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RULES AND DIRECTIVES BRANCH

Rules, Announcements, and Directives Branch
Office of Administration
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Ref: Draft Regulatory Guide DG-8051, Bioassay at Uranium Mills (March 2012)

To whom it may concern,

After review of your Draft Bioassay Guide for Uranium Mills, I would like to submit the following comment on *Section 3 Frequency part c.*: You may want to consider an upper bound limit for a urinalysis sampling time frame, <90hours, for uranium mill workers under the following conditions:

a) Calcining to 1200 degrees F in a multiple hearth dryer using a feed of ammonium diuranate $(NH_4)_2\ U_2O_7$.

(ref: 1)*Solubility Classification of Yellowcake Produced by a Brazilian Uranium Mill,* E.S. Mansur and S.M. Carvalho, Instituto de Radioprotaçãc e Dosimatria, Cx. Postal 37025, CEF 22602, Rio de Janeiro, RJ, Brazil http://www.irpa.net/irpa7/cdrom/VOL.3/S3_87.PDF
2) *InVitro Solubility of Yellowcake Samples From Four Uranium Mills and the Implications For Bioassay Interpretation*, Eidson, Arthur F.; Mewhinney, James A., Health Physics - December 1980 - Volume 39 - Issue 6)

Reference the attached paper for the following information:

Even though the final product is Class Y, by definition, and would be the suspected potential source of airborne uranium, the major source of airborne uranium experienced in the mill may very well be Class D material. Generally an enclosed dryer and scrubber are designed to handle a specific percent solids feed rate for the dryer and specific volume of gas for the scrubber to handle. When the percent solids, yellowcake feed to the dryer, are higher than design capacity, plugging of the dryer can and does occur. In this case, the dryer has to be shut down, cooled, opened up and cleaned out manually. This constitutes an overexposure potential and subsequent personnel monitoring, use of protective clothing, smoke tested full face respirators, and causes operational down time. Operations personnel soon learn to err on the low side of designed feed capacity. This can create more drier off-gas than the scrubber is designed to handle. This low density material is fed to the drier on the top hearth which is around 750 degrees F. The off-gas produced is primarily coming from the top hearth of the dryer. When, not if, this gas escapes the drying enclosure it produces a soluble form of airborne uranium. When the situation is bad enough, a "haze" is visible in the dryer and precipitation area of the mill. Follow up air sampling confirmed elevated levels of airborne uranium in the drying and precipitation area.

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Add = J.A. Jervey (RJJ)
M. Case (MJC)

Because overexposure potential has been anticipated in the barreling (packaging) operation, packaging is done in an enclosed, negative pressure, area located below the bottom (yellowcake storage hopper) of the dryer. Barreling personnel were required to wear protective clothing, smoke tested full face respirators and personnel monitoring devises. Off-gases are not produced in the barreling enclosure and this process is not effected by changes in dryer feed rates. Proper operation should prevent airborne Class Y material in the mill. In-vivo lung counting once per year helped confirm this assumption.

The following are notes on information not included in the attached paper:

1) In hind-site, the paper should have stated that "the primary *anticipated* source of airborne U exposure was high-temperature-dried (923° K) yellowcake". It was not intended to imply that high-temperature-dried uranium was soluble. Only that we were seeing soluble airborne uranium. (3rd paragraph page 2 (p.196 of Health Physics Journal))

2) Mill operating personnel were routinely rotated to each operating position, grinding and leach, CCD, solvent extraction, and precipitation and drying. That way, no one was placed at one operating position continually and all were trained at each position. Barreling was normally conducted on dayshift.

3) All in-vivo counting was conducted once annually for selected mill personnel with everyone counted during their first year of employment. Every count period included the mill person with the highest exposure potential (no credit was taken for respirator use) during the preceding year. The average annual counting data were all below the minimum detection limit.

