Working Draft

A PAPER STUDY OF THE SEC PETITION AND NIOSH EVALUATION REPORT FOR PANTEX

Revision 1

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Prepared by

S. Cohen & Associates
1608 Spring Hill Road, Suite 400
Vienna, Virginia 22182

Saliant, Inc.
5579 Catholic Church Road
Jefferson, Maryland 21755

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The attached "Pantex Plant SEC Issues Matrix – Draft Preliminary SC&A Assessment" is a revision of the document, *A Paper Study of the SEC Petition and NIOSH Evaluation Report for Pantex*, issued on December 9, 2008. It reflects some non-technical streamlining and reordering of issues to improve the structure of the matrix in preparation for work group deliberations.

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1	Adequacy of Internal Dose Records	• 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 Pu-239 and 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 Helgesen 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 (pg. 35). • Data available for estimating internal doses due to potential	(1) Although the presence of radioactive material at the site has existed 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 exists for worker intakes prior to 1991, and only intermittent data exists 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 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

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		uranium, plutonium, and thorium exposures are predominantly from sampling/analyses performed in 1989 or later (pg. 36). • Hardcopy air monitoring results applicable to specific activities have been documented and are available to NIOSH (see Attachment One of the ER). • Based on the available data and the re-evaluation of the hundreds of documents in the SRDB related to Pantex, specifically in the area of internal dose, NIOSH concludes that the methods described in ORAUT-TKBS-0013-5 provide reasonable approaches to conservatively bound doses for all members of the class under evaluation. New information revealed since the TBD 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 continually performed workplace monitoring to determine whether contaminated weapons were brought onsite or in the case of an inadvertent release of radioactive materials.	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 is 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 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	Internal Dose Models for the Assignment of Internal Dose from Uranium	• 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 (pg. 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	(1) The ER 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

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		release and, therefore, not considered a significant potential exposure source for the proposed worker class evaluated (pg. 22). • Some DU was also released at the hydrotest firing sites when hydroshots involved DU (pg. 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 (pg. 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 (pg. 39). • Internal doses are calculated based on methods outlined in ORAUT-TKBS-0013-5 (Hickey et al. 2007, pp. 41–42).	1989. The ER and TBD 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 EU were handled at Pantex. The ER recognizes that plutonium was handled in a sealed form and assigns a potential missed dose from plutonium. EU presents the same potential for exposure, yet the ER has not addressed potential missed dose from this source. (3) The TBD contains unexplained and implausibly extreme changes in sensitivity values for uranium urinalysis and minimum detectable activity (MDA), as well as significant data gaps. The TBD (Hickey et al. 2007) shows an apparent improvement in sensitivity values of 2 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 or the TBD provides a technically valid basis for applying uranium bioassay analysis data to coworker applications and intake calculations spanning these gaps and years.

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3	Dose Estimate Approach for Plutonium	• 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 to 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 DAC-hours (290 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 1 intake per year and the possibility that the air-sampling system is not representative. The	The ER 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 the internal TBD. 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-hr 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 mrem total effective dose equivalent (TEDE), may not have been detectable, and is not supported by the 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.

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		bounding intake for the period from 1991 through 2000, therefore, is 400 DAC-hr (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 (pg. 23). • Internal doses are calculated based on methods outlined in ORAUT-TKBS-0013-5.	
4	Dose Estimate Approach for Thorium	• 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 (pg. 24). • It is assumed that workers could have encountered oxidized thorium components during disassembly of weapons in the mid-1960s (pg. 24). • Bounding doses from thorium can be evaluated for Pantex employees (pg. 40). • From 1980 to 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….For workers who had the highest possibility of intake for each year from 1980 to 1991, a single acute intake of 40 DAC-hrs (48 pCi) of Th-232 (in equilibrium with progeny) was assumed. For Category 2 workers in Table 5-2 of the ORAUT-TKBS-0013-5, 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	(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 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 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.

