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National Institute for Occupational Safety and Health

PANTEX PLANT SITE PROFILE ISSUES AND RESOLUTION

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ABBREVIATIONS AND ACRONYMS

Board or ABRWH	Advisory Board on Radiation and Worker Health
AEC	Atomic Energy Commission
Am	americium
CFR	*Code of Federal Regulations*
cm	centimeter
Co	cobalt
Cs	cesium
DAC	derived air concentration
DOE	U.S. Department of Energy
DOELAP	Department of Energy Laboratory Accreditation Program
DU	depleted uranium
ER	evaluation report
ERDA	Energy Research and Development Administration
HE	high explosive
HERS	Historical Exposure Records System
Hp10	deep dose
hr	hour
IAAP	Iowa Army Ammunition Plant
ICRP	International Commission on Radiological Protection
keV	kiloelectron volt
m	meter
MCNP	Monte Carlo N-particle
MDA	minimum detectable activity
mR	milliroentgen
mrem	millirem
NIOSH	National Institute for Occupational Safety and Health
n/p	neutron-to-photon ratio
NTA	nuclear track emulsion, type A (film)
ORAUT	Oak Ridge Associated Universities Team
OTIB	ORAUT technical information bulletin

pCi	picocurie
SEC	Special Exposure Cohort
SRDB	Site Research Database
TBD	technical basis document
TEDE	total effective dose equivalent
TLD	thermoluminescent dosimeter
WG	Work Group
Z	atomic number

1 INTRODUCTION

This report lists the site profile issues, and the resolution of those issues, for the Pantex Plant (replacing Revision 4 of the Pantex issues matrix, September 2014 [SC&A 2014][1]). It reflects deliberations conducted at the Work Group (WG) meeting held on August 4, 2016 (ABRWH 2016), and SC&A's review of revised Pantex site profile technical basis documents (TBDs) (SC&A 2017). The Pantex WG has resolved and closed all Pantex site profile issues.

2 ISSUES AND RESOLUTIONS

2.1 Issue 1: Adequacy of Internal Dose Records

2.1.1 SC&A's Understanding of the NIOSH Evaluation Report Position

- During essentially all years under evaluation, there was no Pantex bioassay program for uranium, thorium, or plutonium that would be considered "routine." Instead, bioassay was performed for specific events and for known or suspected exposure incidents.
- According to both procedures and interviewed employees, evidence of potential exposures was always followed by additional area monitoring/media sampling (as appropriate), and also included personnel bioassay monitoring (if deemed necessary).
- The routine bioassay program for radionuclides other than tritium was short-lived, occurring mostly in 1991 and 1992. Research did not reveal the level of air concentrations or other workplace indicators that triggered special bioassays before 1991.
- Except for a single measurement made for plutonium-239 and americium-241 (Am-241) at the Los Alamos Scientific Laboratory in 1978, no records of in-vivo measurements made within the 1951 through 1991 evaluation period are available.
- More than 200 personnel working on a disassembly program were monitored by the Helgeson in-vivo counter in 1989; however, the results of the in-vivo counts were later determined to contain a positive bias and were deemed not credible (Helgeson 1989).
- While the quantity of Pantex internal data collected during the proposed class time is relatively low, it is consistent with the internal exposure potential associated with work conducted at the Pantex Plant (OTIB-TKBS-0013-5, Revision 01, *Pantex Plant – Occupational Internal Dose* [NIOSH 2007a, page 35]).
- Data available for estimating internal doses due to potential uranium, plutonium, and thorium exposures are predominantly from sampling/analyses performed in 1989 or later (NIOSH 2007a, page 36).
- Hardcopy air monitoring results applicable to specific activities have been documented and are available to the National Institute for Occupational Safety and Health (NIOSH) (see Attachment One of the petition evaluation report (ER), *SEC Petition Evaluation Report Petition SEC-00068*, Revision 0 [NIOSH 2008]).

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[1] The Pantex issues matrix table had become too large to be compliant with Section 508 of the Workforce Rehabilitation Act of 1973. We have converted this final issues summary into report format to ensure Section 508-compliant public access per CDC requirements.

- Based on the available data and the reevaluation of the hundreds of documents in the Site Research Database (SRDB) related to Pantex, specifically in the area of internal dose, NIOSH concludes that the methods described in ORAUT-TKBS-0013-5, Revision 01 (NIOSH 2007a), provide reasonable approaches to conservatively bound doses for all members of the class under evaluation. New information revealed since Revision 01 to ORAUT-TKBS-0013-5 was issued confirms that internal dose assessment was performed on an appropriate, as-needed basis. As proven based on the available program documentation, the Pantex Plant operations were performed under strict radiological cleanliness controls, and the plant continually performed workplace monitoring to determine whether contaminated weapons were brought on site or in the case of an inadvertent release of radioactive materials.

2.1.2 SC&A Initial Review

1) Although radioactive material has been present at the site since 1952, the bioassay program was limited to incident-based sampling for a majority of the Pantex operating period in question. Limited routine monitoring for tritium was initiated in 1976, although there were a few samples prior to that time. Thorium and plutonium bioassay began to a minimal extent in 1991 and 1992, respectively. No routine internal monitoring data exist for worker intakes prior to 1991, and only intermittent data exist for some isolated incidents before then (with no documented trigger level for monitoring). Operations, work practices, and the potential for intakes changed over the 40 years in question (1951–1991), making back extrapolation or bounding approaches problematic. NIOSH has not demonstrated equivalency for use of more current data for the extrapolation back through time.

2) The ER's (NIOSH 2008) reliance on assumed compliance with past procedures and employee recollections is not a sufficient basis to assume positive uptakes were caught. The understood "cleanliness" of the materials and work performed do not provide an acceptable basis for overriding the wide gaps in bioassay records. The application of generalized bounding doses drawn from disparate documents that are not necessarily specific to either time or place, and post-date the exposure era in question, is neither technically coherent nor sufficiently accurate.

3) Pantex did not have a lung-counting capability for in-vivo measurements of plutonium, americium, or uranium in the lungs of workers. There is no mention of a routine fecal monitoring program. Some consideration needs to be given to the inherent difficulties with determining potential acute and chronic exposures of insoluble plutonium, americium, uranium, and thorium. In addition, the Tiger Team assessment indicates that prior to 1989, the plant was not conducting baseline bioassay sampling (DOE 1990).

4) Few air-sampling records are available for key areas, such as the explosive cell, and gaps exist in the data for 1959–1963, 1973, 1978, and 1988–1991. Lapel air sampling is available for only 1989 and 1991. High-volume air sampling is also available for some years. There are also air-sampling data for the burning grounds and firing sites for a limited number of years. Many of the sources cited in the ER (NIOSH 2008) are used across many years. The preponderance of data is from general area air sampling, which may not be representative of the workers' breathing zone. When using air-sampling data, the ER recommends applying a factor of 10 (in the case of plutonium) for the upper limit of the triangular distribution to

account for the possibility that the air-sampling system is not representative of the workers' breathing zone. There is no information on placement of air monitoring equipment in relation to the source term and the employees. An assumed bounding factor of 10 may be too low for such an adjustment. Further analysis of the air-monitoring program is necessary to determine its appropriateness for use.

2.1.3 SC&A Reading of Highlights of NIOSH Response (February 25, 2010, and March 10, 2011, Responses)

The Prologue statement (NIOSH 2010) emphasized how "basic characteristics of the Pantex mission and operations," "national security assurance requirements" (e.g., "diamond stamped" quality assurance), and "comprehensive radiation safety programs" provided "compelling evidence" sufficient to justify its conclusion that "exposure potential during the early periods of Pantex were essentially nil, and/or can be adequately bounded for claimant favorability." Mere "presence of radioactive material at the site" does not in and of itself define a credible internal intake potential. There is ample evidence of a comprehensive radiation safety program. Most hazardous radioactive materials are contained in sealed vessels, welded barriers, cladding, etc. High degree of "cleanliness," housekeeping, and order were assured in the weapons assembly and storage areas. Records provide an extensive listing of "incidents," and the internal dosimetry data and evaluations are in the claimant dosimetry files and the NIOSH records repository. Low internal intake potential was particularly evident during early years of operations.

2.1.4 SC&A Response (April 2010 Issues Update Response; Supplemented by May 4, 2010, and May 3, 2011, WG responses)

SC&A submitted its draft assessment of *Data Completeness and Adequacy for the Pantex Plant* (SC&A 2011a), which addresses the adequacy of internal dose records. In its April 2010 update and at both Work Group meetings, SC&A challenged NIOSH's reliance on "descriptive memos," a presumed "comprehensive radiation protection program," and so-called "strict requirements" of the nuclear weapons program as a basis for characterizing exposure potential, as opposed to actual and demonstrable monitoring or field data of any kind. SC&A pointed out that it finds such reliance inconsistent with the interpretation of 42 CFR 82.17 provided by NIOSH at the Advisory Board's November 2010 meeting; i.e., that "it is incumbent on NIOSH to quantitatively evaluate exposures associated with known source terms." At the May 3, 2011, WG meeting, SC&A likewise challenged NIOSH's statements in its prologue position, noting that program quality and assurance provides no "compelling evidence" of little early exposure potential for depleted uranium (DU) and thorium, that "diamond stamp" is merely an overall quality assurance program, and that many outside audits of Pantex have shown the lack of a comprehensive radiation protection program going back to at least 1980. SC&A recommended to the WG that it judge dose reconstructability not on subjective program assumptions or health physics professional perspectives, but on the objective merits of whether the available quantitative data are sufficient and adequate to support dose reconstruction with sufficient accuracy for all the workers and years defined by the petition class.

2.1.5 SC&A Status Update (October 8, 2013)

Based on discussions and agreement by the WG at its June 18, 2013, meeting, this issue was **closed**. Closure reflects that there were no Special Exposure Cohort (SEC)-level issues with the adequacy and completeness of bioassay data outside of uranium and thorium issues, which were dispositioned as part of the Board's SEC recommendation at its full meeting on July 17, 2013. However, site profile issues remain to be resolved, as identified in SC&A's *Data Completeness and Adequacy for the Pantex Plant* (SC&A 2011a).

2.2 Issue 2: Internal Dose Models for the Assignment of Internal Dose from Uranium

2.2.1 SC&A's Understanding of the NIOSH ER Position

- The only nuclear component involved at Pantex prior to 1957 was DU. Because DU components were new at the time of assembly, there was minimal potential for DU oxide contamination (NIOSH 2007a, page 22).
- All of the unsealed uranium used at the Pantex facility was either DU or natural uranium. Enriched uranium was always associated with a sealed component with little likelihood of release and, therefore, not considered a significant potential exposure source for the proposed worker class evaluated (NIOSH 2007a, page 22).
- Some DU was also released at the hydrotest firing sites when hydroshots involved DU (NIOSH 2007a, page 23).
- No bioassay data were found for Pantex workers involved in the burning of DU-contaminated high explosives and hydroshots; however, the doses can be adequately bounded by doses calculated from air-sampling data (NIOSH 2007a, page 39).
- The DU intake data related to the contamination incident in February 1989 can be used for bounding the potential uranium doses for assembly/disassembly workers. Isotopic determination of uranium alpha activity in urine samples is available, and the data set contains sufficient data to perform statistical analysis (NIOSH 2007a, page 39).
- Internal doses are calculated based on methods outlined in ORAUT-TKBS-0013-5 (NIOSH 2007a, pages 41–42).

