15/72	1.016	7.5	neg.	neg.	0-4	0-2	rare	0.020
2/16/72	1.017	6.0	neg.	neg.	0-4	5-8	none	0.100
3/ 6/72	1.022	5.0	neg.	neg.	0-4	0-2	rare	0.021
4/ 3/72		5.5	neg.	neg.	0-4	3-8	rare	0.022
6/14/72	1.023	6.0	neg.	neg.	0-3	2-5	rare	0.016
6/23/72	1.019	6.0	neg.	neg.	3-6	3-10	none	2.850
6/24/72								0.220
6/30/72	1.023	5.5	neg.	neg.	0-4	3-10	none	0.440
7/ 3/72		6.0	neg.	neg.	1-4	12-15	rare	0.170
8/31/72	1.021	5.5	neg.	neg.	0-4	5-12	none	0.031
10/24/72	1.023	5.0	neg.	neg.	0-4	0-3	none	0.016
11/ 1/72		5.5	neg.	neg.	0-4	0-4	none	0.013

(1) White blood cells per microscope high power field.
(2) Red blood cells per microscope high power field.

Table 5. Employee E Urinalysis Data

Date	Sp. Gravity	pH	Protein	Sugar	WBC (1)	RBC (2)	Casts	Uranium mg/l
9/ 1/65								0.021
11/ 2/65		5.0	neg.	neg.	1-3	rare	none	0.110
11/ 4/65	1.020	5.0	neg.	neg.	2-5	0-2	rare	0.160
11/ 5/65	1.020	5.0	neg.	neg.	rare	rare	rare	0.120
11/ 8/65	1.012	7.0	neg.	neg.	rare	none	none	0.110
12/ 2/65								0.073
12/ 3/65	1.015	5.0	neg.	neg.	rare	rare	none	0.130
12/ 6/65	1.020	6.5	neg.	neg.	rare	none	none	0.073
12/17/65	1.012	5.5	neg.	neg.	5-7	1-3	none	0.059
12/20/65	1.014	5.5	neg.	neg.	5-7	2-4	none	0.044
12/22/65	1.017	6.0	neg.	neg.	5-7	3-4	none	0.072
12/27/65	1.010	6.0	neg.	neg.	2-4	rare	rare	0.054
12/28/65	1.015	5.5	neg.	neg.	2-7	0-4	rare	0.120
12/29/65	1.015	6.0	neg.	neg.	2-4	0-3	none	0.045
12/30/65	1.020	6.0	neg.	neg.	0-4	0-4	few	0.043
1/ 3/66	1.025	5.5	neg.	neg.	rare	none	none	0.037
1/ 4/66								0.033
1/ 5/66	1.017	5.5	neg.	neg.	rare	none	none	0.001
1/ 6/66	1.015	6.0	neg.	neg.	2-5	1-4	none	0.001
1/ 7/66	1.020	6.0	neg.	neg.	large no.	1-3	none	0.032
1/10/66	1.014	5.5	neg.	neg.	10-15	0-2	none	0.037
1/12/66	1.012	6.0	neg.	neg.	1-3	rare	rare	0.028
1/13/66	1.015	6.0	neg.	neg.	0-3	rare	rare	0.035
1/14/66	1.015	5.5	neg.	neg.	3-5	rare	none	0.045
1/17/66	1.018	5.5	neg.	neg.	1-5	0-3	few	0.004

(1) White blood cells per microscope high power field.
(2) Red blood cells per microscope high power field.

Table 6. Employee F Urinalysis Data

Date	ΔT Hrs. (1)	Sp. Gravity	pH	Protein	Sugar	WBC (2)	RBC (3)	Casts	Uranium mg/l
8/ 5/64	0.6	1.024	7.0	neg.	neg.	0-3	1-6	none	0.380
8/ 5/64	2.1								1.200
8/ 5/64	5.6								0.560
8/ 6/64	20.1								0.120
8/ 6/64	21.6	1.021	7.0	neg.	neg.				0.045
8/ 6/64	23.1								0.120
8/ 6/64	27.1								0.038
8/ 6/64	28.6								0.029
8/ 6/64	29.6								0.019
8/ 6/64	31.3								0.035
8/ 6/64	34.1								0.025
8/ 7/64	38.1								0.025
8/ 7/64	43.3								0.028
8/ 7/64	45.6	1.015	7.0	neg.	neg.				0.008
8/ 7/64	48.1								0.049
8/ 7/64	50.6								0.180
8/ 7/64	52.1								0.057
8/ 7/64	53.8								0.032
8/10/64	117.6	1.015	7.0	neg.	neg.				0.007
8/13/64	189.6	1.020	7.0	neg.	neg.				0.012
8/14/64	214.6		6.0	neg.	neg.	0-3	0-2	none	0.004