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		the mode to account for the possibility of more than 1 intake per year and the possibility that the air-sampling system is not representative (Hickey et al. 2007). • The ER 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 (pg. 44). • Internal doses are calculated based on methods outlined in ORAUT-TKBS-0013-5 (Hickey et al. 2007).	(4) From 1980 to the present, the same intake (40 DAC-hrs) is assigned for thorium-232. The 40 DAC-hr 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 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.
5	The Internal Dose Approach for Metal Tritides	• 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 (pg. 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 (pg. 23). • The assessment of metal tritides revealed that the doses would not impact the bounding dose established for tritium in ORAUT-TKBS-0013-5 (Hickey et. al. 2007) (ER, pg. 42).	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. RSD-TBD-0036, *Metal Tritides—Technical Basis Document* (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 indicates that metal tritides would not impact the bounding dose for tritium because it constitutes 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

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			not work for insoluble compounds, such as some metal tritides handled at Pantex.
	Interpretation of External Dosimetry Data	• 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 (pg. 24). • Industrial radiography operations had the potential to exposure some workers to x-ray, gamma, and neutron radiation (pg. 24). • Am-241 was an increasingly significant source of exposure to workers performing weapons disassembly, which often occurred many years after assembly (pg. 25).	(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 keV photon associated with Am-241, which is a factor of 10 lower than the calibration photon energy for Co-60 and/or 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 (mg/cm^2) (or 0.88 millimeters (mm)) 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.

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			(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 and TBD (Fix et al. 2007), 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.
7	Data does Not Support the Assumption that the 95th Percentile Neutron-to-Photon Ratio is Bounding for All Exposure Scenarios	The ER (pg. 26 states) 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*	While the recommended neutron-to-photon ratio method may bound some of the Pantex workers' neutron dose, 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 n/p value of 0.8 and 1.7 was obtained from

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		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 (pg. 47) 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 (pg. 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 unknown date). 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*	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. 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 indicates that using a neutron-to-photon ratio value of 1.7 would not bound the neutron dose. See **Attachment 1** for some examples where the neutron-to-photon ratio values ranged from 2.0 to 13.6, with a GM=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, pp. 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

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		this report. 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 (Strom, unknown date). This median value, when applied to the assigned photon dose for monitored workers, will yield a bounding neutron dose to unmonitored workers. ER pages 46 states *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 (pg. 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 LANL and LLNL-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	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 TBD and SEC ER states photon dosimetry was correct, while IAAP, for similar operations, state 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

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		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.	
8.	Completeness and Interpretation of Historic Radiological Exposure Sources	(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 depleted uranium 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 (pg. 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 (pg. 35).	(1) There is a need to characterize the types of radiation exposure associated with particular weapons programs or time periods, including 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 of 1960-1967. The default intake rate of DU for the burning ground was 130 pCi/day for 1952 to present. No air-sampling data were available for 1952-1959 and 1963 (Hickey et al. 2007). (See Addendum regarding Burn Area exposures for further background.) (4) The ER 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

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			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 is 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 (NTS), weapons accident recovery, and field modifications of weapons. The ER 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.
9.	Incidents Discussed in the ER and TBDs are Limited	• 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 (pg. 28). • Documented monitoring data obtained from response work is available for bounding the doses associated with incidents that occurred during the evaluation period (pg. 27). • A list of Pantex incident/accident report titles applicable to the NIOSH evaluated time frame have been reviewed by NIOSH (pg. 26).	(1) The ER 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 TBD, 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

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			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 assumes all individuals involved in incidents were monitored; however, occurrences considered incidents by current standards historically were considered routine in some cases.
10	Adequate Consideration has not been given to the Potential Exposures at the Firing Sites	The summary of the dose assessment methodology for the firing sites is outlined in the ER. 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 (pg. 42).	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 (Drummond 1961). 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 TBD (Hickey et al. 2007). The raw data SC&A reviewed does not support use of the 95th percentile of the 1960s outside air concentration of 24 pCi/m^3 as appropriate or

No.	Issue	SC&A's Understanding of the NIOSH ER Position	SC&A Initial Review
			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.
11	Validation that the Most Highly Exposed Workers [Petitioner Issue][1]	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 were considerably less.	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 that data can be used to create a coworker database for unmonitored workers. The external TBD does an analysis of the collective exposure received by fifteen job categories, which indicated that assembly/production workers, warehouse operators, and quality control/inspectors received the highest collective dose. The petition and the external TBD 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.

[1] 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.