2.2.2 SC&A Initial Review

1) The ER (NIOSH 2008) uses unsupported assumptions for modeling DU exposures and makes inappropriate use of the air-sampling detection limit for assigning uranium worker exposures. The internal DU proposed model for unmonitored workers (1980–1993) may be inappropriate and not claimant favorable. Given that bioassay data at Pantex are very limited and have been event-driven since 1993, NIOSH elected to use a worker bioassay dataset that was derived from a radiological incident in February 1989. The ER and TBDs provide no confirmatory information that characterizes the "1989 contamination incident" in terms of verifying that the 305 assessed workers in fact represent assemblers/disassemblers, radiation safety technicians, and quality assurance personnel who, moreover, were employed for a full 10-year period, as assumed in the model. SC&A questions the basis of the assumption that

unmonitored workers over Pantex's operating history were no different from the 305 workers monitored in 1989.

2) Significant quantities of enriched uranium were handled at Pantex. The ER (NIOSH 2008) recognizes that plutonium was handled in a sealed form and assigns a potential missed dose from plutonium. Enriched uranium presents the same potential for exposure, yet the ER has not addressed potential missed dose from this source.

3) ORAUT-TKBS-0013-5 contains unexplained and implausibly extreme changes in sensitivity values for uranium urinalysis and minimum detectable activity (MDA), as well as significant data gaps. ORAUT-TKBS-0013-5 (NIOSH 2007a) shows an apparent improvement in sensitivity values of two orders of magnitude between 1960 and 1963, which then diminishes by a factor of 50 between 1968 and 1978. Gaps also appear in the data with no historical information on sensitivity from 1968–1978, 1978–1983, and 1983–1990. With these inherent uncertainties and wide variations in values, SC&A does not believe the ER (NIOSH 2008) or ORAUT-TKBS-0013-5 provides a technically valid basis for applying uranium bioassay analysis data to coworker applications and intake calculations spanning these gaps and years.

2.2.3 SC&A Reading of Highlights of NIOSH Response (February 25, 2010, and March 10, 2011, Responses)

NIOSH can back-extrapolate bioassay data collected following the 1989 B-28 disassembly incident, because it is the "most robust set" of uranium urinalysis data, which generated a "bounding quantity of depleted uranium oxide contamination from weapons disassembly." It is noted that this operation had occurred in the late 1980s prior to the complex-wide implementation of 10 CFR Part 835, and "hence, the bioassay data collected from this bounding contamination exposure potential scenario (due to workplace practices, operations, and engineering controls) can be applied to the earlier times as a very conservative, claimant-favorable, scientifically validated default." There are also some "4300+ air sample results from several decades of plant experience, as well as uranium urinalysis sampling beginning in the late 1950s to validate the claimant favorability of the overestimation."

2.2.4 SC&A Response (April 2010 Issues Update Response; Supplemented by May 4, 2010, and May 3, 2011, WG Responses)

SC&A agreed at the May 3, 2011, WG meeting to provide a "real-time" response to this issue to expedite resolution on behalf of the WG. However, at this meeting, SC&A noted that there were previous weapons disassemblies that involved evident DU contamination for which fewer or no samples were taken, but that may have involved even greater contamination levels based on recently identified data. If the cited 4,300+ air samples were, in fact, credible and useful, it would seem that NIOSH would have already applied them for dose reconstruction purposes or for direct corroboration of its position. However, the vast majority of these samples were apparently not taken for dosimetry purposes and were not, in any case, positioned to ensure representative breathing zone sampling. The same problem holds for the older uranium urinalysis samples; if there were enough of them to be statistically reliable, they would be cited as a "quantitative basis" for back extrapolation of the 1989 data. SC&A concludes that there is no corroboration of NIOSH's contention that its back-extrapolation of DU oxide exposure is bounding of all workers previously exposed.

2.2.5 SC&A Status Update (October 8, 2013)

Based on discussions and agreement by the WG at its June 18, 2013, meeting, this issue was **closed**. Closure reflects that the issue of internal dose models for uranium was resolved with NIOSH at the WG meeting prior to the full Board's action on the SEC at its July 17, 2013, meeting.

2.3 Issue 3: Dose Estimate Approach for Plutonium

2.3.1 SC&A's Understanding of the NIOSH ER Position

- Bounding doses from plutonium can be calculated for Pantex employees.

    1) For the period from 1958 (the year that plutonium was introduced to Pantex) to 1991 (except 1961, as discussed below), air-sample levels that would have triggered bioassay are not known. However, fewer disassemblies occurred, and the plutonium was newer, meaning that there was less potential for oxidation and, therefore, personnel exposures to plutonium. Assemblies would have involved newly sealed plutonium metal. Consequently, the possibility of intakes and the severity of intakes would have been less. However, because the documentation of the number of disassemblies and the contamination levels are not available, unmonitored workers may be assigned an intake that is the same as the intake from the 1991–2000 period. (This excludes workers involved in the 1961 Cell Incident, which have a separate bounding dose.)

    2) Because intakes were rare for the period 1991 to 2000 (1991 for the evaluated class), the criterion for investigation of possible acute intake (including obtaining special bioassay) can be used to support establishing bounding intake estimates for the proposed worker class evaluated in this report. During this period, when the number of disassemblies was highest and the plutonium was oldest, the criterion for investigation was any workplace indicator, indicating that an intake of 40 derived air concentration (DAC)-hours (290 picocuries [pCi]) might have occurred. These intakes can be assigned to the workers with the highest exposure potential as the mode of a triangular distribution with a minimum of 0 and a maximum of 10 times the mode. The factor of 10 for the upper limit of the distribution is set to account for the possibility of more than one intake per year and the possibility that the air-sampling system is not representative. The bounding intake for the period from 1991 through 2000, therefore, is 400 DAC-hours (2,900 pCi acute intake) per year of employment for high-risk tasks.

- Plutonium at Pantex was in the form of encapsulated pits of nuclear weapons. Strict workplace monitoring practices, including smears for contamination, were completed during assembly and disassembly to ensure the integrity of the encapsulation (NIOSH 2007a, page 23).

- Internal doses are calculated based on methods outlined in ORAUT-TKBS-0013-5, Revision 01 (NIOSH 2007a).

2.3.2 SC&A Initial Review

The ER (NIOSH 2008) assumes a single acute exposure of 40 DAC-hours per year, based on the investigation criteria for the period 1991 to 2000, and applies the internal dose methodology for plutonium outlined in ORAUT-TKBS-0013-5, Revision 01. Intakes of 290 pCi are assigned to the workers with the highest potential as the mode of a triangular distribution with a minimum of 0 and a maximum of 10 times the mode. The 40 DAC-hour per year intake assumes that workplace monitoring, in the absence of adequate personal monitoring, was representative of the exposure conditions to the worker without providing a basis for this assumption. The use of the 40 DAC-hour annual exposure recommended by the ER, which equates to 100 millirem (mrem) total effective dose equivalent (TEDE), may not have been detectable and is not supported by the U.S. Department of Energy (DOE) findings and investigation report (DOE 2001), even for workers as late as 2000, with all the latest sensitivities and air monitoring capabilities taken into consideration. For workers that had, in fact, been monitored based on the 40 DAC-hour criterion (but for whom no records exist), the assigned value of 40 DAC-hours may only represent a lower bound or threshold value. The ER and supporting documents have not demonstrated that this approach bounds the thorium dose.

2.3.3 SC&A Reading of Highlights of NIOSH Response (February 25, 2010, and March 10, 2011, Responses)

NIOSH refers to its Prologue (NIOSH 2010) statements regarding program assurance and reliability. It also notes that the design of, and interest in, the integrity of sealed pits would have raised concerns if any uncontained plutonium would have occurred in their handling. A suggested use of a factor of 10 is applied to an air-sampling assumption of 40 DAC-hours, for a default assignment of 400 DAC-hours intake for routine unmonitored exposures.

2.3.4 SC&A Response (April 2010 Issues Update Response; Supplemented by May 4, 2010, and May 3, 2011, WG Responses)

Pending a final data capture being scheduled at Pantex by June 2011, SC&A recommends that this issue be closed. While SC&A still questions the methodology for the reasons stated, this issue appears to be moot, given the lack of any historic evidence that routine plutonium internal exposures occurred due to lack of integrity of components handled.

2.3.5 SC&A Status Update (October 8, 2013)

Pursuant to SC&A's 2010 recommendation, and based on additional discussion at its June 18, 2013, meeting, the Work Group **closed** this issue.

2.4 Issue 4: Dose Estimate Approach for Thorium

2.4.1 SC&A's Understanding of the NIOSH ER Position

- Workers handled thorium compounds during assembly and disassembly of certain weapons. Pantex used strict workplace monitoring practices, including smears for contamination on components to verify the encapsulation of the thorium (NIOSH 2007a, page 24).

- It is assumed that workers could have encountered oxidized thorium components during disassembly of weapons in the mid-1960s (NOISH 2007a, page 24).

- Bounding doses from thorium can be evaluated for Pantex employees (NIOSH 2007a, page 40).

- From 1980 to the present, the methods for assigning intakes of thorium are the same as for plutonium because of similar workplace conditions. Specifically, there were fewer disassemblies containing thorium; thus, the plutonium methods are claimant favorable for thorium-232. For workers who had the highest possibility of intake for each year from 1980 to 1991, a single acute intake of 40 DAC-hours (48 pCi) of thorium-232 (in equilibrium with progeny) was assumed. For Category 2 workers in Table 5-2 of ORAUT-TKBS-0013-5 (NIOSH 2007a), 0.1 times the intake was assigned. These intakes are modes of triangular distributions with a minimum of 0 and a maximum of 10 times the mode to account for the possibility of more than one intake per year and the possibility that the air-sampling system is not representative (NIOSH 2007a).

- The ER (NIOSH 2008) proposes a methodology for assessing a bounding dose for thorium using uranium data for time periods before 1980. Because DU contamination and thorium contamination would have been in the oxide form and behaved similarly in the workplace on a mass basis, it was assumed that the bounding intakes for inhalation of Type S and insoluble ingestion of thorium were the same as the bounding intakes for DU on a mass basis (NIOSH 2007a, page 44).

- Internal doses are calculated based on methods outlined in ORAUT-TKBS-0013-5 (NIOSH 2007a).