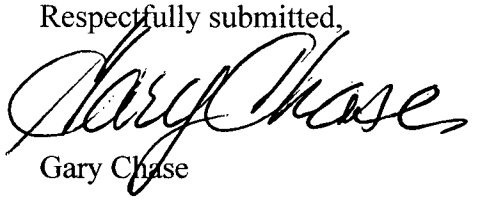
4) Special exposures, personnel monitoring results, were not included in the average annual airborne uranium exposure level estimates for people working in the mill. It was assumed that respirator protection would preclude any inhalation of airborne uranium for the purpose of this attempted correlation. Respirators were not worn for routine mill operation. The airborne uranium level was based upon the average airborne uranium level measured at the 23 sample location in the mill with the 23 samples collected once per month.. The mass balance calculation was done to check the assumed correlation.

5) There was an extremely low rate of turnover at this mill. The data reflect a learning curve for the operators and the effect of engineering controls. There was no turnover in the radiation safety department, no change in mill analytical procedures or contract laboratory used for urinalysis data during this time frame. Side-by-side airborne uranium sampling was crossed checked with Nuclear Regulatory Commission (NRC) personnel on their inspections of the mill and the results were considered acceptable by the NRC.

6) Had a 15 μg/liter lower limit of detection in-vitro uranium urinalysis been used after a >90 hour time off sampling time frame, most of these data would not have been observed. (i.e. there are 24/7 rotating shifts that have 4 days, >192 hours, off.) If the barreling operation is under control the amount of soluble uranium in the air could be missed entirely.

The only statistical application that would apply to these data is the law of large numbers. There are far too many variables involved from person to person, day to day. Although the levels of uranium reported in this paper are far below any levels of concern, they do demonstrate that uranium milling can be conducted in a safe manner. It should also be noted that mill production, for the referenced mill, was doubled during the early years of operation.

Respectfully submitted,



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● *Paper*

CORRELATION BETWEEN AIRBORNE U EXPOSURE AND U URINALYSIS RESULTS AT BEAR CREEK URANIUM

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(*Received* 16 *December* 1985; *accepted* 26 *September* 1988)

***Abstract*—Inhalation exposure history and U urinalysis data collected at Union Pacific Resources Company's Bear Creek Uranium milling operation, located in the Powder River Basin area of Wyoming, were studied to determine if a correlation could be made between airborne U exposure and U urinalysis results. It was observed from these data that U urinalysis results correlate with airborne U exposure levels when averaged over a period of time. The urinary U excretion rate, empirically derived from these data, was 1.8×10^{-1} μg U in urine d^{-1} per μg U inhaled d^{-1} for samples collected after 2.9 d of no exposure.**

INTRODUCTION

AIRBORNE U samples and urinalysis measurements are required in U milling facilities licensed by the U.S. Nuclear Regulatory Commission (USNRC) to estimate the U exposure of the personnel employed in these facilities. The purpose of urinalysis is to verify the adequacy of the air sampling program and ensure that control procedures used to limit airborne exposures to workers are effective.

A study published in 1984 cited U urinalysis bioassay results to be "highly variable and thus unreliable as a monitoring tool for determining whether mill workers have been exposed to airborne uranium" (Spitz et al. 1984). However, evaluation of data collected at Bear Creek indicates that urine bioassay can be used to verify the adequacy of air sampling and subsequent personnel exposure estimates.

METHODS

During the 9-y operating history of the Bear Creek Uranium mill, 4,500 individual urine samples and 2,600 airborne U samples were collected and analyzed to estimate the exposure of the employees to U.

Airborne U samples were collected at 23 stationary sample locations inside the mill, with at least one sample collected each working day of the month. The samples were collected with high-volume air samplers with an average face velocity of 116 cm s^{-1}. The collection efficiency of the filter paper used was calculated to be 98% with 0.3-μm diameter particle size (ACGH 1978). The filter papers were wet-ash-digested and analyzed by fluorimetric analysis at Bear Creek. Split samples were sent to commercial laboratories for analytical cross-checks. The calculated lower limit of detection (LLD) for this fluorimetric procedure is 1.5×10^{-5} Bq m^{-3} U (4×10^{-16} μCi mL^{-1} U).

Urine samples were collected from each mill employee on a monthly frequency. Single-void urine samples were collected after each employee had been away from the mill for a minimum of 48 h and a maximum of 96 h. Mill employees working day shift, Monday through Friday, were sampled upon their return to work on Monday morning after 63 h away from the mill or 2.6 d of no exposure to airborne U. Due to their rotating shift schedule to maintain continuous operation of the mill, the mill operators were sampled after 3.3 d of no exposure. Based upon the number of people employed in the mill and their respective sample collection times, the calculated weighted average for sample collection time was 2.9 d of no exposure.