No.	Issue	SC&A's Understanding of the NIOSH ER Position	SC&A Initial Review
12	Accuracy of Available Radiation Exposure Data [Petitioner Issue][2]	• 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 (Fix et al. 2007) (ER, pg. 52).	(1) The ER implies that early film dosimeter data for Pantex are reliable. The ER and external TBD 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 that concluded the following (DOE 1980, p. 51): • *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 Item #8 for a discussion on neutron dose.

PANTEX PLANT SEC ISSUES MATRIX – DRAFT PRELIMINARY SC&A ASSESSMENT

No.	Issue	SC&A's Understanding of the NIOSH ER Position	SC&A Initial Review
13	Too Few Workers Monitored for Valid Dose Reconstruction [Petitioner Issue][3]	• 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 make it feasible to bound the external dose (reconstruct the dose with sufficient accuracy) for the Pantex proposed worker class evaluated in this report (pg. 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 onsite. 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 (pg. 51)	(1) Statistics provided for external monitoring by year are based on limited data prior to 1958. (2) The ER 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 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.
14	Records Incomplete for Subcontractor, Temporary, or Short-Term Employees [Petition Issue][4]	Response not specifically provided in the ER.	SC&A response is pending additional records review.

PANTEX PLANT SEC ISSUES MATRIX – DRAFT PRELIMINARY SC&A ASSESSMENT

No.	Issue	SC&A's Understanding of the NIOSH ER Position	SC&A Initial Review
15	Exposure from Tritium Leaks [Petition Issue][5]	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 (pg. 39).	(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 indicates that Pantex tritium monitoring focused on workers with the highest likely exposure. Furthermore, they indicate this 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 1960–1971. 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 the internal dose TBD indicates that the number of workers monitored for tritium uptakes was not constant, and few workers were monitored per year from 1972–1975 (Hickey et al. 2007, pg. 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. The TBD 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 (Hickey et al. 2007). (4) The TBD 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

No.	Issue	SC&A's Understanding of the NIOSH ER Position	SC&A Initial Review
			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.
16	Badge Placement [Petition Issue][6]	Response not specifically provided in the ER.	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 there laps during work processes. In its analysis of workplace radiation fields, the ER 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 the TBD may not be appropriate for situations encountered by Pantex workers, where radioactive material is often handled directly against the body. The ER should evaluate potential organ exposures exceeding the measured whole-body dose.
17	Efficacy of the HP and IH Programs [Petitioner Issue/Raised in ER][7]	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 which indicated that the Pantex Plant radiological program was deficient in implementing DOE Order 5480.11 requirements, the report did not find that	(1) SC&A has addressed adequacy of employee exposure records under Items #2 and #7 for internal and external exposure data, respectively. (2) The characterization of the workplace exposure conditions is addressed under Item #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

No.	Issue	SC&A's Understanding of the NIOSH ER Position	SC&A Initial Review
		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.	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.

Addendum: Note regarding Burn Area Exposures

Weapons components were in some cases recovered. To sanitize weapons components to render them unclassified, parts were removed and subjected to granulation, smelting, crushing, shredding, burning, incineration, and other processes. The average amount of hazardous material generated averaged about 75 pounds per weapon. This included DU as well as other metals and components (DOE 1995). In the early years, this material was handled with bare hands. In addition, burn pits were used to dispose of chemical wastes. The basis for determining exposure to uranium from burning activities was air-sampling activity for the period of 1960–1967. The default intake rate of DU for the burning ground was 130 pCi/day for 1952 to present. No air-sampling data were available for 1952–1959 and 1963 (Hickey et al. 2007).

Furthermore, dose assignment from hydroshot and burning operations should 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 claimant favorable. SC&A reviewed available air-sampling data at 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 TBD (Hickey et al. 2007). The raw data SC&A reviewed does not support the determination that using the 95th percentile of 1960s outside air concentration of 24 pCi/m’ is 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. The 19 pCi/d intake factor at Pantex is inconsistent with that used for IAAP.

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ATTACHMENT 1: EXAMPLES OF NEUTRON-TO-PHOTON RATIO (n/p) VALUES GREATER THAN THE RECOMMENDED 1.7 VALUE AT PANTEX

(a) 1960 and 1979 n/p Values for Some Inspectors and Warehouse Workers Exceeded 1.7

See pages 41 and 42 of 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 claimant.