2.4.2 SC&A Initial Review

1) NIOSH has not provided evidence of workplace monitoring practices verifying the encapsulation of thorium. Furthermore, it is indicated that workers could have encountered oxidized thorium. Workers have, in fact, confirmed the existence of oxidized metal in thorium-bearing weapons.

2) For thorium, the assumption of an acute uptake in unmonitored thorium workers during disassembly is inconsistent with the argument for chronic exposure to DU for workers during disassembly, given documented incidents of thorium contamination problems as early as the 1960s, although the exposure conditions for both types of workers are similar.

3) For the era prior to 1980, the ER (NIOSH 2008) recommends a bounding uptake the same as the bounding intakes for DU on a mass basis (i.e., 5.2 pCi/day). The basis for this is the similar behavior of thorium and uranium in the workplace. There has been no consideration of the relative quantity of materials in these assumptions. The ER and supporting documents have not demonstrated that this approach bounds the thorium dose.

4) From 1980 to the present, the same intake (40 DAC-hours) is assigned for thorium-232. The 40 DAC-hour per year intake assumes that workplace monitoring, in the absence of adequate personal monitoring, was representative of the exposure conditions to the worker without

providing a basis for this assumption. The use of the 40 DAC-hour annual exposure recommended by the ER (NIOSH 2008), which equates to 100 mrem TEDE, may not have been detectable. For workers that had, in fact, been monitored based on the 40 DAC-hour criterion (but for whom no records exist), the assigned value of 40 DAC-hours may only represent a lower bound or threshold value. The ER and supporting documents have not demonstrated that this approach bounds the thorium dose.

2.4.3 SC&A Reading of Highlights of NIOSH Response (February 25, 2010, and March 10, 2011, Responses)

NIOSH's ER (NIOSH 2008) acknowledges the limited amount of bioassay data available for thorium. Thorium dose for Category I workers is assigned based on a triangular distribution, with the minimum set at 0, the mode at 48 pCi, and the maximum at 480 pCi, with the modes corresponding to 40 DAC-hours (with the maximum being set at 10 times the mode to account for possibility of more than one intake per year and the non-representativeness of air sampling). Bioassay data and lapel sample results from the 1990s can be used to bound historical exposures, given that the source term was "cleaner and lower" in the earlier days (due to fewer disassemblies and less time since fabrication), and because engineering controls were largely unchanged. A conservative upper-bound estimate for an oxidized uranium source term potentially found during disassembly would be 300 grams; for thorium, an upper bound for the source term mass would be an order of magnitude lower (30 grams). NIOSH notes that "ONLY 3–5%" of the filters analyzed contain thorium particulates; in these cases, 95% of the isotopic particulate matter on the filters is uranium. For the specific case of W55 disassembly, "worst case equivalent dose" resulting from acute and chronic intakes for those involved in that disassembly showed that uranium, not thorium, was the radionuclide of concern. Thorium fecal, urine, and lung counts exist for about 25 employees.

2.4.4 SC&A Response (April 2010 Issues Update Response; Supplemented by May 4, 2010, and May 3, 2011, WG Responses)

SC&A agreed at the May 3, 2011, WG meeting to provide a "real-time" response to this issue (in conjunction with DU) to expedite resolution on behalf of the WG. As noted in SC&A's *Data Completeness and Adequacy for the Pantex Plant* (SC&A 2011a), the largest gaps in incident-based bioassay data exist for thorium exposures. There were no thorium bioassay data available for the evaluated population during the SEC period. There were some personnel identified who encountered thorium oxide when working with thorium-containing systems, and there were workers identified as working with such systems on the Employee Health Physics Checklist for the plant. The NIOSH assumption regarding episodic or acute uptake in unmonitored thorium workers during disassembly is not consistent with the known work being performed. No quantitative basis is provided by NIOSH, as required by 42 CFR 82.17, to corroborate its contention that its approach is bounding of thorium dose for all workers exposed during disassembly operations.

2.4.5 SC&A Status Update (October 8, 2013)

Based on discussions and agreement by the WG at its June 18, 2013, meeting, this issue was **closed**. Closure reflects that the issue of an internal dose approach for thorium was resolved with NIOSH and the WG prior to the full Board's action on the SEC at its July 17, 2013, meeting.

2.5 Issue 5: The Internal Dose Approach for Metal Tritides

2.5.1 SC&A's Understanding of the NIOSH ER Position

- Tritides were formed as a result of tritium gas reacting with metal components of weapons and producing tritiated compounds. In addition, tritium compounds were used in some weapons programs (NIOSH 2007a, page 23).

- A Cockcroft Walton neutron generator also produced some tritium in the off-gas, and tritium particulate contamination existed in the target and the area where the target connected (NIOSH 2007a, page 23).

- The assessment of metal tritides revealed that the doses would not impact the bounding dose established for tritium in ORAUT-TKBS-0013-5 (NIOSH 2007a) and the ER (NIOSH 2008, page 42).

2.5.2 SC&A Initial Review

In interviews conducted by SC&A and backed by documents reviewed, some of the Pantex workers recognized that tritides were present in some of the operations. *Metal Tritides Technical Basis Document*, RSD-TBD-0036, Issue A (Jones and Levell 2004), addressed some of the concerns and issues regarding tritides and the disassembly program types that may have metal tritides present. Elemental tritium and tritiated water interact with metals and organics over time, producing special tritium compounds. In addition, processes at Pantex exposed workers directly to metal tritides. The ER (NIOSH 2008) indicates that metal tritides would not impact the bounding dose for tritium because they constitute such a small percentage of tritium in the workplace. However, no formal evaluation is apparent in the ER of the types of tritium compounds present and their relative concentrations. Compounds such as metal tritides and other insoluble forms of tritium would be expected to have substantially longer residence times in the body and, therefore, provide a higher dose than what is assumed for elemental tritium or tritiated water. Bioassay techniques typically implemented for soluble compounds of tritium do not work for insoluble compounds, such as some metal tritides handled at Pantex.

2.5.3 SC&A Reading of Highlights of NIOSH Response (February 25, 2010, and March 10, 2011, Responses)

Tritium is contained in sealed reservoirs, whose stainless steel composition mitigates against corrosion effects. Fabrication and application of tritides did not take place at Pantex. The only potential exposure pathway existed with "boom box" operations, for which exposure may have occurred during the removal of the debris from the firing tube and during cleaning of the boom box. An upper-bound estimate was calculated based on an assumed upper-bound intake rate, a maximum contamination level in the box, and use of titanium tritide (absorption Type M) as a source term to calculate a 50-year committed lung equivalent dose of 0.0691 mrem, which would equate to about 1 mrem, assuming 15 cleanouts.

2.5.4 SC&A Response (April 2010 Issues Update Response; Supplemented by May 4, 2010, and May 3, 2011, WG Responses)

Pending a final data capture being scheduled at Pantex by June 2011 to ascertain actual compounds in use, SC&A recommends that this issue be closed. While information is lacking regarding actual compounds handled and to what extent diffusion issues may have figured at Pantex, SC&A has found no documented evidence of exposure pathways of significance from a dose standpoint.

2.5.5 SC&A Status Update (October 8, 2013)

Pursuant to SC&A's 2010 recommendation, and based on additional discussion at its June 18, 2013, meeting, the WG **closed** this issue. No further information was found in its data capture to indicate that tritides were implicated with the issue of tritium permeation of reservoirs at Pantex.

2.6 Issue 6: Interpretation of External Dosimetry Data

2.6.1 SC&A's Understanding of the NIOSH ER Position

- The nature of the radiation fields a worker could have encountered depends on the type of facility in which the work occurred. Nuclear weapons components emit alpha, beta, x-ray, gamma rays, and neutrons; however, dose to workers depends strongly on the configuration (i.e., material and shielding) of the source radiation and work performed (NIOSH 2007a, page 24).

- Industrial radiography operations had the potential to expose some workers to x-ray, gamma, and neutron radiation (NIOSH 2007a, page 24).

- Am-241 was an increasingly significant source of exposure to workers performing weapons disassembly, which often occurred many years after assembly (NIOSH 2007a, page 25).

2.6.2 SC&A Initial Review

1) Early recorded deep dose (Hp10) may not be reliable. It is clear that for proper assessment of a film dosimeter, calibration curves must be used that resemble photon energies of the work environment. The dominant photon energy for Pantex workers was the 60 kiloelectron volt (keV) photon associated with Am-241, which is a factor of 10 lower than the calibration photon energy for cobalt-60 (Co-60) and/or cesium-137 (Cs-137), which had been used historically at the plant. The use of Cs-137 or Co-60 as the calibration source for the dominant workplace photon energy of 60 keV would lead to an **over-response for the open window** (as a result of photographic film containing silver bromide with Z values of 47 and 35, respectively) and an **under-response for the deep dose**, which is subject to the attenuation effects of 1,000 milligrams per centimeter squared (or 0.88 millimeters) of lead, which has a Z value of 82.

2) Calibration and dosimeter processing methods by outside contractor services cannot be assumed without further information. Three contractor services were used between 1952 and 1973 for processing film dosimeters. While the competency of these vendors is not questioned, it is without basis to assume without further information that each would have used the proper calibration curves that matched the expected photon energies of the Pantex work environments. Given the variability of photon energies to which workers may have been exposed and the highly classified nature of the Pantex operations, it is reasonable to question whether vendor dosimeter services can be expected to have known which calibration curves to apply to individual Pantex dosimeters.

3) Exposures from skin contamination were possible with weapons programs involving oxidized metal. External exposure from this route should be considered for skin cancers. The current methodology of assigning whole-body penetrating dose in situations where nonpenetrating dose is unavailable may underestimate the dose, particularly in situations where uranium is involved.

4) Derived estimates of the photon and neutron dose for unmonitored workers are likely to be too low. Pantex worker photon dose statistics, as defined in the ER (NIOSH 2008) and ORAUT-TKBS-0013-6, *Pantex Plant – Occupational External Dose*, Revision 01 (NIOSH 2007b), are based solely on dosimeter records for monitored workers whose photon dose was equal to or greater than 30 mrem per monitoring period. For the 10-year period of 1952–1962, dosimeters were exchanged weekly, which may explain the fact that for the period 1952–1958, all Pantex recorded doses (for monitored workers) were less than 30 mrem. Thus, on the basis of these statistics and guidance, all unmonitored workers would also not be assigned any photon or neutron doses for the years 1952–1958. For years 1959 to the present, the exclusion of missed photon doses for deriving the median dose of monitored workers will also impact the estimated dose for unmonitored workers. SC&A does not consider the current guidance for dose reconstruction of unmonitored workers claimant favorable. For deriving photon and neutron doses for unmonitored workers, missed photon doses for monitored workers should be included.