Before the employees entered the mill area, urine samples were collected and shipped to a commercial laboratory for analysis. Blanks, sample splits and splits of the same sample spiked with known amounts of National Bureau of Standards (NBS) U were included with each shipment as recommended by the USNRC Regulatory Guide 8.22 (USNRC 1978). Samples were spiked to 15 μg L^{-1} U and 30 μg L^{-1} U. The same commercial laboratory was used from July 1978 until operation of the mill ceased in January 1986. The reported LLD for the laboratory's fluorimetric method of analysis was 5 μg L^{-1} U.

For the purpose of interpreting and averaging the urinalysis data, all sample results reported as <5 μg L^{-1} U were assigned a value of 2 μg L^{-1} U. The assignment of this value was based upon the calculated difference between the known value and the reported value of samples split and spiked with a known amount of NBS U and reported as <5 μg L^{-1} U on an unspiked split of the same

sample. The assigned value of 2 $\mu g\ L^{-1}$ U was based on the average value calculated for 431 samples that had been split and spiked in this manner.

Example: A single-void urine sample, A, was split into two samples, A_1 and A_2.

A_1 was submitted without spiking and the measured result was $<5\ \mu g\ L^{-1}$ U. A_2 was spiked with NBS U to obtain a concentration of 15 $\mu g\ L^{-1}$ U and submitted for analysis. The measured result was 17 $\mu g\ L^{-1}$ U. The difference between the measured result for A_2, 17 $\mu g\ L^{-1}$ U, and the spiked value for A_2, 15 $\mu g\ L^{-1}$ U, was 2 $\mu g\ L^{-1}$ U and should approximate the true value of A_1.

The primary source of airborne U exposure at Bear Creek was high-temperature-dried (923°K) yellowcake. The wet-grinding process employed in the mill precluded any significant U exposure from ore dust.

The urinary U excretion rate was calculated by dividing the average value of the 4,500 individual U urinalysis results, converted to $\mu g\ U\ d^{-1}$, by the average airborne U exposure level converted to μg U inhaled d^{-1} (Table 1, columns E and C, respectively).

Individual urinalysis results were estimated by multiplying the empirically derived urinary U excretion rate, converted to $\mu g\ L^{-1}$ U in urine by the calculated average airborne U exposure level for the month preceding the urinalysis sample collection for each individual.

RESULTS

A summary of the data collected and averaged for all of the employees is presented in Table 1. A graph comparing the annual average cumulative airborne U exposure to the annual average observed urinalysis result is shown in Fig. 1. Figure 2 is a graph of the variation experienced between the expected urinalysis results and the observed results.

The amount of U estimated to deposit in the pulmonary region of the lung is approximately equal to the amount of U calculated to be in the urine. This is based on the assumption that 25% of the air inhaled remains in the pulmonary region of the lung and 1.4 $L\ d^{-1}$ of urine is excreted by a worker. Twenty-five percent of the total cumulative exposure (see Table 1, column B) would be 786.2 Bq (21.2 nCi), and the average urinalysis result (see Table 1, column E) would be equivalent to 795.5 Bq (21.5 nCi) of U in the urine for the 9-y period of time.

The data presented in Table 2 represent exposure history and urinalysis data for two mill workers. These particular data were selected as examples for the following reasons:

Table 1. Annual average personnel exposure data.

YEAR	A	B	C	D	E
1977	655 (177)	777 (21)	0.314 (0.085)	15	16
1978	611 (165)	740 (20)	0.293 (0.079)	14	18
1979	407 (110)	481 (13)	0.196 (0.053)	10	8
1980	333 (90)	407 (11)	0.159 (0.043)	8	6
1981	204 (55)	259 (7)	0.096 (0.026)	5	4
1982	159 (43)	185 (5)	0.078 (0.021)	4	4
1983	85 (23)	111 (3)	0.040 (0.011)	2	2
1984	52 (14)	74 (2)	0.026 (0.007)	1	2
1985	100 (27)	111 (3)	0.048 (0.013)	2	2
Total:	2606 (704)	3145 (85)			
Average:			0.139 (0.038)	6.8	6.9

