NIOSH Response to Comments and Issues Raised at the SEC-00250 Y-12 Work Group

Response Paper

National Institute for Occupational Safety and Health

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BACKGROUND

During the September 24, 2020 meeting of the SEC-00250 Y-12 Work Group (WG) of the Advisory Board on Radiation and Worker Health (ABRWH), NIOSH committed to preparing a paper that would respond to the comments and issues raised during that meeting. The comments and issues came from three sources:

- A document prepared by the Y-12 petitioners titled, *Analysis of Working Conditions, Worker Exposures and Monitoring, 1980–1994, Y-12 Plant, Oak Ridge, TN* [Name redacted 2020a]. This document was submitted to the WG in August 2020 in preparation for the September meeting.

- A PowerPoint presentation prepared by the Y-12 petitioners titled, *Y-12 SEC Petition 250 Petitioner's Response* that was delivered during the September meeting [Names redacted 2020b]. This presentation contained several issues not included in the petitioner document above.

- A PowerPoint presentation prepared by SC&A that was delivered during the September meeting [SC&A 2020a]. The ensuing discussion was the source of one issue documented in the meeting transcript [ABRWH 2020].

In addition, following the WG meeting, a series of interviews were held with individuals identified by the petitioner and petitioner representative as having additional information for NIOSH consideration. The issues raised during the interviews are also addressed in this response.

APPROACH TO ISSUES RAISED AT THE 2020 Y-12 WG MEETING

The issues raised by the petitioners, SC&A, and during the interviews were wide-ranging and covered many topics. Issues from the various source documents were grouped. The grouped issues are as follows:

- Section A: Issues identified in the Y-12 petitioners' paper, *Analysis of Working Conditions, Worker Exposures and Monitoring, 1980–1994, T-12 Plant, Oak Ridge, TN*

- Section B: Issues identified in the Y-12 petitioners' presentation, *Y-12 SEC Petition 250 Petitioner's Response,* that were not included in the petitioner paper above

- Section C: An issue raised in the SC&A presentation of their review of the SEC-00250 Y-12 evaluation report (ER)

- Section D: Issues raised in additional interviews with former Y-12 employees initiated by the petitioners

SECTION A: ISSUES RAISED IN PETITIONERS' PAPER

ISSUE A1: Inaccuracies within worker exposure cited during the development of the Center for Epidemiologic Research (CER) epidemiological study render the data unusable for dose reconstruction.

Relevant excerpts from the Y-12 petitioners' paper:

> *The Center for Epidemiological Research (CER) was in receipt of electronic files derived from hardcopy records of worker exposure data from Y-12 from 1978 through 1991 or later, for the purpose of epidemiological studies relating to worker exposures. It was found there were discrepancies between the hardcopy radiation records and the electronic files. There was a reconciliation performed; but, it only sampled 210 worker records, which is only 1% of the worker population. Conversely, the Radiation Exposures for DOE and DOE Contractor Employees Annual Report published every year from 1974 depicts a much larger population from which to sample, numbering in the thousands. This would dictate a challenge to the NIOSH statistical analysis to arrive at co-worker assumptions used in dose reconstruction for the unmonitored population [Name redacted 2020a, PDF p. 4].*
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> *The data found in the electronic copy would not have been adequate for dose assessment and review of the hardcopy data would be required. When this review was conducted, only a small sample of 210 workers was looked at and did not include the data for the whole Y-12 workforce [Name redacted 2020a, PDF p. 5].*
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> *There were also data-entry and transposition errors in the electronic files found and while they were stated to have been corrected, as of 1991 this process was still underway and a final evaluation of the fixes has not been published [Name redacted 2020a, PDF p. 5].*

NIOSH Response: The Y-12 co-exposure study, documented in ORAUT-TKBS-0014-5 [ORAUT 2012], employs bioassay results obtained from the Oak Ridge Institute for Science and Education CER Dosimetry Database. This database contains uranium urinalysis records from the Y-12 Plant from 1950 to 1988. The CER obtained this database from Y-12 to conduct an epidemiology study of site workers. The process used to review and validate these data is detailed in the document cited above by the petitioner [Watkins 1993]. As part of the validation process, a stratified random sample was taken of 500 workers in the same race/gender proportions as the study cohort. Data from this group were verified by comparing dataset values to facility hardcopy and source records [Watkins 1993]. Although the petitioner takes issue with