2.6.3 SC&A Reading of Highlights of NIOSH Response (February 25, 2010, and March 10, 2011, Responses)

SC&A's 2008 site profile review made a series of findings regarding the reliability of early recorded deep dose (Hp10), how calibration and dosimeter processing were performed by outside vendors, how the current dose estimation methodology assigned exposures from skin contamination, and how missed photon doses for monitored workers should be reflected in the derivation of photon and neutron doses for unmonitored workers. It was agreed that the site profile review lays out these concerns in detail, including the implications of a 1980 DOE investigation report (DOE 1980) that cited deficiencies in how the dosimetry program was administered and with the credentials of the Pantex personnel responsible for that program. The WG agreed that NIOSH's response during the May 4, 2010, meeting suggested that these concerns were not likely of SEC significance; however, NIOSH agreed to clarify its dose estimation approach keying on the SC&A site profile review findings. The WG also tasked SC&A with evaluating the adequacy and completeness of the external and internal dose records being used for dose reconstruction for Pantex.

2.6.4 SC&A Response (April 2010 Issues Update Response; Supplemented by May 4, 2010, and May 3, 2011, WG Responses)

SC&A noted during the May 2, 2011, WG meeting that while these were site profile issues in nature, some of them involved incorrect adjustment factors or values that would affect the accuracy of dose estimates if used as stated. NIOSH agreed to review the external dose findings from SC&A's site profile review in that context. With respect to adequacy and completeness, SC&A has submitted *Data Completeness and Adequacy for the Pantex Plant* (SC&A 2011a).

2.6.5 SC&A Status Update (October 8, 2013)

Discussion at the WG's June 18, 2013, meeting clarified that NIOSH provided a response (in NIOSH 2011) to SC&A's *Data Completeness and Adequacy for the Pantex Plant* (SC&A 2011a) white paper that addressed a number of the key issues involved. These issues are also addressed in other matrix items for which responses have been provided or will be forthcoming (e.g., Items 7, 12, and 16). One issue remains to be clarified based on NIOSH's white paper response: For 1976 onward, how would dose reconstructors interpret "zero" entries when these may represent blanks, which could have been either actual zero dose monitored or reflect lack of monitoring? In both cases, "missed dose" would presumably be applied; for the latter case (lack of monitoring), this assignment would be less than that provided by a coworker dose assignment.

2.6.6 SC&A Status Update (September 4, 2014)

NIOSH agrees that it needs to clarify how "zero" entries will be interpreted for 1976 onward. A note or memo providing this clarification will be provided to the WG within 6 weeks, with subsequent revision of the ORAUT-TKBS-0013-6. Pending this resolution, this issue is held **in abeyance**.

2.6.7 Pantex Work Group Meeting, August 4, 2016

NIOSH provided clarification of this issue during the August 4, 2016, Pantex WG meeting (ABRWH 2016, pages 6–14). NIOSH clarified the issue by verifying that zeros were recorded only if a person was monitored and the results were read and found to be zero or the readings were less than the lower limits of detection. In addition, NIOSH stated that the use of 1988 as the year all personnel at Pantex were monitored for external exposures was incorrect in the issues matrix and that the year 1989 is correct, as used in ORAUT-TKBS-0013-6, Revision 03, *Pantex Plant – Occupation External Dose* (NIOSH 2016). SC&A verified that 1989 was the year used in the revised ORAUT-TKBS-0013-6, Revision 03 (e.g., pages 13, 39, etc.). However, SC&A would like to point out that the text on page 5 of ORAUT-OTIB-0086, Revision 00, *Pantex External Coworker Model* (NIOSH 2015a), uses the incorrect wording "In such cases for years before 1988" The phrase "before 1988" should be changed to "before 1989" to refer to a period when all personnel were not monitored for external exposure. This issue was **closed** at the August 4, 2016, Pantex WG meeting.

2.6.8 SC&A's Evaluation January 30, 2017 (SC&A 2017)

Note that this was an issue identified in SC&A's review of ORAUT-OTIB-0086 (SC&A 2015); it did not originate in ORAUT-TKBS-0013-6 but was included in the Pantex matrix. SC&A

recommended closure in the Pantex site profile matrix, and that the use of the year 1988 be changed to 1989 in the next revision of ORAUT-OTIB-0086 (NIOSH 2015a). The issue has been resolved and closed per the August 4, 2016, Pantex WG meeting (ABRWH 2016, pages 6–14).

2.7 Issue 7: Data Do Not Support the Assumption that the 95th Percentile Neutron-to-Photon Ratio Is Bounding for All Exposure Scenarios

2.7.1 SC&A's Understanding of the NIOSH ER Position

The ER (NIOSH 2008, page 26) states the following:

> *The TBD neutron-to-photon ratios are based on worker dosimeter measurements that were recorded using the Panasonic UD-809/UD-812 system and correspond to doses in which both the photon and neutron doses of the individual exceeded 50 mrem per year. From these data, a median neutron-to-photon ratio of 0.8 and a 95th percentile value of 1.7 were calculated. For dose reconstruction of monitored workers, NIOSH recommends the 95th percentile neutron-to-photon ratio of 1.7.*

The ER (NIOSH 2008, pages 47–48) states the following*:*

> *Neutron doses measured at Pantex since this time* [1993] *with this new system are considered reliable for use in this radiological dose reconstruction program, and these measurements provide a basis for using neutron-to-photon dose ratios to permit estimating worker neutron doses for the periods prior to the accreditation. Based on NIOSH's review and evaluation of the weapons systems handled at Pantex, and the assembly of the list that permits comparison across all times associated with this evaluation, NIOSH is able to establish that the neutron-to-photon dose ratios, applied to bounding photon doses, result in calculated neutron doses that are considered bounding across all time periods. The method used to bound neutron doses is addressed in Section 7.3.4.*

Section 7.3.4 of the ER (NIOSH 2008, page 50) states the following:

> *Photon doses (with appropriate corrections for lead apron use and dosimeter response uncertainty) were reliably measured from* ***1994 forward*** *and can be used with a neutron-to-photon dose ratio of 1.7 to calculate neutron doses for the years prior to 1994 (ORAUT-TKBS-0013-6; Strom,* [2004, page 33]*). The average neutron-to-photon dose ratio determined from reliable collective neutron and photon doses measured since 1994 is only 0.25 (see Table 6.1 in ORAUT-TKBS-0013-6). Thus, this method for calculating neutron doses prior to 1994 will result in average neutron doses to workers that are approximately 6.8 times the expected doses, which will be bounding (ORAUT-TKBS-0013-6) for the class evaluated in this report.* [emphasis added]

Typically, there should not be a significant neutron exposure to unmonitored workers. However, for an unmonitored worker with some evidence of potential neutron exposure, neutron doses can be estimated by applying a median neutron-to-photon dose ratio of 0.8, as determined by the log probability analysis of grouped Pantex and neutron dosimeter data, as determined by Strom. This median value, when applied to the assigned photon dose for monitored workers, will yield a bounding neutron dose to unmonitored workers.

The ER (NIOSH 2008, pages 46) states the following:

> *Since first used, the film badges and TLDs assigned at Pantex have been capable of measuring photon exposures in the workplace with sufficient accuracy to permit the calculation of bounding photon exposures. There is strong evidence that workers who had the highest potential for radiation exposure were monitored with state-of-the-art dosimeters (National Bureau of Standards, 1955) and the measured photon doses were reasonably accurate and complete (ORAUT-TKBS-0013-6). Dosimetry records maintained by the Radiation Safety Department have been independently reviewed by the HERS project to verify accuracy and to ensure complete documentation (Rawlston, 1991).*

The ER (NIOSH 2008, page 50) states that an alternate method has been developed for conservatively estimating missed neutron doses. Neutron and gamma dose rates associated with various weapons configurations are available for Los Alamos National Laboratory and Lawrence Livermore National Laboratory-designed nuclear weapons handled at Pantex. Dose rate data for individual weapons have been located at Pantex to cover the weapons configurations encountered during assembly and disassembly operations. The dose rate data, coupled with the exposure times derived from time and motion studies of the nuclear explosive operations, allow the calculation of exposure time-weighted neutron-to-photon dose ratios. Using the neutron-to-photon dose ratios, the missed neutron doses can be estimated based on the measured photon doses and assigned to the personnel performing the nuclear explosive operations. These data allow determination of bounding neutron doses.

2.7.2 SC&A Initial Review

While the recommended neutron-to-photon ratio method may bound some of the Pantex workers' neutron doses, it cannot be assured that it will bound all workers' neutron doses for 1951–1992, because of the following issues:

(a) **Back-extrapolating to previous 42 years not supported.** The neutron-to-photon ratio (n/p) values of 0.8 and 1.7 were obtained from 43 data points taken during the period of 1993–2003. There is no supporting evidence that the operating conditions and radiation fields were sufficiently similar during this period to the previous 42-year period, 1951–1992. Benchmark measurements would have to have been made to establish this relationship. Nuclear track emulsion, type A (NTA) film results cannot be used for this purpose, because they have been deemed unreliable.

(b) **Examples where n/p of 1.7 is not bounding.** There are numerous examples over a significant time period (1960–1995) that indicate that using a neutron-to-photon ratio value of 1.7 would not bound the neutron dose. See **Attachment A** for some examples where the neutron-to-photon ratio values ranged from 2.0 to 13.6, with a geometric mean value of 5.0, when measured during surveys. Additionally, if a worker's recorded NTA film results show a dose greater than that calculated using a neutron-to-photon ratio value of 1.7, it cannot be used, because the correct neutron dose is not known from the NTA film results, which have been deemed unreliable. Dose reconstruction cases have used neutron-to-photon ratio values ranging from 0.25 to 2.5.

(c) **Comparison to collective dose neutron-to-photon ratio value not valid.** The statement that the recommended neutron-to-photon ratio value of 1.7 is 6.8 times the neutron-to-photon ratio value of 0.25 derived from collective doses is not a valid comparison, because much of the collective photon dose was from workers who had only photon doses; hence, the results were diluted by photon doses (see ORAUT-TKBS-0013-6, pages 33 and 56).

(d) **Reliability of recorded photon dose not established.** While SC&A agrees that the systems used to create and store external dose records at Pantex appear to be adequate, we question whether the measured photon doses are sufficiently reliable for use in assigning photon dose and deriving neutron doses, while relying on only one measured parameter—the photon dose. An error in photon dose assignment is magnified by a factor of 2.7 (i.e., 1 photon + 1.7 neutron-to-photon ratio = 2.7 total error). SC&A has identified the following areas of concern, which have been discussed elsewhere in this matrix and are applicable to neutron dose calculations:

- Calibrated using medium- to high-energy photons (Co-60 and Cs-137), but major photon fields were 60 keV.
- Early photon dosimetry under-response, as well as over-response, must be considered.
- Wide range of photon energies present in work areas.
- Three different dosimetry vendors used without access to classified photon energy spectra.
- Pantex ORAUT-TKBS-0013-6 and the SEC ER (NIOSH 2008) state photon dosimetry was correct, while Iowa Army Ammunition Plant (IAAP), for similar operations, states that only 37% of 60 keV dose was measured.
- DOE investigation board findings **are** relevant to the credibility of photon, and hence, neutron dose reconstruction at Pantex.