(1) Time, in hours, following exposure. Re-exposure occurred after the sample voided at ΔT = 21.6 hrs.
(2) White blood cells per microscope high power field.
(3) Red blood cells per microscope high power field.

Table 7. Employee G Urinalysis Data

Date	ΔT Hrs. (1)	Sp. Gravity	pH	Protein	Sugar	WBC (2)	RBC (3)	Casts	Uranium mg/l
2/14/66	2.5			(4)					1.800
2/14/66	3.6			(4)					1.800
2/14/66	6.1			(4)					1.200
2/14/66	7.8			(4)					1.200
2/14/66	10.3			neg.					0.540
2/14/66	12.6			neg.					0.470
2/15/66	18.0			neg.					0.320
2/15/66	19.6			neg.					0.200
2/15/66	22.3			neg.					0.120
2/15/66	25.3			neg.					0.055
2/15/66	26.9			neg.					0.051
2/15/66	29.1			neg.					0.041
2/15/66	32.3			neg.					0.032
2/15/66	35.7			neg.					0.026
2/16/66	40.3			neg.					0.049
2/16/66	43.4			neg.					0.038
2/16/66	46.5			neg.					0.029
2/16/66	49.2			neg.					0.018
2/16/66	50.7	1.002	5.5	neg.	neg.	0-2	rare	rare	0.012
3/24/66			5.5	neg.	neg.	rare	rare	rare	

(1) Time, in hours, following exposure.
(2) White blood cells per microscope high power field.
(3) Red blood cells per microscope high power field.
(4) These samples were received from the hospital 24-29 hours after voiding. Heavy sediment and bacterial growth prevented analysis.

Table 8. Employee H Urinalysis Data

Date	Sp. Gravity	pH	Protein	Sugar	WBC (1)	RBC (2)	Casts	Uranium mg/l
2/14/66	1.018	5.0	neg.	neg.	0-2	0-3	few	1.300
2/14/66	1.030	5.0	neg.	neg.	rare	rare	none	1.200
2/14/66			neg.					0.550
2/14/66			neg.					0.240
2/15/66			neg.					0.200
2/15/66			neg.					0.190
2/15/66	1.034	5.0	neg.	neg.	rare	rare	none	0.079
2/15/66	1.019	5.0	neg.	neg.	rare	rare	none	0.056
2/16/66	1.026	5.5	neg.	neg.	0-2	0-3	rare	0.029
2/16/66	1.017	5.0	neg.	neg.	0-4	0-2	none	0.023
2/17/66								0.007
2/17/66	1.012	7.5	neg.	neg.				0.012
2/23/66	1.022	5.0	neg.	neg.	rare	rare	none	

(1) White blood cells per microscope high power field.
(2) Red blood cells per microscope high power field.

Table 9. Employee I Urinalysis Data

Date	Sp. Gravity	pH	Protein	Sugar	WBC (1)	RBC (2)	Casts	Uranium mg/l
2/14/66	1.018	5.5	neg.	neg.	0-2	rare	none	1.200
2/14/66	1.017	7.5	neg.	neg.				0.340
2/14/66			neg.					0.190
2/14/66			neg.					0.120
2/15/66	1.007	6.0	neg.	neg.	0-2	rare	none	0.027
2/15/66	1.017	5.0	neg.	neg.	0-2	rare	none	0.052
2/15/66	1.014	5.0	neg.	neg.	rare	rare	none	0.033
2/16/66	1.015	5.0	neg.	neg.	0-2	0-2	none	0.016
2/17/66	1.015	5.0	neg.	neg.	0-4	0-2	none	0.008
2/18/66	1.022	5.0	neg.	neg.	4-8	0-2	none	0.010
2/21/66	1.021	5.5	neg.	neg.	1-3	0-2	none	0.012
2/23/66	1.026	5.5	neg.	neg.	rare	rare		

(1) White blood cells per microscope high power field.
(2) Red blood cells per microscope high power field.