the fact that only 210 of the 500 had Y-12 employment, that fact alone does not discount the analysis results, which indicates a good correlation between the CER data and the source data. Watkins found an exact match between the CER and source data in 205 of 210 cases (97.6%). NIOSH has concluded that this is a sufficient data subset to characterize the integrity of the underlying data. The petitioner cites correspondence from 1991 [Martin Marietta 1991], which is related to the use of the internal monitoring data by the epidemiological study; this is not necessarily germane to the use of these data for NIOSH's EEOICPA effort. The nature of epidemiological work requires a best estimate of worker internal exposure based on the available data. In the case of the CER data, information on the nature (acute versus chronic) and duration of exposure complicates the ability to use these data for epidemiological purposes. These same limitations are not problematic for using the data for internal dose reconstruction for EEOICPA claimants because claimant-favorable assumptions can be used to arrive at a bounding estimate of internal exposure. In addition, NIOSH has employed these data to develop a co-exposure model for use when sufficient claimant-specific data are not available.

The use of the CER data was the subject of Finding 2 of the SC&A review of ORAUT-OTIB-0029 (Y-12 co-worker data), which was subsequently incorporated into ORAUT-TKBS-0014-5:

> *The ORISE CER database of uranium urinalysis records for the Y-12 site for 1950–1988 was used, without questioning the accuracy of these records. The records were used despite the problems pointed out by ORAUT-OTIB-0029* [ABRWH 2007, PDF 2].

The Board Review System documents the following conclusion:

> *SC&A accepts the use of CER database for the calculation of intakes and doses of the unmonitored workers, as described in Attachment B, Internal Dosimetry Coworker Data for Y [-12], ORAUT-TKBS-0014-5, Revision 3, 2012. SC&A accepts NIOSH arguments that the CER database is considered the official dose of record for the site and is used for supplying claimant results* [ABRWH 2007, PDF 3].

This issue (i.e., Finding 2 of the SC&A review of ORAUT-OTIB-0029) was formally closed during the May 16, 2016 meeting of the Advisory Board On Radiation and Worker Health – Subcommittee on Procedures, as follows:

> *I think SC&A accepts NIOSH arguments for Finding Number 2, that the database is considered official of records for the site. And it's used to supply claimant results. So we recommend it should be closed* [ABRWH 2016, PDF p. 20].

Based on the validation performed by the CER [Watkins 1993] and the fact that the bioassay data contained in the CER database are the same data used by the Y-12 site for dose-tracking purposes, NIOSH has concluded that the data are valid for use in both individual dose reconstruction efforts and as a basis for the internal dose co-exposure study published in ORAUT-TKBS-014-5 [ORAUT 2012]. The dataset has been accepted as valid by both the Y-12 Advisory Board Work Group and their independent contractor (SC&A). NIOSH is not aware of any inaccuracies within the data that would negate this conclusion.

ISSUE A2: It is certain that workers involved in thorium processing after 1984, up until 1999, were not monitored for thorium exposure by lung count, whole-body count, or by using testing methods compliant with ANSI standards

Relevant excerpts from the Y-12 petitioners' paper:

> *The in vivo lung count was the only monitoring technique for monitoring thorium exposure in the body during the Plant's first decades. Thorium lung activity was inferred from 228 Ac and/or 212 Pb lung activity (Souleyrette 2003). Thorium lung counting was conducted from 1958 to 1984 with routine lung counts, scheduled at approximately 6-month intervals, starting in 1961. (BWXT, 2005)" However, the background levels for 212 Pb were too high to read worker levels accurately* [Name redacted 2020a, PDF p. 5].
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> *In spite of the continuation of thorium 232Th processing at Y-12 through 1999, the routine lung count testing was discontinued in 1984. As late as 2012, machining equipment was found to be contaminated with thorium, returning readings of 240,000 dpm/100cm2 fixed plus removable beta and gamma* [Name redacted 2020a, PDF p. 6].
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> *The test that was used to monitor 232Th did not meet ANSI N42.22 or ANSI N13.30 standards. The test used to monitor 230Th was only developed to meet these standards in 2007* [Name redacted 2020a, PDF p. 7].

NIOSH Response: The SEC-00251 Y-12 ER [NIOSH 2018] established an SEC class based on the infeasibility to reconstruct internal doses from thorium (and plutonium-241) from January 1, 1958 through December 31, 1976. This class was expanded through July 31, 1979 by the SEC-00250 ER [NIOSH 2019]. The SEC-00250 ER provided an evaluation of available Ac-228 and Pb-212 monitoring data along with a methodology for using those data to estimate Y-12 thorium dose from August 1, 1979 through December 31, 1986 (the period January 1, 1987 through December 31, 1994 was reserved awaiting the receipt of additional data).