2.7.3 SC&A Reading of Highlights of NIOSH Response (February 25, 2010, and March 10, 2011, Responses)

The current external dose site profile for Pantex recommends using the following method to assign neutron dose prior to 1994:

- For unmonitored workers who may have had the potential to be exposed to neutrons, multiply the claimant's photon dose by 0.8 (the 50th percentile n/p value) to assign neutron dose.
- For monitored workers, if monitored for neutrons, or had the potential for neutron exposure, multiply the claimant's photon dose by 1.7 (the 95th percentile n/p value) to assign neutron dose.

- For 1994 forward, use the recorded neutron dose with appropriate International Commission on Radiological Protection (ICRP) Publication 60 adjustments.

In response to concerns that while the recommended neutron-to-photon ratio method may bound some of the Pantex workers' neutron doses, it cannot be assumed that it will bound all workers' neutron doses for 1951–1993, NIOSH proposed a new approach that mirrors a similar one proposed by NIOSH in the course of the Mound WG SEC review proceedings. This approach applies measured doses in place of n/p ratios (with corresponding correction factors for NTA film) and Monte Carlo N-particle (MCNP) modeling for missed doses at certain energies for the coworker model.

2.7.4 SC&A Response (April 2010 Issues Update Response; Supplemented by May 4, 2010, and May 3, 2011, WG Responses)

In response to a WG request that SC&A review the new approach to neutron dose estimation, SC&A provided a review that was forwarded to the WG and NIOSH on December 27, 2010 (SC&A 2010). At the May 3, 2011, WG meeting, SC&A also raised the need for NIOSH to demonstrate, in its upcoming response to this SC&A review, how the proposed parameters for MCNP are bounding for the range of systems assembled and disassembled for the period 1951–1991 at Pantex. SC&A will clarify this implication in a memo report, now that its notes have been cleared by DOE.

2.7.5 SC&A Status Update (October 8, 2013)

SC&A provided a memo report on May 18, 2011 (SC&A 2011b), to the WG and NIOSH regarding remaining questions surrounding the application of MCNP in the specific setting of Pantex operations. (No NIOSH response to these questions has been located; at about this time, the WG turned to remaining SEC issues as its priority.) Since then, NIOSH has revisited the neutron monitoring issues and believes it has a "good correction factor for the NTA film period," but that the "early TLD period still was an open question, because the TLD had failed DOELAP testing for neutron exposure" (ABRWH 2013, pages 118–119). NIOSH committed to provide "new" information associated with this most recent analysis to SC&A which, combined with its review of NIOSH 2011, will enable a full response to the WG on remaining questions regarding reconstructing Pantex external dose. This issue remains **open** until pending disposition before the Work Group.

2.7.6 SC&A Status Update (September 4, 2014)

NIOSH originally proposing application of the MCNP model as means to correct for NTA film shortcomings in the pre-1977 period, use of thermoluminescent dosimeter (TLD) data as corrected by the Stanford algorithm for the 1977–1993 period, and use of adequate TLD data after 1994. However, NIOSH has observed some substantial anomalies with recorded n/p ratios, leading to the conclusion that use of a full distribution of measured neutron doses is preferable. In cases where n/p ratios are skewed, application of the skewed ratio produces implausibly high neutron doses. Most of the observed neutron doses at Pantex are relatively low. NIOSH commits to providing a white paper to the WG within 6 weeks, with a subsequent revision of ORAUT-

TKBS-0013-5 once resolution is achieved. Pending this resolution, this issue is held **in abeyance**.

2.7.7 SC&A September 23, 2015

From reviewing the revised ORAUT-TKBS-0013-6 (NIOSH 2016) and the related document ORAUT-OTIB-0086, SC&A found that instead of using the neutron-to-photon method, NIOSH recommends using the recorded neutron dose, with the NTA film results adjusted for energy response, angular response, and track fading. As summarized and detailed in SC&A's review of ORAUT-OTIB-0086 (SC&A 2015), SC&A did not find the neutron adjustment factors to be claimant favorable for Pantex workers.

2.7.8 Pantex Work Group Meeting, August 4, 2016

The sources and justification of the adjustment factors were discussed during the meeting, and the WG recommended **closure** pending SC&A's verification of NIOSH's sources and use of adjustment factors (ABRWH 2016, pages 15–43).

2.7.9 SC&A's Evaluation January 30, 2017 (SC&A 2017)

SC&A performed a study and comparison of the various correction factors and reached the consensus, in view of the information currently available, that an overall modification factor of 2.9 for NTA film is reasonable for the Pantex site. SC&A released a memo with this information to the Pantex WG on October 19, 2016 (SC&A 2016). The issue has been resolved.

2.8 Issue 8: Completeness and Interpretation of Historic Radiological Exposure Sources

2.8.1 SC&A's Understanding of the NIOSH ER Position

1) The primary sources of internal radiation contamination have been depleted uranium oxide and tritium. The primary sources of external radiation exposure include plutonium pits and DU or thorium components (Personal Communication October 1, 2003).

2) The burning grounds were used to burn high explosive (HE) waste, some of which was contaminated with uranium.

    - Data that did not indicate contamination and/or exposures ("negative" data) were often not saved for future reference, particularly in the earliest years of operations (Personal Communication April 8, 2008). This Pantex recordkeeping practice, coupled with the relative cleanliness of the materials and work performed at Pantex, and the site's practice of only collecting bioassay samples when other monitoring/events dictated a need, has resulted in apparent monitoring data gaps for many types of internal monitoring data over the years (NIOSH 2007a, page 29).

    - Exposure records from previous employment at other sites were also collected and incorporated into workers' exposure files, as were exposures while employed at Pantex (NIOSH 2007a, page 35).

2.8.2 SC&A Initial Review

1) There is a need to characterize the types of radiation exposure associated with particular weapons programs or time periods, including the impacts of improvements in development technology. Operations, work practices, and the potential for intakes changed over the 40 years in question (1951–1991). Certain programs are more prone to internal contamination and pose a greater internal dose risk to disassembly and other workers.

2) The predominant source of external exposure is during the assembly, disassembly, and modification of weapons where radioactive material is unshielded and often held close to the body. The radiation characteristics vary in energy with the different configurations and radiation-generating devices used. To further complicate this, there are few gamma and neutron radiation surveys available prior to the mid-1970s.

3) The basis for determining exposure to uranium from burning activities was air-sampling activity for the period 1960–1967. The default intake rate of DU for the burning ground was 130 pCi/day for 1952 to the present. No air-sampling data were available for 1952–1959 and 1963 (NIOSH 2007a). (See Section 5.2.2.5 of NIOSH 2007a regarding Burn Area exposures for further background.)

4) The ER (NIOSH 2008) indicates that internal monitoring gaps are the result of the relative cleanliness of materials and work at Pantex, and the site's practice of collecting bioassay samples based on field indicators or incidents. SC&A site expert interviews conducted as a part of the site profile review indicate routine tritium off-gassing and significant oxidation of components (not always the pit) related to particular programs. Per the ER, records containing negative exposure or contamination data were not retained. In light of the opposing opinions of former workers, actual field monitoring data are critical to characterizing and ascertaining the true potential for internal exposure.

5) Pantex workers were involved in offsite operations, such as the Tweezer Project at Nevada Test Site, weapons accident recovery, and field modifications of weapons. The ER (NIOSH 2008) does not address internal and external exposure from these offsite and nonroutine operations conducted by Pantex employees. Pantex also received and evaluated debris and components from joint test assembly operations and weapons accidents. This extramural work potentially exposed Pantex workers to different source terms while at other facilities and while working with damaged weapons components. Exposure from these activities is not discussed in the ER.

2.8.3 SC&A Reading of Highlights of NIOSH Response (February 25, 2010, and March 10, 2011, Responses)

The types and sources of radiation exposure at Pantex Plant, from a historical standpoint, have been fully characterized in both the Pantex Plant TBDs or in the ER.

2.8.4 SC&A Response (April 2010 Issues Update Response; Supplemented by May 4, 2010, and May 3, 2011, WG Responses)

SC&A submitted its draft assessment of *Data Completeness and Adequacy for the Pantex Plant* (SC&A 2011a), which addresses the adequacy of internal and external dose records, and whether all exposure sources have been sufficiently characterized. As noted at the May 3, 2011, WG meeting, SC&A still awaits information regarding offsite exposures to Pantex workers that may have occurred at other DOE facilities.

2.8.5 SC&A Status Update (October 8, 2013)

NIOSH provided its response to SC&A's *Data Completeness and Adequacy for the Pantex Plant* (SC&A 2011a) in Faust and Ruhter's *NIOSH Responses to SC&A Draft Data Completeness and Adequacy Review for the Pantex Plant* (NIOSH 2011). At the June 18, 2013, Work Group meeting, SC&A and NIOSH committed to revisit SC&A's SC&A 2011 paper and NIOSH's August 2011 response, to disposition remaining site profile issues. SC&A's review of NIOSH's response to this issue indicates that the one remaining question to be resolved is the need for the Pantex site profile to reflect the historic role Pantex personnel played in "work for others" in terms of weapons test activities at the Nevada Test Site, weapons accident recoveries, and field modifications of weapons. This matrix item remains **open** pending that review.

2.8.6 SC&A Status Update (September 4, 2014)

NIOSH agreed to add information in the TBDs, upon revision, to inform dose reconstructors of this history. Pending the revision of the TBDs, this issue is **in abeyance.**

2.8.7 SC&A's Evaluation January 30, 2017 (SC&A 2017)

SC&A found that sections had been added to ORAUT-TKBS-0013-5 (NIOSH 2015b) and ORAUT-TKBS-0013-6 (NIOSH 2016) with information concerning Pantex's history and workers at other Atomic Energy Commission (AEC)/DOE facilities that resolved this issue and recommended closure. The issue was closed at the August 4, 2016, Pantex WG meeting (ABRWH 2016, pages 51–53).

2.8.8 Pantex Summary at August 23, 2017, Advisory Board Meeting

This issue was **closed** at the August 4, 2017, Pantex WG meeting (ABRWH 2016, pages 51–53).

2.9 Issue 9: Incidents Discussed in the ER (NIOSH 2008) and TBDs Are Limited

2.9.1 SC&A's Understanding of the NIOSH ER Position

- To support the incident/suspected exposure-driven internal monitoring program, all aspects of work at Pantex have always involved procedures and routine contamination checks (e.g., smears, air sampling) to assist in identifying work locations with potential for internal exposure (NIOSH 2007a, page 28).

- Documented monitoring data obtained from response work are available for bounding the doses associated with incidents that occurred during the evaluation period (NIOSH 2007a, page 27).

- A list of Pantex incident/accident report titles applicable to the NIOSH evaluated timeframe have been reviewed by NIOSH (NIOSH 2008, page 26).