Where: A = The annual average cumulative exposure to airborne U expressed as : Bq-h m^{-3} U (10^{-10} μCi-hr cc^{-1} U)

B = The annual average cumulative exposure to airborne U expressed as : Bq U (nCi U)

C = The annual average exposure level, assuming 2080 h y^{-1}, expressed as : Bq m^{-3} U (10^{-10} μCi cc^{-1} U)

D = The expected annual average urinalysis value expressed as : $\mu g\ L^{-1}$ U

E = The observed annual average urinalysis value expressed as : $\mu g\ L^{-1}$ U

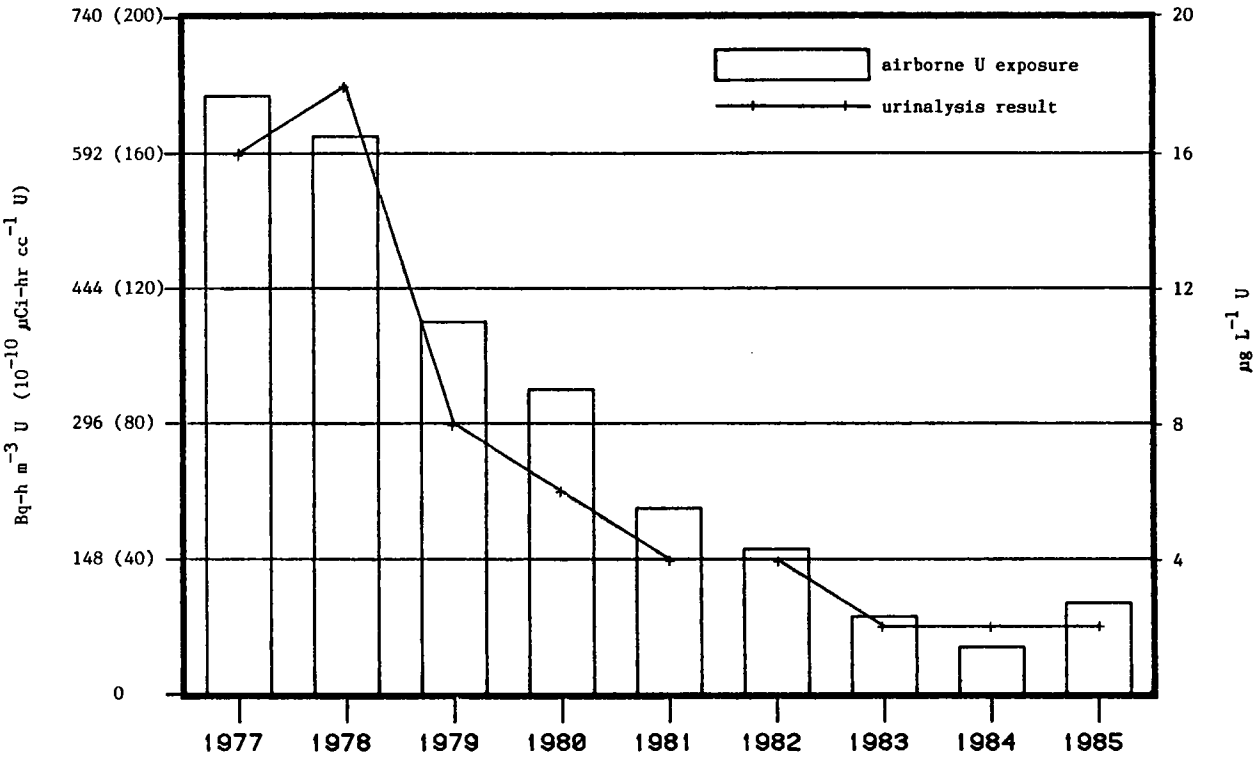

Fig. 1. Annual average cumulative personnel exposure to airborne U for all mill employees versus the annual average observed U urinalysis for all mill employees.

