<u>White Paper</u>:

NIOSH's Method and Supporting Basis for Bounding Uranium Internal Exposure at Pantex

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Executive Summary

The Secretary of Health and Human Services has designated a single class of employees at the Pantex Plant for addition to the Special Exposure Cohort (SEC) authorized under EEOICPA. On January 18, 2012, NIOSH designated a class that includes all employees of the Department of Energy, its predecessor agencies, and their contractors and subcontractors who worked at the Pantex Plant in Amarillo, Texas, during the period from January 1, 1958 through December 31, 1983, for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more other classes of employees included in the SEC. This report presents a method and supporting basis for bounding uranium internal dose associated with the maintenance, assembly, and disassembly of weapons at the Pantex Plant beginning on January 1, 1984.

Natural uranium in rock (by weight, 99.27% U-238, 0.72% U-235, and 0.006% U-234) has approximately equal activity concentrations of U-238 and U-234. Studies summarized by the U.S. Environmental Protection Agency (EPA, 1991) have indicated that U-234 (via Th-234) has a greater environmental mobility than U-238 and may well have a higher concentration in ground water. To establish the Pantex environmental baseline against which employee urine samples could be compared, 75 urine samples were obtained over a three-year period from Pantex site personnel not occupationally exposed to uranium. These samples were radiochemically analyzed for their U-234 and U-238 content (Long, 1994).

Data from this study led to the conclusion that the U-238 activity in a sample and its ratio relative to U-234 were independent variables. The 95th percentile of the lognormal distributions of U-238 and U-234 in a sample were 0.16 dpm/d and 1.2 dpm/d, respectively (Long, 1994). The Long report concluded that, for the Pantex site, elevated concentrations of U-234 with respect to U-238 in a urine sample are more indicative of an individual's consumption of well water in the area than occupational exposure to enriched material.

The NIOSH white paper, *Analysis of Pantex 1990 Uranium Bioassay Results for Workers Identified as Being Production Technicians on the W28 Program* (Bihl, 2012), revealed that the exposure scenario yielding the highest intake consistent with the measured bioassay data is one in which a chronic intake occurred over a single year in 1984. Based on results of this paper, NIOSH intends to apply the single-year (1984) exposure scenario to dose reconstructions for energy employees who worked at Pantex during any portion of the 1984-1990 time period. For employees who worked during this time period who may have been hired after January 1, 1984, the single-year intake scenario will be applied to the first year of employment.

It is possible that some of the uranium detected in the 1990 urine samples was due to intakes prior to 1984. However, intake and dose for the 1984-to-1990 period are maximized by assuming that the intake occurred during 1984. A later end to the intake period yields a smaller intake rate. An earlier assumed intake period would yield a larger intake rate, but would fall entirely within the SEC period, during which it has been determined that dose reconstruction is infeasible.

Pantex provided routine urinalysis of uranium in 1991 and 1992. Since 1993, monitoring of uranium exposures has been event-driven and is identified by air-monitoring data. Since the mid-1990s, Pantex has used lapel air samplers to monitor for intakes and trigger bioassay measurements. NIOSH intends to use any available monitoring data for reconstruction of internal doses that may have occurred during or after 1991. When bioassay data are not available to assess the intake of a worker whose job had a lower potential for intake, but might have had incidental exposure to contamination from disassembly activities, NIOSH has suggested that dose reconstructors should assign 10% of the average worker intake for that year (ORAUT-TKBS-0013-5, Section 5.2.2.3.2, pdf p. 26).

Method and Supporting Basis

The following sections present the method and supporting basis for bounding uranium internal dose associated with the maintenance, assembly, and disassembly of weapons at the Pantex Plant.

Bounding Method 1984-1990

NIOSH intends to apply the single-year (1984) exposure scenario to dose reconstructions for energy employees who worked at Pantex during any portion of the 1984-1990 time period. For employees who worked during this time period who may have been hired after January 1, 1984, the single-year intake scenario will be applied to the first year of employment. For reconstruction of internal doses that may have occurred during or after 1991, NIOSH intends to use any available monitoring data from the routine urinalysis performed during 1991-1992 and event-driven sample data from 1993 onward.

Background

A large set of urine samples (305) was collected from February 10 to April 2, 1990 and analyzed by the Y-12 Plant for uranium. Isotopic analyses were performed on the samples with results reported in units of disintegrations per minute (dpm). These bioassay samples were taken to assess potential intakes of DU-oxide by technicians working on the weapons disassembly program in the 1980s that resulted in observations of visible quantities of depleted uranium contamination. A statistical analysis was performed by Dan Strom at PNNL. Dr. Strom removed four results that had radiochemical recoveries reported as zero. Using the sum of the isotopic results for a given sample, there were 299 results greater than zero. Those were fit with the lognormal analysis, producing a GM of 0.188 dpm/d (Strom, 2004a; Strom 2004b). The results of the lognormal statistical analysis on this dataset were reported in the Pantex Occupational Internal Dose technical basis document (ORAUT-TKBS-0013-5, pdf p. 25). These data also formed the basis for the default median chronic DU intakes of 1.3 pCi/d for Type M inhalation and 19 pCi/d for Type S inhalation (ORAUT-TKBS-0013-5, 2007).