2.9.2 SC&A Initial Review

1) The ER (NIOSH 2008) does not sufficiently discuss incidental internal exposures. These incidental situations form the basis for the bioassay program prior to 1991. There is no information on what defined an incident, how incidents were formally communicated, and whether the exposure to the personnel involved was integrated into the exposure records. SC&A is concerned about radiological incidents not identified in the ER and ORAUT-TKBS-0013-5, and for which the personnel files do not include bioassay data. The internal dose reconstruction assumptions for plutonium and thorium indicate that a single acute intake should be assumed. Exposures to these radionuclides are usually the result of incidental exposure, rather than continuous exposures. The ER should outline incidents resulting in exposure to workers to inform the dose reconstructor of potential exposure situations. Furthermore, the monitoring for incidents and exposure to cleanup workers from these incidents should be carefully evaluated to determine the completeness and adequacy of monitoring data available.

2) The ER (NIOSH 2008) assumes all individuals involved in incidents were monitored; however, occurrences considered incidents by current standards historically were considered routine in some cases.

2.9.3 SC&A Reading of Highlights of NIOSH Response (February 25, 2010, and March 10, 2011, Responses)

There are some 100 or more incident reports listed in the SRDB. The treatment of incidents by the operating contractor was consistent with how other site contractors (in DOE) performed prompt and thorough investigations, followed by detailed reports. This is evidenced by the number and quality of the Pantex Incident Report files. There is no evidence that anything abnormal was considered routine from the very beginning of operation, and that anything abnormal was treated accordingly and promptly, which included bioassay and dose assignment, if appropriate.

2.9.4 SC&A Response (April 2010 Issues Update Response; Supplemented by May 4, 2010, and May 3, 2011, WG Responses)

This issue is addressed by SC&A in its recent report submitted to the WG and NIOSH, *Data Completeness and Adequacy for the Pantex Plant* (SC&A 2011a). At the May 2, 2011, WG meeting, NIOSH indicated that it would review SC&A's contention that not all incidents resulted in directed bioassays as part of its response to this report.

2.9.5 SC&A Status Update (October 8, 2013)

NIOSH provided its response to SC&A's *Data Completeness and Adequacy for the Pantex Plant* (SC&A 2011a) in Faust and Ruhter's *NIOSH Responses to SC&A Draft Data Completeness and Adequacy Review for the Pantex Plant* (NIOSH 2011). At the June 18, 2013, WG meeting, SC&A and NIOSH committed to revisit SC&A's SC&A 2011 paper and NIOSH's August 2011 response, to disposition remaining site profile issues, including conduct of event-driven bioassays. SC&A's review of NIOSH's response indicates that while the definition and implementation of an incident reporting system evolved over time at Pantex (as it did across DOE), recorded event-driven bioassays became progressively more complete (with fewer exceptions noted for lack of worker identification, inconsistent dates) until a clearly comprehensive program was implemented by the late 1980s. Recognizing that the SEC period encompasses this earlier era and accepting that SC&A's sampling of incidents suggests exceptional cases to more complete event-driven bioassay results, SC&A recommends that this issue be closed. However, this matrix item remains **open** pending WG consideration.

2.9.6 SC&A Status Update (September 4, 2014)

Based on SC&A's recommendation, the WG determined this issue is **closed.**

2.10 Issue 10: Adequate Consideration Has Not Been Given to the Potential Exposures at the Firing Sites

2.10.1 SC&A's Understanding of the NIOSH ER Position

The summary of the dose assessment methodology for the firing sites is outlined in the ER (NIOSH 2008, page 42). A bounding intake can be determined using air-sampling results and additional assumptions. Because the employees at the firing sites were likely different than the assembly/disassembly workers, a separate bounding dose appropriate is provided for these workers.

2.10.2 SC&A Initial Review

Hydroshots were conducted at Firing Site 5 using DU as a surrogate material, resulting in uranium contamination at the firing sites. Significant quantities of DU were used in test fire shots during the late 1960s and early 1970s. Approximately 83% of the uranium was recovered, and approximately 95% could be accounted for at the firing site. The remaining 5% was vaporized and dispersed in the test fire cloud. Microscopic uranium was dusted beyond the perimeter under certain meteorological conditions, and sizeable pieces of uranium were propelled considerable distances.

Consideration of dose assignment from hydroshot and burning operations should be conducted to adequately reflect potential internal and external exposures, particularly from cleanup activities and incidental entries into these areas. Based on a limited amount of air-sampling data, NIOSH developed inhalation dose models for site operators and drivers that are based on 95th percentile values and appear to be claimant favorable. SC&A reviewed available air-sampling data from Firing Station 4 starting October 27, 1959, and ending December 22, 1961, and compared these data with information presented in Figures 5-1 and 5-2 of the ORAUT-TKBS-0013-5 (NIOSH

2007a). The raw data SC&A reviewed do not support use of the 95th percentile of the 1960s outside air concentration of 24 pCi/m^3 as appropriate or claimant favorable. SC&A questions the use of 1 DAC-hour in this case, and finds it inconsistent with other calculated intakes for unmonitored workers, particularly considering the nature of the fired materials that were being remediated.

2.10.3 SC&A Reading of Highlights of NIOSH Response (February 25, 2010, and March 10, 2011, Responses)

Both the ER (NIOSH 2008) and the Pantex occupational internal dose TBD, ORAUT-TKBS-0013-5, Revision 01 (NIOSH 2007a), deal effectively with dose assignment from potential intakes from hydroshots and burning uranium-contaminated HE.

2.10.4 SC&A Response (April 2010 Issues Update Response; Supplemented by May 4, 2010, and May 3, 2011, WG Responses)

This area remains the subject of further data capture and will be addressed following SC&A's remaining site visit.

2.10.5 SC&A Status Update (October 8, 2013)

No additional information was identified from SC&A's site visit that would raise a question regarding the adequacy and completeness of information upon which NIOSH's dose estimation approach for firing sites is based. The only remaining question is one of the conservatism of the proposed use of the 95th percentile of the 1960s outside air concentration of 24 pCi/m^3, based on SC&A's review of available air sampling data from Firing Station 4 starting October 27, 1959, and ending December 22, 1961. Pending a WG discussion of this question, this item remains **open**.

2.10.6 SC&A Status Update (September 4, 2014)

NIOSH noted that with the SEC covering all uranium sources for 1958–1991, this issue is moot. The WG agreed that this issue is **closed.**

2.11 Issue 11: Validation that the Most Highly Exposed Workers Were Badged [Petitioner Issue]

This issue correlates to the following petition concern: The assumption that available records reflect worst-case scenarios or highest-exposed work groups does not appear to be borne out by worker histories.

2.11.1 SC&A's Understanding of the NIOSH ER Position

Overall, personal monitoring was focused on those workers most likely to be exposed to radiation—radiography technicians, production technicians, material handlers, transportation workers, quality control technicians/inspectors, and warehouse production workers. Other workers at Pantex had little occasion to enter radiological areas, and their potential for radiation exposure or intakes of radioactive materials was considerably less.

2.11.2 SC&A Initial Review

The criteria or guidance that were used to determine who was badged (and how well that policy and wearing of the badges were enforced) and for what type of exposure (i.e., photon, beta, and neutrons), and how the badging policy varied as a function of job type (including transient-location workers), facility, and time, needs to be determined to assess if workers were appropriately badged to allow adequate dose reconstruction, and if those data can be used to create a coworker database for unmonitored workers. ORAUT-TKBS-0013-6 does an analysis of the collective exposure received by 15 job categories, which indicated that assembly/production workers, warehouse operators, and quality control/inspectors received the highest collective dose. The petition and ORAUT-TKBS-0013-6 provided information on monitoring by year indicating little monitoring prior to 1957, with the number of monitored workers peaking in 1996. Assuming that workers who were badged were the most highly exposed does not validate this assumption, nor justify using the distribution of coworker doses for unmonitored workers. Verification of monitoring policies and evaluation of changing badging practices over time should be completed.

2.11.3 SC&A Reading of Highlights of NIOSH Response (February 25, 2010, and March 10, 2011, Responses)

The documented policy of who was monitored at Pantex was based on the AEC/Energy Research and Development Administration (ERDA)/DOE Manual Chapter 0524 (and later the Radiological Control Manual) requirement to monitor all workers who had the potential to exceed 10% of the applicable radiation dose limit. This requirement was carried down into applicable Pantex operating requirements and Standard Operating Procedures. NIOSH cites evidence that the coworker study (Strom 2004) included all of the highest exposed workers during the 1994–2000 disassembly period. NIOSH concludes that there is a “solid” technical basis for defining the 95th percentile doses from 1994–2000 from Strom’s study as bounding doses for use in estimating the radiation doses for unmonitored workers for the entire 1952–1991 period.

2.11.4 SC&A Response (April 2010 Issues Update Response; Supplemented by May 4, 2010, and May 3, 2011, WG Responses)

The information presented by NIOSH addresses practices in the later disassembly years (1980–2000), but not in the earlier era. While no documentation is available regarding the implementation of monitoring against these requirements, the issue of back-extrapolating exposure experience and monitoring effectiveness has been challenged by SC&A for internal dose estimation (addressed in Issue 1). For external dose estimation, SC&A indicated at the May 2, 2011, WG meeting that it believes the use of latter-day dose distributions for coworker dose assignment (per Strom) is sufficiently accurate for the weapon systems involved.

2.11.5 SC&A Status Update (October 8, 2013)

Based on discussions and agreement by the WG at its June 18, 2013, meeting, this issue was **closed**. Closure reflects that the remaining questions surrounding external dose monitoring were resolved at the May 2, 2011, WG meeting (with internal dose monitoring issues subsumed in Issue 1).

2.12 Issue 12: Accuracy of Available Radiation Exposure Data [Petitioner Issue]

This issue correlates to the following petition concerns: In addition to the paucity of radiologic monitoring data, the accuracy of the available radiation exposure data is called into question by the lack of quality assurance data; as is the case for most facilities, records for exposures and releases were apparently not always well documented or maintained.

2.12.1 SC&A's Understanding of the NIOSH ER Position

- The measured photon dose data, with appropriate corrections for lead apron use and dosimeter response uncertainty, provide reliable bounding photon doses. The available beta-dose data can also be used to calculate/establish bounding beta doses.

- Neutron doses measured at Pantex with a new system since 1994 are reliable, and these measurements are suitable for use in bounding the doses received by Pantex workers. Photon doses (with appropriate corrections for lead apron use and dosimeter response uncertainty) were reliably measured and can be used with a neutron-to-photon ratio to calculate conservatively bounding neutron doses for the years prior to 1994 (NIOSH 2007b) (NIOSH 2008, page 52).