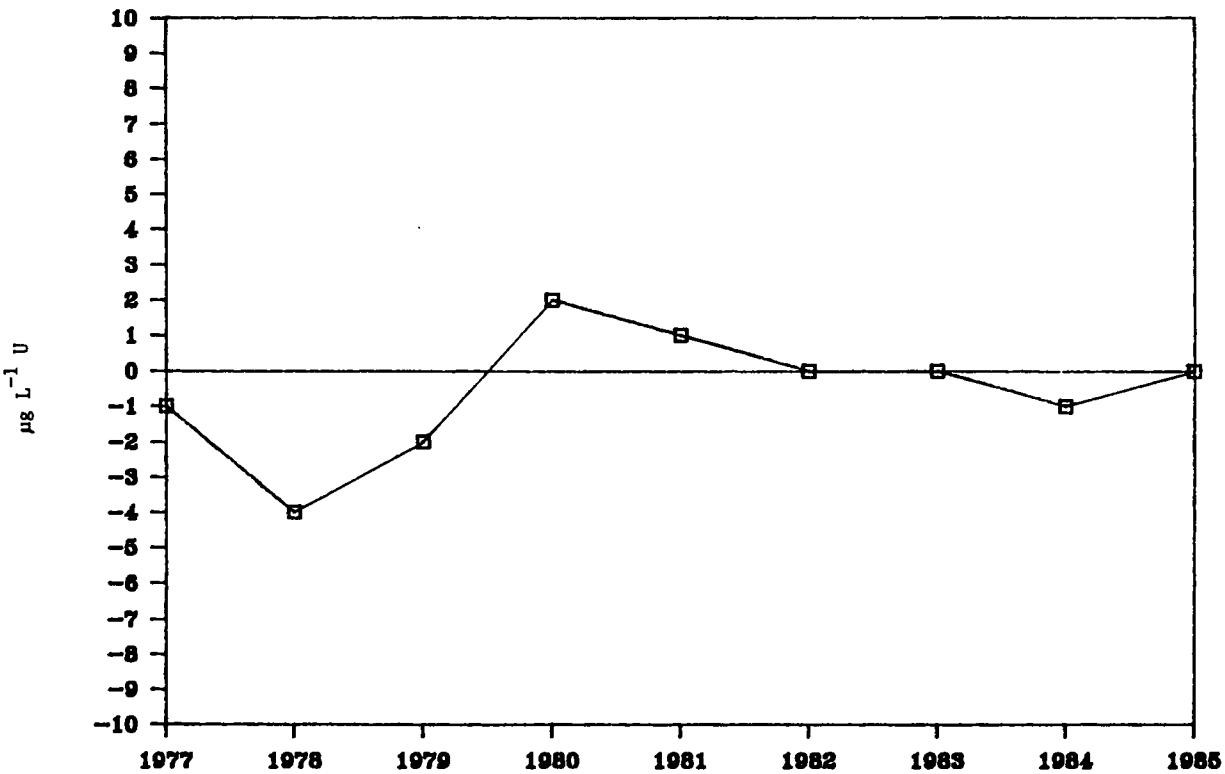

Fig. 2. Annual average expected urinalysis result minus the annual average observed urinalysis result.

Table 2. Monthly individual exposure data.

Mill operator data - hire date 19 June 1979

YEAR	MONTH	A	B	C	D	E
1979	6	88	5.2 (1.4)	0.059(0.016)	3	-
	7	160	11.8 (3.2)	0.074(0.020)	4	<5
	8	225	39.6 (10.7)	0.178(0.048)	9	8
	9	171	66.2 (17.9)	0.388(0.105)	19	19
	10	183	21.8 (5.9)	0.118(0.032)	6	9
	11	180	11.8 (3.2)	0.067(0.018)	3	<5
	12	168	2.6 (0.7)	0.015(0.004)	1	<5