Because there was a need to determine a bounding dose, and because the research and interviews conducted from 2004 until recently indicated that the highest risk of U contamination and possible intakes came from the W28 disassembly project, ORAUT was requested to redo the analysis of the 1990 U bioassay using only the results from the production technicians (PTs) associated with the W28 disassembly. The thought process was that the PTs were at the highest risk of chronic intakes and, therefore, represented the bounding group. A Pantex Health Protection memo was used to identify the PTs on the W28 project (Monitoring Results, 1989-1990, pdf p. 47). Excretion results from those workers were extracted from the original 305 results.

In a 2012 white paper, *Analysis of Pantex 1990 Uranium Bioassay Results for Workers Identified as Being Production Technicians on the W28 Program,* NIOSH explored various intake scenarios that could have resulted in the bioassay measurements recorded in 1990 (Bihl, 2012). As explained in the W28 paper, the results from the production technicians (PTs) were analyzed twice: once for all PTs who had worked on the W28 project and once for only PTs who were still active on the project in 1989 when the project was suspended. The names for both groups came from the Pantex Health Protection memo (Monitoring Results, 1989-1990, pdf p. 47). These groups were analyzed separately because of the effect on the urine excretion rate of the time between last intake and sample collection. The same chronic intake rate will produce different excretion rates if samples are collected on different days after the end of the intake period, with daily excretion decreasing over time. When the analysis goes from excretion back to intake, and the time from end of intake to collection date is not known, different intakes would be calculated from the different excretion rates, even if the intakes were in fact the same. The actual intake scenarios for each of the workers in the "all PTs" dataset is not known and potentially could vary considerably. It was assumed that the time from end of intake to collection date had less variability for the small dataset for PTs still active on the W28 project in 1989. However, because the dataset is smaller it is less statistically robust.

Potential Intake Scenarios

In the first scenario, it is assumed that the workers continued to be exposed to DU through other work activities at the plant after the cessation of the W28 program. The next two scenarios look at short periods of work in the project (one year of exposure) and gaps between the end of chronic intake and the sample date in which no exposure occurred. A fourth set of scenarios all start in January 1984 and involve intake periods that increase in one-year increments. A fifth set of scenarios ends in February 1989, but varies the intake start dates.

The scenarios are listed below:

- Intake started January 2, 1984 and was continuous through to the sample date (2257 days). This assumption used the geometric mean (GM) for the workers active in February 1989.
- Intake occurred in 1984 for one year only. This used the GM for all W28 workers.
- Intake occurred in 1987 for one year only. This used the GM for all W28 workers.
- A series of intakes all starting January 2, 1984 and occurring for 2, 3, 4, 5, and 6 years, respectively. These used the GM for all W28 workers.
- A series of intakes all ending on February 28, 1989 but with start dates of January 2, 1988; January 2, 1987; January 2, 1986; January 2, 1985; and January 2, 1984. These used the GM for the workers active in February 1989.

The analysis presented in the W28 Program white paper revealed that the exposure scenario yielding the highest intake consistent with the measured bioassay data is one in which a chronic intake occurred over a single year in 1984.

For the purpose of maximizing dose, the single-year exposure scenario is still assumed to be bounding if the employee had the potential to have received an intake prior to 1984. Material exposures prior to 1984 would contribute to the uranium detected in the urine. Assuming all of the material was taken in during the single year maximizes internal dose as compared to assuming that the exposure occurred over a protracted period of timr.

Post-1990 Method

Pantex dose records in the 1990s specifically state whether internal emitters were monitored (and provide a dose) or not monitored (N/M). Pantex provided routine urinalysis of uranium in 1991 and 1992. Since 1993, monitoring of uranium exposures has been event-driven and is identified by air-monitoring data. Since the mid-1990s, Pantex has used lapel air samplers to monitor for intakes and trigger bioassay measurements. *Analysis of Biological Samples for Uranium, Thorium, and Plutonium* (Kerr, 1991) provided the following workplace indicators that would trigger bioassay:

- *All personnel … not wearing … respiratory protection whose tracked internal annual exposure is equal to 40 DAC-hours*
- *All personnel whose breathing zone monitor indicates that they have been exposed to 40 DAC-hours* [also lists the DAC for U-238 as 6×10^{-11} μCi/mL]

- *All personnel found to have skin contamination equal to or greater than … 1000 dpm/100 cm^2 ^{238}U.*

Table 1 presents the total numbers of available bioassay records.