2.12.2 SC&A Initial Review

1) The ER (NIOSH 2008) implies that early film dosimeter data for Pantex are reliable. The ER and ORAUT-TKBS-0013-6 do not recognize the inaccuracies in calibration methods and uncertainties introduced into the dosimetry program by poor or improper practices. In an assessment of the external dosimetry program, the Investigative Board cited key findings with the Pantex external dosimetry program (DOE 1980):

    - *Gamma calibration response curves for TLDs … did not have sufficient range.*
    - *The scientist and laboratory technicians assigned to the Pantex dosimeter program were inadequately trained.*
    - *There were no formal operating procedures for the Pantex dosimetry program.*
    - *The quality of the Pantex dosimetry program was less than adequate.*

    SC&A considers the deficiencies identified by the DOE Investigative Board to be highly relevant to the credibility of dosimetry data for Pantex. The ER needs to consider these deficiencies for their implications on the accuracy of external dose reconstruction.

2) Further complicating matters are issues with individuals not wearing their dosimeters all the time. During a survey of film badge utilization in June 1969, Poynor found several instances where personnel were not wearing their badges (Poynor 1969). The extent of issues that

involved inappropriate wearing of dosimetry is unknown; however, radiological control staff subsequently established a program to spot check badge racks to determine whether individuals were wearing their badges.

3) Refer to Issue 8 for a discussion on neutron dose.

2.12.3 SC&A Reading of Highlights of NIOSH Response (February 25, 2010, and March 10, 2011, Responses)

The deficiencies noted in DOE (1980) only apply to the 1972–1980 period that the TLD program was operated "in-house." Prior to 1972, film badge service was supplied by a reliable commercial service (uncertainty: +/- 30%). From 1980 to 1993, the TLD dosimetry program was based on reliable Panasonic TLDs and readers, with an estimated uncertainty in measured photon doses of +/- 20%. After 1993, the Panasonic TLD program accredited by the Department of Energy Laboratory Accreditation Program (DOELAP) had an uncertainty of +/- 10%.

2.12.4 SC&A Response (April 2010 Issues Update Response; Supplemented by May 4, 2010, and May 3, 2011, WG Responses)

SC&A notes this additional information in response to petitioner's issues and recommends that the WG consider this issue closed.

2.12.5 SC&A Status Update (October 8, 2013)

At its June 18, 2013, meeting, the WG confirmed that this matrix issue is now **closed**.

2.13 Issue 13: Too Few Workers Monitored for Valid Dose Reconstruction [Petitioner Issue]

This issue correlates to the following petition concern: One argument made is that too few workers were monitored for statistical purposes for generalizations to the rest of the workforce to be valid. Until 1979, the majority of the Pantex workforce went completely unmonitored. The assumption that the most-exposed workers were monitored was not found to be valid at IAAP and is likely not valid at Pantex.

2.13.1 SC&A's Understanding of the NIOSH ER Position

- The bounding doses for monitored workers can be used with coworker study statistics to assign bounding doses to unmonitored workers, because the monitored workers are considered the maximally exposed work group within the proposed class (based on historical Pantex radiological program documentation). The combination of these dose calculation methods makes it feasible to bound the external dose (reconstruct the dose with sufficient accuracy) for the Pantex proposed worker class evaluated in this report (NIOSH 2008, page 50).

- NIOSH has obtained credible information stating that prior to 1988, Pantex issued dosimeters only to workers likely to receive 10% or more of the radiation protection guidance. There is also strong evidence that a majority of the workforce was not exposed to radiological sources during that time period. From 1952 through 1957, the number of badged workers was particularly low, as industrial radiography and medical x-rays were the only significant sources of radiation exposure onsite during that time. Variations in the number of badged radiation workers from 1958 through 1988 reflect changes in weapons productions rates and the quantity of radioactive materials present on site. Reviews conducted of the Pantex Plant health protection and monitoring programs have repeatedly found that monitoring levels are consistent with exposure potentials. Interviews with Pantex safety officers and health physicists working within the class timeframe also supported a proper correlation between exposure potentials and monitoring levels (NIOSH 2008, page 51).

2.13.2 SC&A Initial Review

1) Statistics provided for external monitoring by year are based on limited data prior to 1958.

2) The ER (NIOSH 2008) does not provide the population of radiological and non-radiological workers by year for comparison to the number monitored.

3) Early monitoring was concentrated on radiographers, whereas later years included multiple job categories.

4) The ER (NIOSH 2008) has not demonstrated that variations in badged radiation workers are the result of changes in weapons production rates and the quantity of the radioactive material present.

2.13.3 SC&A Reading of Highlights of NIOSH Response (February 25, 2010, and March 10, 2011, Responses)

NIOSH cites ORAUT-TKBS-0013-6 and Carr (1992) to provide statistical responses to SC&A questions regarding this concern raised by the petitioners.

2.13.4 SC&A Response (April 2010 Issues Update Response; Supplemented by May 4, 2010, and May 3, 2011, WG Responses)

SC&A addresses this issue in more detail in its recent *Data Completeness and Adequacy for the Pantex Plant* (SC&A 2011a) and will defer further conclusions until a response is forthcoming from NIOSH on it.

2.13.5 SC&A Status Update (October 8, 2013)

NIOSH provided its response to SC&A's *Data Completeness and Adequacy for the Pantex Plant* (SC&A 2011a) in Faust and Ruhter's *NIOSH Responses to SC&A Draft Data Completeness and Adequacy Review for the Pantex Plant* (NIOSH 2011). SC&A's review of NIOSH's response finds agreement that limited monitoring existed prior to the arrival of sealed plutonium pits in 1958, and that relatively small variations in historic badging can be linked to weapons production and dismantlement rates, and changing DOE policies. NIOSH also cites its statistical treatments in ORAUT-TKBS-0013-6 and Carr (1992) regarding use of Pantex external monitoring data. At its June 18, 2013, meeting, the WG asked NIOSH and SC&A to revisit this material prior to further WG review. Based on its review, as noted, SC&A recommends that this issue be closed. However, this matrix item remains **open** pending WG consideration.

2.13.6 SC&A Status Update (September 4, 2014)

The WG accepted SC&A's recommendation and considers the issue **closed.**

2.14 Issue 14: Records Incomplete for Subcontractor, Temporary, or Short-Term Employees [Petition Issue]

Reference was made to subcontractor, temporary, probationary, and short-term employees who, when exposed to high levels of radiation, were in the words of participants, "flushed." To this day, they are not fully represented in the records.

2.14.1 SC&A's Understanding of the NIOSH ER Position

A response was not specifically provided in the ER (NIOSH 2008).

2.14.2 SC&A Initial Review

SC&A response is pending additional records review.

2.14.3 SC&A Reading of Highlights of NIOSH Response (February 25, 2010, and March 10, 2011, Responses)

All short-term or temporary workers were treated as visitors and monitored as such. These records were preserved by name and other identifying information.

2.14.4 SC&A Response (April 2010 Issues Update Response; Supplemented by May 4, 2010, and May 3, 2011, WG Responses)

SC&A will be reviewing additional data capture information in its upcoming site visit to Pantex; however, unless additional information is found that would be inconsistent with NIOSH's characterization of past practice in this regard, SC&A would recommend WG closure of this issue.

2.14.5 SC&A Status Update (October 8, 2013)

SC&A reported to the WG at its June 18, 2013 meeting, that its subsequent onsite review did not find any new information that is inconsistent with NIOSH's assessment of past practices at Pantex for visitors and temporary workers. The WG subsequently **closed** this issue.

2.15 Issue 15: Exposure from Tritium Leaks [Petition Issue]

In addition, SC&A heard about several situations in which tritium leaks occurred and believes there is uncertainty in the accuracy and completeness of radiation exposure data regarding such events. The impression from reading the available NIOSH documents is that one such exposure occurred, whereas workers indicated that such events were not uncommon and reported a practice of the medical office sending workers home with prescriptions for a "case of beer."

2.15.1 SC&A's Understanding of the NIOSH ER Position

From available procedures, program reviews, and interviews conducted, it is evident that Pantex tritium monitoring has been appropriately focused on workers with the highest likelihood of exposure. As such, the data obtained can be used to bound tritium doses for all workers (NIOSH 2008, page 39).

2.15.2 SC&A Initial Review

1) Reservoirs began arriving at Pantex in late 1956 or early 1957; however, there is no mention of how tritium doses prior to 1960 will be assessed.

2) The ER (NIOSH 2008) indicates that Pantex tritium monitoring focused on workers with the highest likely exposure. Furthermore, it indicates these data can be used to bound tritium dose. Prior to 1972, the ER suggests that 10 individuals were randomly selected per month for tritium bioassay from 1960 to 1971. The ER does not explain how the "highest likely exposed" individuals were selected and how they have verified this assumption.

3) Evaluation of Table 5-3 of ORAUT-TKBS-0013-5 indicates that the number of workers monitored for tritium uptakes was not constant, and only 0–4 workers were monitored per year from 1972 to 1975 (NIOSH 2007a, page 15). In the absence of bioassay data prior to 1972, NIOSH has proposed to assign twice the highest uptake from the 1970s for the years 1957–1971. For the period 1972 to the present, unmonitored tritium exposures are assigned to production technicians, radiation safety technicians, and quality assurance technicians. ORAUT-TKBS-0013-6 uses a triangular distribution with a minimum of zero and a mode and maximum as defined in Table 5-6 to assign the missed dose (NIOSH 2007a).

4) ORAUT-TKBS-0013-6 does not clearly define either the data used to derive values in Table 5-6 or the number of data points used for determining the mode. Many of the values are assumed without adequate basis for the assumption. It is supposed that tritium bioassay occurred, yet few monitoring data were discovered in the dosimetry files. Unmonitored tritium exposures are also limited to three job classifications, which is not inclusive of all individuals handling reservoirs or tritium-contaminated components or those in the immediate vicinity when these activities are performed. For example, this would include those disposing of retired reservoirs and other tritium-contaminated equipment and materials and those receiving or preparing components for shipment, to name a few.

2.15.3 SC&A Reading of Highlights of NIOSH Response (February 25, 2010, and March 10, 2011, Responses)

NIOSH cites ORAUT-TKBS-0013-5 (NIOSH 2007a) as explaining the approach and methodology to obtain a claimant-favorable dose estimation for tritium.

2.15.4 SC&A Response (April 2010 Issues Update Response; Supplemented by May 4, 2010, and May 3, 2011, WG Responses)

SC&A addresses this issue in more detail in its recent *Data Completeness and Adequacy for the Pantex Plant* (SC&A 2011a) and will defer further conclusions until a response is forthcoming from NIOSH on it.

2.15.5 SC&A Status Update (October 8, 2013)

NIOSH provided its response to SC&A's *Data Completeness and Adequacy for the Pantex Plant* (SC&A 2011a) in Faust and Ruhter's *NIOSH Responses to SC&A Draft Data Completeness and Adequacy Review for the Pantex Plant* (NIOSH 2011). At the June 18, 2013, WG meeting, NIOSH and SC&A committed to disposition remaining issues addressed in both respective papers and to bring them to the next WG meeting for discussion. SC&A's review of NIOSH's response indicates that its original issues regarding the bases of determining the "highest likely exposed" to tritium and how it was corroborated (e.g., using additional bioassay data for 1962–1971), and the inclusion of only three job classifications for unmonitored dose estimation, remain unaddressed (other than referring back to the site profile). However, given that the time period of concern for tritium is the same as that of the existing SEC period, SC&A defers to the WG for direction regarding the value of a full analysis of these and any remaining site profile-related issues surrounding tritium. This matrix item remains **open** pending further review.