Mill mechanic data - hire date 14 November 1978

YEAR	MONTH	A	B	C	D	E
1978	11	116	17.4(4.7)	0.148(0.040)	7	-
	12	160	56.6(15.3)	0.352(0.095)	17	10
1979	1	206	58.8(15.9)	0.285(0.077)	14	6
	2	152	41.4(11.2)	0.274(0.074)	13	<5
	3	219	21.8(5.9)	0.100(0.027)	5	<5
	4	182	42.6(11.5)	0.233(0.063)	11	6
	5	172	48.5(13.1)	0.281(0.076)	14	7
	6	159	20.7(5.6)	0.130(0.035)	6	8
	7	205	13.3(3.6)	0.067(0.018)	3	<5
	8	200	31.1(8.4)	0.155(0.042)	8	7
	9	195	56.6(15.3)	0.289(0.078)	14	13
	10	208	34.8(9.4)	0.166(0.045)	8	8
	11	144	16.6(4.5)	0.115(0.031)	6	8
	12	124	33.3(9.0)	0.270(0.073)	13	15

Where: A = hours worked

B = calculated monthly exposure expressed as: Bq-h m^{-3} U (10^{-10} uCi-hr cc^{-1} U)

C = calculated average exposure level expressed as: Bq m^{-3} U (10^{-10} uCi cc^{-1} U)

D = estimated urinalysis result expressed as: ug L^{-1} U

E = observed urinalysis result expressed as: ug L^{-1} U

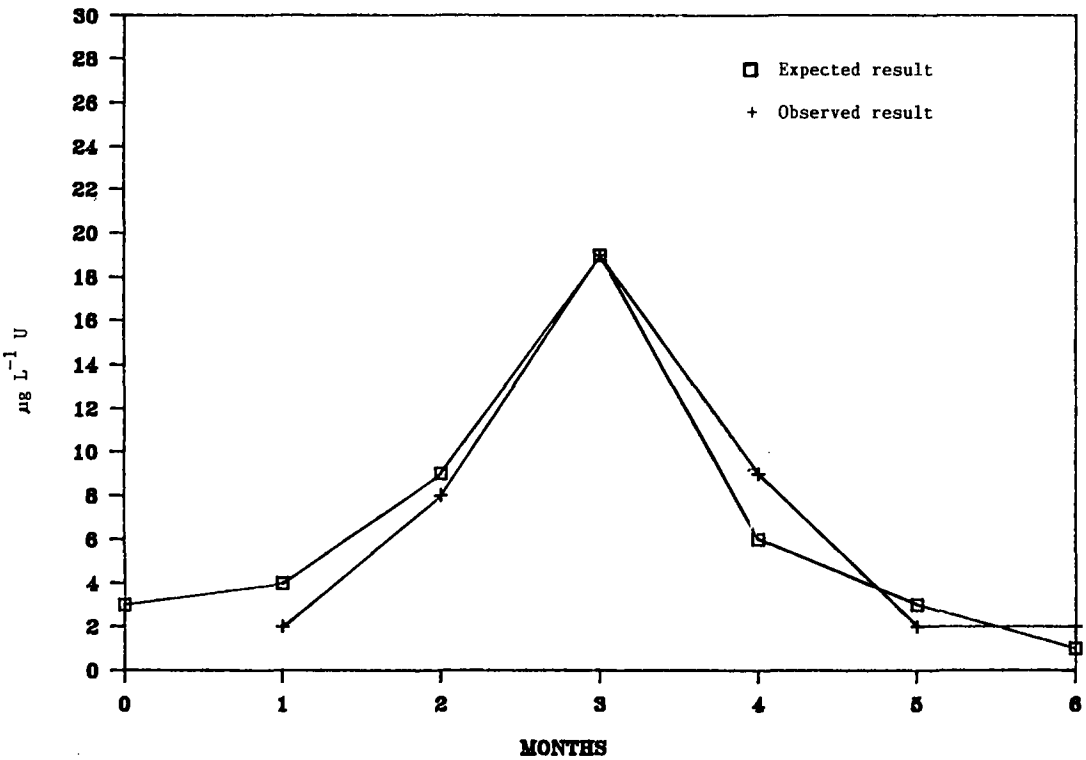

Fig. 3. Monthly expected urinalysis result versus monthly observed urinalysis result for a mill operator.