Table 1: Pantex Urinalysis Records					
Isotope	**Number of Individuals Providing Samples**				
	1990	**1991**	**1992**	**1993**	**1994**
Uranium	385	671	463	538	455
Plutonium	---	---	9	81	105
Thorium	---	---	4	87	88

The site's technical basis manual at the time (BWXT Pantex, 1992) stated that the uranium urinalysis method was isotopic analysis using alpha spectrometry that "can detect 0.03 pCi/isotope/sample." The document reported an environmental background urinary excretion rate of 0.15 dpm/d of U-238 based on studies of potentially-exposed and unexposed Pantex workers. This environmental screening level was carried over to the internal dose assessment procedure (MHSMC, 1991), which indicated that dose assessment was to occur for any uranium result with a net activity greater than or equal to 0.15 dpm. Average, non-zero urine concentrations of uranium isotopes are presented in Table 2.

Table 2: Pantex Uranium Concentrations in Urine					
Isotope	**Mean Uranium Concentrations in Urine (dpm/ml)**				
	1990	**1991**	**1992**	**1993**	**1994**
U-234	0.1423	0.1347	0.1436	0.1300	0.1528
U-235	0.0233	0.0143	0.0111	0.0418	0.0175
U-236	0.0086	0.0059	0.0073	0.0267	0.0115
U-238	0.0622	0.0673	0.0935	00.1093	0.0884

When bioassay data are not available to assess the intake of a worker whose job had a lower potential for intake, but might have had incidental exposure to contamination from disassembly activities, NIOSH has suggested that dose reconstructors should assign 10% of the average worker intake for that year (ORAUT-TKBS-0013-5).

Position Basis

The evaluation documented in the 2012 white paper, *Analysis of Pantex 1990 Uranium Bioassay Results for Workers Identified as Being Production Technicians on the W28 Program* (based on the urinalyses taken after the W28 incident), is a reasonable basis for a bounding estimate of potential exposures to claimants. The W28 units had the highest potential for exposure based on information received during interviews with former Pantex workers and documentation from the SRDB (Personal Communication, 2011a; Personal Communication, 2011b).

The bases for this position are:

1. The W28 weapon was the weapon system with the largest potential uranium exposure for workers at Pantex.

2. The large-scale dismantlement of the W28 weapon during the 1984-1989 time period presents greater exposure potential to workers than earlier assembly operations or disassemblies for the Stockpile Surveillance Program or modification.

3. Because the above exposures resulted from the highest potential uranium exposure operations at Pantex, the exposure rate for this period is a bounding estimate for the exposure rates to workers at Pantex from 1984 to 1989.

The reasons for concluding that the W28 weapon represented the largest potential uranium exposure to Pantex workers are listed below.

- The U metal was not alloyed in the W28 unit; uranium metal associated with W28 had a much greater potential for corrosion than the material from weapons with a uranium alloy material.

- Corrosion was time-dependent; therefore, internal exposure potential was a greater issue during disassembly, not during assembly when the components were new.

- The "28" warhead weapons were stored in various temperature and humidity conditions throughout the world until returned for disassembly, including conditions known to result in greater corrosion.

- Mason & Hanger identified the "28" program as one in which uranium oxide problems were anticipated (others included the W43, W50, W53, W55, W56, W69, and B83 programs) (Incident Report, 1990).

- Mason & Hanger workers disassembled W28 units during period of 1984-1989 (Incident, 1989; Monitoring Results, 1989-1990).

- The W28 had one of the largest depleted uranium surface areas of all the various weapons; hence, more metal was exposed to potentially-corrosive environments.
- The W28 weapons were returned for disassembly after many years in the stockpile or storage (approaching 30 years) which tends to maximize corrosion.

Conclusions

Although the personnel exposure consequences were relatively minor, the 1989 W28 incident became a notable event, ultimately being classified as an unusual occurrence based upon employee concerns. When asked about assembly and disassembly of other weapon systems (i.e., W55, W56), no other contamination event or uranium uptakes stood out compared to the W28 event occurring in February 1989 (Personal Communication, 2011a; Personal Communication, 2011b). Consequently, for this reason and those discussed above, the potential exposure from W28 disassembly represents a bounding assessment of uranium exposures to Pantex workers. The analysis of data from that event and from air sampling data over a period of many years indicates that the potential calculated intakes are less than the intakes based on bioassay data recommended by the Pantex Site Profile (ORAUT-TKBS-0013-5).

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