2.15.6 SC&A Status Update (September 4, 2014)

SC&A provided additional clarification in advance of the WG meeting regarding its concerns over the current approach to tritium dose reconstruction in ORAUT-TKBS-0013-5, particularly the use of MDA in Table 5-3 based on an appraisal of the Pantex health physics program, not actual instrumentation or methods at Pantex. NIOSH agreed to revise Tables 5-1, 5-2, and 5-3 and corresponding guidance in ORAUT-TKBS-0013-5 to reflect the actual Pantex MDA. These proposed changes will be provided in a note or memo to the WG, followed by a subsequent revision of ORAUT-TKBS-0013-5. Pending this resolution, the WG considers this issue to be held **in abeyance**.

2.15.7 Pantex Work Group Meeting, August 4, 2016

This issue was **closed** at the August 4, 2016, Pantex WG meeting (ABRWH 2016, pages 54 – 55).

2.16 ISSUE 16: BADGE PLACEMENT [PETITION ISSUE]

Most dosimeters have routinely been worn on the lapel of coveralls and shirts at a greater distance from the source than target organs.

2.16.1 SC&A's Understanding of the NIOSH ER Position

A response was not specifically provided in the ER (NIOSH 2008).

2.16.2 SC&A Initial Review

Worker geometry and proximity to radioactive material is pertinent to organ dose reconstruction, particularly for those workers required to work in close proximity to the pits or those who held units in their laps during work processes. In its analysis of workplace radiation fields, the ER (NIOSH 2008) has not provided an adequate basis for assigning partial-body exposures during weapons component handling. Dosimeters were worn at the collar, as instructed by health physics staff. The highest exposures may have been at the waist or lower, resulting in an underestimate of dose to organs at waist level. Dosimetry on the collar or even chest would not adequately reflect the exposure to lower organs. The correction factors applied for glovebox workers proposed in ORAUT-TKBS-0013-6 may not be appropriate for situations encountered by Pantex workers, where radioactive material is often handled directly against the body. The ER (NIOSH 2008) should evaluate potential organ exposures exceeding the measured whole-body dose.

2.16.3 SC&A Reading of Highlights of NIOSH Response (February 25, 2010, and March 10, 2011, Responses)

Petitioners have stated that some workers held bare pits on their laps during some work practices, such as cleaning the pit surface. It was determined that the surface of a new pit could be cleaned in only a few minutes prior to assembly. It was also determined that throughout the history of Pantex operations, pits and other components have been handled in fixtures of various kinds. NIOSH acknowledges that while some workers could have held pits in their laps, it would be possible to estimate conservative doses requiring some adjustment to calculated organ doses for work in the early years (1959–1970), when use of fixtures for handling pits was not rigorously required. For pit operations that took place at waist level, the guidance in OCAS-TIB-0010, Revision 1, *Special External Dose Reconstruction Considerations for Glovebox Workers* (OCAS 2005), should apply and would be an adequate basis for any corrections to organ doses.

2.16.4 SC&A Response (April 2010 Issues Update Response; Supplemented by May 4, 2010, and May 3, 2011, WG Responses)

SC&A still questions how NIOSH will apply guidance in OCAS-TIB-0010 (OCAS 2005) for a glovebox geometry to a much more variable (from a geometry standpoint) work procedure involving direct handling by the worker.

2.16.5 SC&A Status Update (October 8, 2013)

This issue remains unresolved on the question of how OCAS-TIB-0010 will be applied at Pantex. The WG kept the issue **open** pending a NIOSH response.

2.16.6 SC&A Status Update (September 4, 2014)

NIOSH indicates that it is revising OCAS-TIB-010 to apply a 95th percentile distribution for badge placement geometry to ensure such variabilities in badge location are addressed. This equates to a factor of 3.5 adjustment to such estimates, which is conservative. The WG and SC&A will have the opportunity to validate this approach via the program evaluation report review process. On this basis, the WG decided to **close** this issue.

2.17 Issue 17: Efficacy of the Health Physics and Industrial Hygiene Programs [Petitioner Issue/Raised in ER (NIOSH 2008)]

This issue addresses real questions regarding the efficacy of the health physics and industrial hygiene programs at the site, as reflected by workers' histories and the Tiger Team report.

2.17.1 SC&A's Understanding of the NIOSH ER Position

Excerpts from a 1990 Tiger Team report at the Pantex Plant relayed information related to (and critical of) the following: health physics support staffing levels and training; questions regarding quality assurance for radiation monitoring data; health and safety program inadequacies; the control of radioactive sources; maintenance of employee exposure records; contamination reports; and discussion of pre-employment or new employee baseline monitoring.

Although the report contains information that indicated that the Pantex Plant radiological program was deficient in implementing DOE Order 5480.11 requirements, the report did not find that radiation exposures and radiation doses were not monitored, either through personal or area monitoring. With the exception of neutron monitoring, the Tiger Team review did not indicate that occupational exposure monitoring data obtained were deficient, inaccurate, or unsuitable for use in bounding doses to Pantex workers.

2.17.2 SC&A Initial Review

1) SC&A has addressed adequacy of employee exposure records under Issues 2 and 7 for internal and external exposure data, respectively.

2) The characterization of the workplace exposure conditions is addressed under Issue 1.

3) Health physics support staffing levels and training, general health and safety program inadequacies, and the control of radioactive sources provide valuable background information on the effective control of the source term but are not directly pertinent to dose reconstruction for an individual.

4) Maintenance of survey records, contamination records, and field air-sampling records are important to the dose reconstruction effort in the absence of personnel monitoring data, at least as a method to verify the reasonableness of the bounding doses for unmonitored or inappropriately monitored workers.

2.17.3 SC&A Reading of Highlights of NIOSH Response (February 25, 2010, and March 10, 2011, Responses)

These issues are addressed elsewhere, as noted. Recommend WG close this issue as separate item.

2.17.4 SC&A Response (April 2010 Issues Update Response; Supplemented by May 4, 2010, and May 3, 2011, WG Responses)

These issues are addressed elsewhere, as noted. Recommend WG close this issue as separate item.

2.17.5 SC&A Status Update (October 8, 2013)

Based on SC&A's previous recommendation, the WG **closed** this issue at its June 18, 2013, meeting.

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ATTACHMENT A: EXAMPLES OF NEUTRON-TO-PHOTON RATIO (N/P) VALUES GREATER THAN THE RECOMMENDED 1.7 VALUE AT PANTEX

1960 and 1979 n/p Values for Some Inspector and Warehouse Workers Exceeded 1.7

See pages 41 and 42 of ORAUT-TKBS-0013-6 for details; Section 6.6.3 recommends using the higher n/p value measured instead of the n/p value of 1.7 for these cases. However, this measured n/p value would be derived from unreliable NTA film results because they are not sensitive to lower energy neutrons. Hence, this is not technically sound or favorable to claimants.

1979 Measurements on Pits in Shipping Containers and in High Explosives

Measurements by instruments in 1979 suggest that the n/p value for pits in shipping containers and pits in high explosives exceed the n/p value of 1.7 for some workers, in such areas as radiography, inspection, storage, and transportation of weapons.

(DOE, *Report of the Investigation of a Radiation Exposure Incident at the Pantex Plant During September 1979*, January 10, 1980, as cited on pages 16 and 109 of SC&A's July 17, 2008, review of the Pantex site profile)

Table 1 shows data from documents listed on Pages 65 and 66 of NIOSH's SEC ER of July 10, 2008 (NIOSH 2008).

Table 1. List of Documents and n/p Values

SRDB Ref. ID	Document pdf.page	Date	Area	Neutron (mrem/hr)	Gamma (mR/hr)	n/p
14319	5	9/12/1975	12-42 North vault	11.159	5.5	2.03
25440	18	10/12/1983	12-2 Source Rm	1.8	0.6	3.00
25440	18	10/12/1983	12-2 Source Rm	2	0.5	4.00
25440	18	10/12/1983	12-2 Source Rm	3	0.4	7.50
25440	18	10/12/1983	12-2 Source Rm	0.4	0.1	4.00
14148	8	4/14/1983	12-2 Source Rm	3.9	0.95	4.11
14158	3	5/21/1986	12-42 Test Bay*	0.5	0.175	2.86
14158	3	5/21/1986	12-42 Test Bay*	0.6	0.188	3.19
25471	4	2/18/1987	12-10 Source Rm**	1.8	0.4	4.50
25471	4	2/18/1987	12-10 Source Rm**	1.8	0.6	3.00
25471	4	2/18/1987	12-10 Source Rm**	1.9	0.4	4.75
25471	4	2/18/1987	12-10 Source Rm**	7.8	1.0	7.80
25471	4	2/18/1987	12-10 Source Rm**	5.3	1.7	3.12
25471	4	2/18/1987	12-10 Source Rm**	7.1	1.0	7.10
25471	4	2/18/1987	12-10 Source Rm**	3.8	0.8	4.75
25471	4	2/18/1987	12-10 Source Rm**	27.1	2.0	13.55
25471	4	2/18/1987	12-10 Source Rm**	26.8	2.0	13.40
25471	4	2/18/1987	12-10 Source Rm**	28.3	3.0	9.43
25471	4	2/18/1987	12-10 Source Rm**	38	7.2	5.28
25471	4	2/18/1987	12-10 Source Rm**	23.1	3.5	6.60
25508	5	8/9/1990	12-21 Neutron Radio.	2.0	0.3	6.67
25508	5	8/9/1990	12-21 Neutron Radio.	1.0	0.3	3.33

* Non-radiation worker area where a value of n/p = 0.8 would be used in dose reconstruction.
**With californium-252 source extended.

Average n/p value was 5.6, with a geometric standard deviation of 5.0, and a range of 2.0–13.6.

1992–1995 Radiation Surveys of Different Weapon Types

Data for Table 2 were obtained from page 65 of SC&A's July 2008 review of the Pantex site profile. Surveys taken with Victoreen 440 and Rem Ball instruments, source: Pantex 1992, Pantex 1993, Pantex 1994, Pantex 1995a, Pantex 1995b (SC&A 2008).

Table 2. List of Weapons Program and n/p Values

Weapons Program	Neutron-to-Proton Ratio Greater than 1.7
48	Yes, in certain configurations
57	No
61	Yes, in certain configurations
62	No
68	Yes, in certain configurations
71	No
76	No
78	No
79	Yes, approximately 10:1 ratio*
80	Yes, in certain configurations
83	No
87	Yes, in certain configurations

*Survey data were limited for this unit.