(b) 1979 Measurements on Pits in Shipping Containers and in High Explosives (HE)

Measurements by instruments in 1979 suggest that the n/p value for pits in shipping containers and pits in HE 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 in pages 16 and 109 of SC&A's 7/17/2008 review of Pantex Site Profile)

(c) Data from Documents listed on Pages 65 and 66 of NIOSH's SEC ER of July 10, 2008

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

SRDB Ref ID#	Document pdf.page	Date	Area	Neutron (mrem/hr)	Gamma (mR/hr)	n/p
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 DR.*					**Average = 5.6**	
***With Cf-252 source extended.*					***GM = 5.0***	
					Range = 2.0-13.6	

(d) 1992–1995 Radiation Surveys of Different Weapon Types

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 was limited for this unit.

Source: Pantex 1992, Pantex 1993, Pantex 1994, Pantex 1995a, Pantex 1995b.
(From page 65 of SC&A's 7/17/2008 review of Pantex Site Profile.
Surveys taken with Victoreen 440 and Rem Ball instruments.)

ATTACHMENT 2: SC&A'S RESPONSE TO NIOSH'S EVALUATION REPORT CONCERNING EXTERNAL DOSE FOR PANTEX SEC-00068

NIOSH's ER Position concerning External Dose for Pantex SEC-00068

Page 26 of the ER 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.* [Emphasis added.]

NIOSH claims that the neutron doses at the Pantex facility can be bound by this method. Page 47 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.* [Emphasis added.]

Section 7.3.4, 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, unknown date). 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.]

Note that there is apparently an error in the first sentence in the statement above, because it currently reads as though the photon doses measured from 1994 forward can be used along with the n/p value of 1.7 to calculate neutron doses for years *prior* to 1994; what it most likely means is that the photon doses measured from 1994 forward can be used to determine the n/p values of 0.8 and 1.7 so that the **photon doses measured prior to 1994** can be used to calculated neutron doses prior to 1994.

<u>SC&A's Response to NIOSH's ER Position concerning External Dose at Pantex</u>

While the recommended n/p method may bound some of the Pantex worker's neutron dose, 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 n/p value of 0.8 and 1.7 was obtained from 43 data points taken during the period of 1993–2003 (no data for 1997), the data is reasonably distributed during this period with 4 to 5 points per each year. However, 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. The only mention of this issue in NIOSH's ER was on page 47 where it is stated, "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…" There is no further supporting evidence or references provided. Bench-mark measurements would have to have been made to establish a relationship between the n/p values during the early period compared to the latter period when the n/p value was derived. NTA film results cannot be used for this purpose because they have been deemed unreliable. Documentation of dose measurements (such as by survey instruments) at various locations and time periods compared to the 1993-2003 neutron and photon dose measurements would be required to determine rather radiation fields were compatible or not to justify use of NIOSH's recommended method and n/p values.

(b) **Examples where n/p of 1.7 is not bounding –** There are numerous examples, over a significant time period (1960–1995) that indicates that using an n/p value of 1.7 would not bound the neutron dose. See Attachment 1 for some examples where the n/p values ranged from 2.0 to 13.6, with a GM = 5.0, when measured during surveys. Additionally, if a worker's recorded NTA film results shows a dose greater than that calculated using an n/p value of 1.7, it cannot be used (as recommended in ORAUT-TKBS-0013-6, page 42) because the correct neutron dose is not known from the NTA film results, which have been deemed unreliable. SC&A performed a preliminary review of 14 Pantex claims and found that where neutron doses were assigned, the dose reconstructions did not always use an n/p value of 0.8 for unmonitored and 1.7 for monitored workers, but instead used n/p values ranging from 0.25 to 2.5; only 50% of the time were the recommended n/p values of 0.8 or 1.7 used. SC&A found that n/p values of 0.25, 0.80, 1.0, 1.7, 2.0, and 2.5 were used in the cases examined to date.

(c) **Comparison to collective dose n/p value not valid –** The statement on page 50 of the ER that the recommended n/p value of 1.7 is 6.8 times the n/p 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. This was discussed by NIOSH in ORAUT-TKBS-0013-6, page 33, where it is stated that "However, these ratios are not directly applicable to claimants because they are derived from collective doses. They do not take into account the "diluting" effect of numerous workers who had photon doses only (Martin, 2006b)." The annotations in brackets are further discussed on page 56. Therefore, the ER statement concerning the factor of 6.8 times is somewhat misleading.