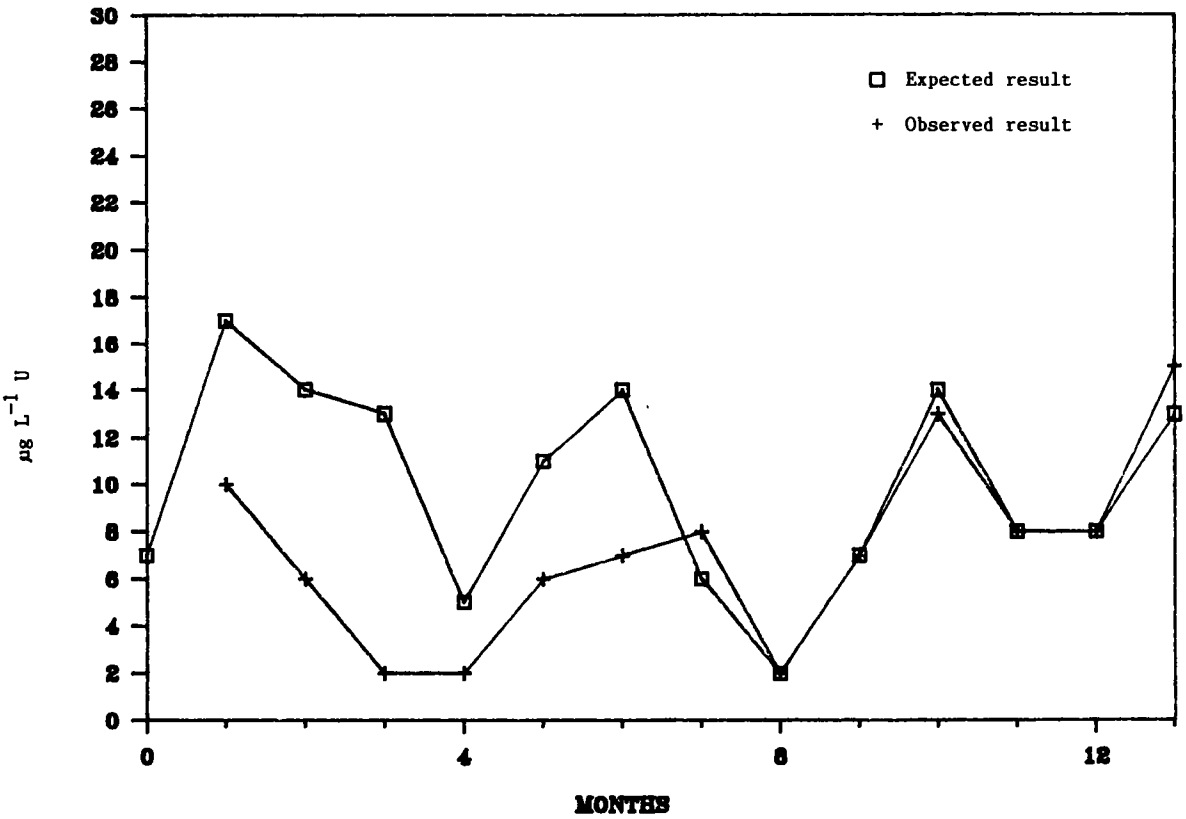

Fig. 4. Monthly expected urinalysis result versus monthly observed urinalysis result for a mill mechanic.

- Neither individual had any previous exposure history to airborne U prior to working for Bear Creek Uranium, Casper, Wyoming.
- Their job functions were typical of the majority of mill workers.
- Urinalysis sample collection times were the same for each, i.e., after 2.6 d of no exposure.
- Their dates of employment overlap and allow for comparison of fluctuations in exposure rate and urinalysis results during the same time frame.

Figures 3 and 4 are graphs of expected urinalysis results versus observed urinalysis results for these two individuals.

CONCLUSIONS

These urinalysis data were used to verify changing trends in airborne U sampling results and estimated personnel exposures. Although considerable variation was experienced between the estimated and observed individual urinalysis results, the data show a trend on a monthly basis. A break in this trend for a period of three consecutive months or a single result three times higher or lower than expected would be reasonable criteria for investigation.

The urinary U excretion rate empirically derived from these data is about three times higher than the excretion rate predicted by the internal dosimetry model described by Alexander et al. (1986).

Acknowledgments—These data were collected with the constant support and commitment to safety of W. F. (Bill) Baumann during his tenure as resident manager at Bear Creek Uranium (1975–1985). The encouragement and suggestions offered by Dr. Allen Brodsky are also appreciated.

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