Table 10. Employee J Urinalysis Data

Date	Sp. Gravity	pH	Protein	Sugar	WBC (1)	RBC (2)	Casts	Uranium mg/l
2/14/66	1.008	5.0	neg.	neg.	rare	rare	none	1.100
2/14/66	1.017	7.5	neg.	neg.	rare	rare	none	0.810
2/14/66	1.016	6.5	neg.	neg.	rare	0-2	none	0.550
2/14/66	1.020	5.5	neg.	neg.	rare	rare	none	0.430
2/14/66			neg.					1.600
2/15/66			neg.					1.900
2/15/66	1.021	5.5	neg.	neg.	rare	0-2	none	0.058
2/15/66	1.013	6.5	neg.	neg.	rare	rare	none	0.017
2/15/66	1.018	5.0	neg.	neg.	0-2	rare	none	0.018
2/23/66	1.022	7.5	neg.	neg.	rare	rare	none	

(1) White blood cells per microscope high power field.
(2) Red blood cells per microscope high power field.

Table 11. Employee K Urinalysis Data

Date	Sp. Gravity	pH	Protein	Sugar	WBC (1)	RBC (2)	Casts	Uranium
2/14/66	1.008	5.5	15 mg %	neg.	0-2	rare	rare	1.100
2/14/66	1.005	5.5	neg.	neg.	rare	rare	none	0.580
2/14/66	1.005	5.5	neg.	neg.	rare	rare	none	0.200
2/14/66	1.000	5.5	neg.	neg.	rare	rare	none	0.120
2/14/66	1.000	5.5	neg.	neg.	rare	rare	none	0.190
2/14/66			neg.					0.360
2/14/66			neg.					0.500
2/15/66			neg.					0.410
2/15/66			neg.					0.230
2/15/66	1.019	5.5	neg.	neg.	rare	0-2	none	0.160
2/15/66	1.022	5.5	neg.	neg.	0-2	rare	none	0.200
2/15/66	1.020	5.0	neg.	neg.	rare	rare	none	0.067
2/16/66	1.019	5.5	neg.	neg.	rare	rare	none	0.028
2/16/66	1.011	5.5	neg.	neg.	rare	rare	none	0.016
2/17/66	1.005	5.0	neg.	neg.	rare	rare	none	0.017
2/17/66	1.018	5.0	neg.	neg.	0-4	0-2	none	0.029
2/18/66	1.012	5.5	neg.	neg.	rare	rare	none	0.017
2/21/66	1.020	5.5	neg.	neg.	rare	rare	none	0.010
3/24/66		5.0	neg.	neg.	rare	rare	none	0.007

(1) White blood cells per microscope high power field.
(2) Red blood cells per microscope high power field.

Table 12. Employee L Urinalysis Data

Date	Sp. Gravity	pH	Protein	Sugar	WBC (1)	RBC (2)	Casts	Uranium mg/l
2/14/66	1.017	6.0	neg.	neg.	0-2	none	none	1.100
2/14/66	1.010	7.5	neg.	neg.	rare			0.810
2/14/66	1.011	7.5	neg.	neg.				0.680
2/14/66			neg.					0.049
2/14/66			neg.					0.082
2/14/66			neg.					0.039
2/15/66			neg.					0.075
2/15/66	1.017	7.5	neg.	neg.	rare	rare	none	0.078
2/16/66	1.014	7.5	neg.	neg.	rare	rare	none	0.033
2/16/66	1.016	7.5	neg.	neg.	rare	rare	none	0.023
2/16/66	1.016	6.0	neg.	neg.	rare	rare	none	0.015
2/17/66	1.021	5.0	neg.	neg.	rare	rare	none	0.040
2/17/66	1.020	5.0	neg.	neg.	0-2	0-2	none	0.020
2/18/66	1.017	5.5	neg.	neg.	1-4	0-2	none	0.019
3/24/66		7.5	neg.	neg.	1-3	0-2	none	0.016

(1) White blood cells per microscope high power field.
(2) Red blood cells per microscope high power field.