(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 appears to be adequate, it is not as apparent that the measured photon doses are as reliability as are required for use to assign both photon dose and to derived the 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 (for example, if a 100 mrem photon reading is in error by 10%, this leads to: 10 mrem photon + 1.7 n/p × 10 mrem = 27 mrem total error; this is a total error of 27%).

In the ER, NIOSH states the following on page 46:

> *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).*

In TKBS-0013-6, page 28, NIOSH states, "Photon radiation in the workplace would have been readily measured at Pantex, with available dosimeter technology, during all years of operation."

However, SC&A has identified the following areas of concern:

- Calibration using medium to high energy photons (Co-60 and Cs-137), when 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 TBD and SEC ER states photon dosimetry was correct, while IAAP TBD, for similar operations, state that only 37% of 60 keV dose was measured.

- DOE Investigative Board findings are relevant to the credibility of photon; and hence, neutron dose reconstruction at Pantex.

The support for these concerns includes the following:

Calibration vs. Work Area Photon Energies
Dosimeters were calibrated using medium to high energy photons (Co-60 and Cs-137, page 23 of ORAUT-TKBS-0013-6), but according to pages 25 and 54 of ORAUT-TKBS-0013-6, the predominant source of radiation dose at Pantex is photons from Am-241, with the 60 keV photon being the most significant energy. This would lead to the film over responding in the open window (OW) of the badge (shallow dose), but could lead to the film **under-responding** under the shielded portion of the badge (deep dose) for some earlier dosimeters with thick filters, such as 1 mm Pb. This is discussed in detail in SC&A's evaluation of the Pantex Site Profile on pages 51–56 [SCA 2008]

Additionally, there was a wide range of photon energies present in the various work areas at Pantex as stated on page 24 of ORAUT-TKBS-0013-6. This would require different calibration factors for different work areas if the dosimeters were calibrated using only one photon energy spectrum.

Three different dosimetry vendors performed the dosimetry services for Pantex, yet the details of the photon energy fields were not available to them for use in calibration because this information was classified. This would not provide for a situation where the dosimeter results could be demonstrated to be technically reliable by matching the calibration photon energy spectra to the work place photon energy spectra.

As illustrated above, NIOSH's SEC ER and the Pantex TBD states that photon dosimetry results were correct without any correction factors, except for lead aprons; while IAAP, a facility with similar operations, TKBS-0018 [ORAUT 2005] states that only 37% of 60keV photon dose was measured and recommends a correction factor of 1/0.30 = 3.33 based on Hanford studies. Comparing the TBDs for IAAP and Pantex leads to the conclusion that the two plants were very similar in operations and functions; however, the recommendations for low-energy photon dose corrections are inconsistent with each other; one using a correction factor of 3 and the other a correction factor of 1.0.

Problems Identified during Investigation are Relevant

DOE Investigative Board finding **are** relevant to the credibility of photon; and hence, neutron dose reconstruction at Pantex. As late as 1979, when TLD dosimeters were being used, the procedures for, and characteristics of, photon exposures at the Pantex plant were not completely documented or understood. The dosimetry section at that time appears to have been under staffed and not sufficiently equipped to support NIOSH's statement that the photon dose of record are accurate and do not require any adjustment factors. Some of the deficiencies are discussed in SC&A's review of the Pantex TBD (SC&A 2008) and provided in detail in a classified report issued in 1980 by DOE, titled, *Report of the Investigation of a Radiation*

Exposure Incident at the Pantex Plant During September 1979 (DOE 1980). These deficiencies in the dosimetry program as late as 1979 raises ever more concerns about the reliability of prior photon dose of record; especially in the early years when dosimetry was less advanced.

References:

ORAUT (Oak Ridge Associated Universities Team) 2005. *Technical Basis Document for Atomic Energy Operations at the Iowa Ammunition Plant (IAAP)*, ORAUT-TKBS-0018, Revision 01, Oak Ridge Associated Universities Team, Cincinnati, Ohio. March 14, 2005.

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