Table 13. Employee M Urinalysis Data

Date	Sp. Gravity	pH	Protein	Sugar	WBC (1)	RBC (2)	Casts	Uranium mg/l
2/14/66	1.004	6.0	neg.	neg.	rare	none	none	0.760
2/14/66	1.001	6.0	neg.	neg.	0-2	rare	rare	0.010
2/14/66								0.470
2/14/66			neg.					0.330
2/14/66			neg.					0.120
2/15/66			neg.					0.150
2/15/66	1.008	5.5	neg.	neg.	rare	rare	none	0.160
2/15/66	1.016	5.0	neg.	neg.	0-2	0-15	none	0.150
2/16/66	1.014	5.0	neg.	neg.	0-2	0-3	none	0.058
2/16/66	1.002	6.0	neg.	neg.	rare	rare	none	0.014
2/17/66	1.012	5.0	neg.	neg.	rare	0-2	none	0.390
2/17/66	1.002	5.0	neg.	neg.	0-2	rare	none	0.009
2/18/66	1.012	5.5	neg.	neg.	rare	rare	none	0.006

(1) White blood cells per microscope high power field.
(2) Red blood cells per microscope high power field.

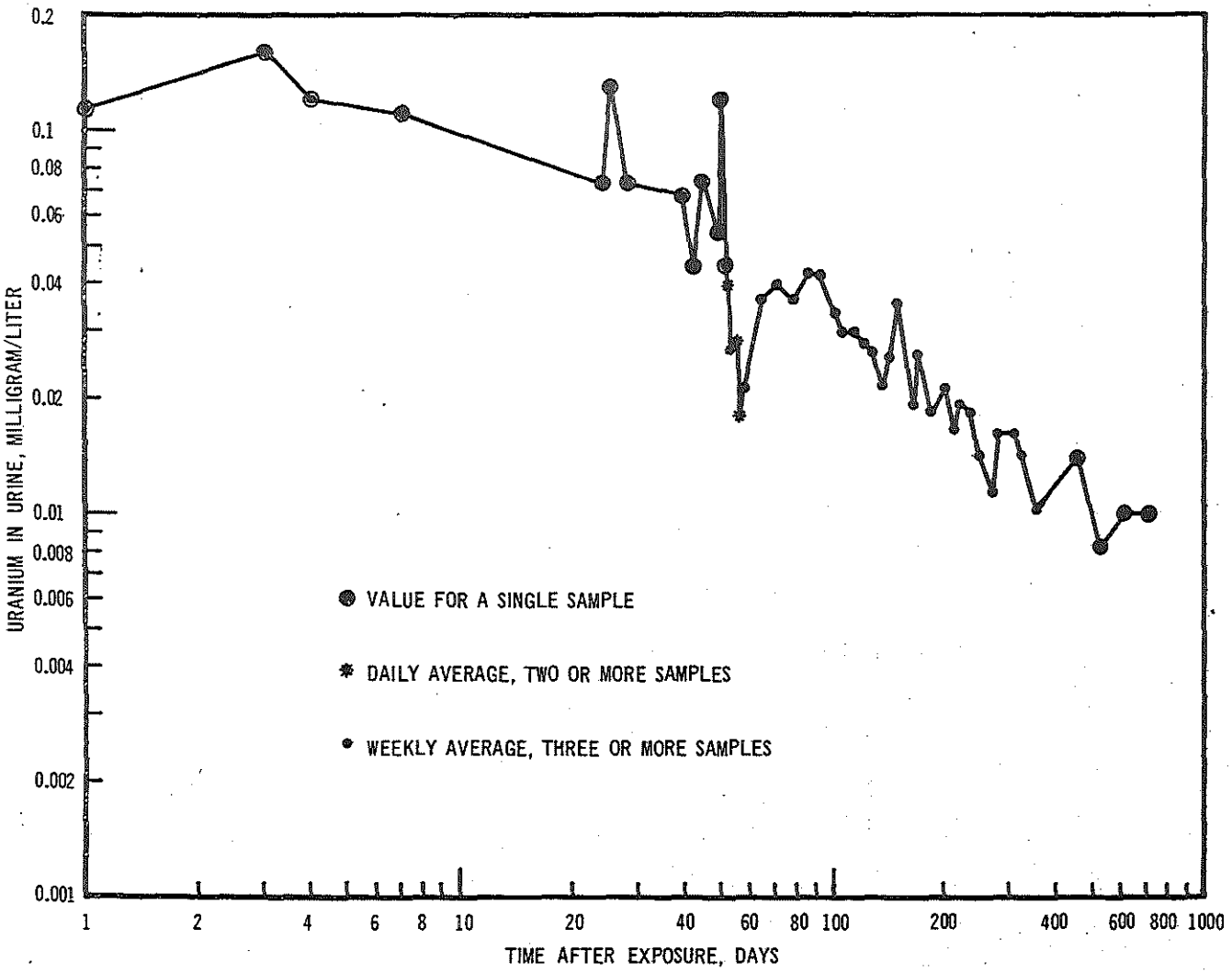

FIGURE 1 EMPLOYEE E – Concentration of Uranium in Urine

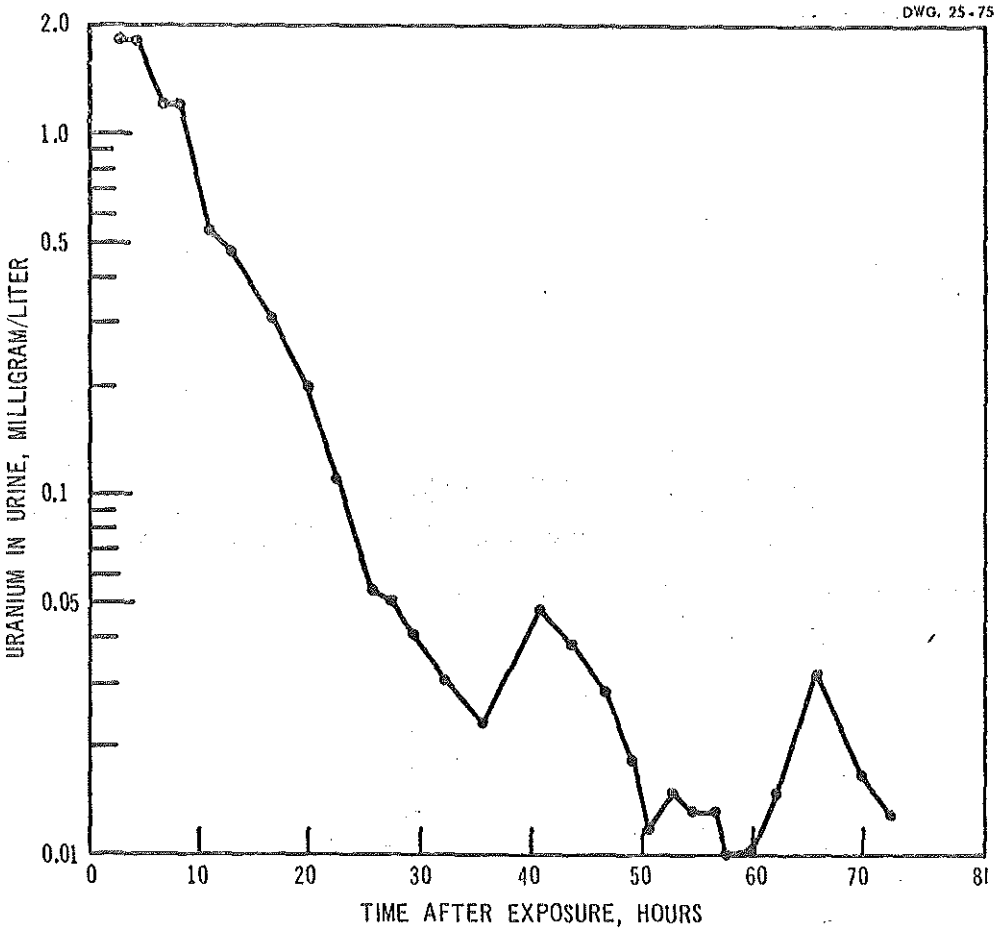

FIGURE 2 EMPLOYEE G – Concentration of Uranium in Urine