In its review of the SEC-00250 Y-12 ER, SC&A reviewed the thorium dose-reconstruction methodology and concurred with NIOSH's conclusion, as reflected in the following SC&A observation:

> *Observation 2: The in vivo monitoring program using the stationary count facilities at the Y-12 Plant employed essentially identical methods and equipment as the Mobile In Vivo Radiation Monitoring Laboratory (MIVRML), which was likewise developed at Y-12. The Board has previously evaluated the adequacy of the MIVRML system at the Fernald site and found it to be a reasonable and scientifically accurate monitoring methodology for use in EEOICPA* [SC&A 2020a, PDF p. 43].

The NIOSH response to SC&A's review of the SEC-00250 ER [NIOSH 2020] as well as recent SC&A presentations related to NIOSH's response [SC&A 2020b,c] have identified issues related to implementing the methodology contained in the ER. Discussions about these issues are currently on-going.

The thorium-monitoring evaluation for the period from January 1, 1987 through December 31, 1994 is currently under development and will be presented in an addendum to the SEC-00250 ER.

Regarding the implementation of ANSI N13.30, the Y-12 whole-body/chest-counting system was upgraded in 1992 to comply with the (then draft) standard [Martin Marietta 1989a, PDF p. 120]. The upgraded system came into service in May 1992.

Y-12's commitment to implementing the ANSI N13.30 standard is documented in the March 1992 Internal Dosimetry Technical Basis Manual [Martin Marietta 1992a], which states:

> *Criteria for the accreditation of radiobioassay service laboratories (in vivo and in vitro) are given in ANSI N13.30 (Draft ANSI92). While this document is still in draft form, Y-12 bioassay programs seek to meet or exceed its requirements* [Martin Marietta 1992a, PDF p. 20].

Bias and precision calculations associated with the Y-12 lung counting system are consistent with ANSI N13.30 requirements [Martin Marietta 1992a, PDF p. 21].

It should be noted that the ANSI N42.22 standard was issued in 1995, which is after both the period evaluated in the SEC-00250 ER (through 1979) and the currently-active SEC-00250 ER Addendum (1979 through 1994).

In summary, compliance with the ANSI standards cited by the petitioner does not impact the ability to use the available monitoring data to generate a claimant-favorable dose reconstruction.

ISSUE A3: (a) Noncompliance with ICRP standards requiring routine bioassay until 1999; and (b) Neither NIOSH nor SC&A have addressed the evidence submitted that Y-12 did not monitor for internal dose prior to 1990.

Relevant excerpts from the Y-12 petitioners' paper and presentation:

> *Historically, the standard for individual monitoring for intakes of radionuclides has been set by the International Commission on Radiological Protection. ICRP Publication 54, Individual Monitoring for Intakes of Radionuclides by Workers: Design and Interpretation, published in 1988. "It was a companion volume to Publication 30 (ICRP, 1979a,b, 1980, 1981a,b, 1982a,b, 1988a) which gave values of Annual Limits on Intake for radionuclides based on then current modes of the respiratory and gastrointestinal tracts and biokinetic models. Since that time there have been major developments in radiation protection…It has become necessary, therefore, to replace Publication 54 (ICRP, 1988b) with a new document." It was replaced by ICRP Publication 78, Individual Monitoring for Internal Exposure of Workers, Replacement of ICRP Publication 54, published in 1997* [Name redacted 2020a, PDF p. 8].
>
> *Internal dose monitoring, or bioassay, was not required until 1989 at Y-12, at which time soluble testing was began. Prior to this time, bioassay testing was only conducted randomly, usually based on an incident* [Name redacted 2020a, PDF p. 10].
>
> *The adoption of DOE Order 5480.11 in 1989 required RadCon and health physics technicians to survey jobs and determine if bioassay was required. But, as is stated further in this report, Y-12 was still not in compliance with this order as late as 1993. The implementation of routine bioassay monitoring for all workers who were at risk would be in line with the ICRP 78 guidelines as stated, "Routine monitoring would only be required in conditions of essentially continuous risk of contamination of the workplace as a result of normal operations." However, this was not done until 1999* [Name redacted 2020a, PDF p. 12].
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> *…Also, the detection limits for uranium before 1989 are only established on a provisional basis. The detection limit for plutonium before 1988 "has not yet been identified"* [Name redacted 2020a, PDF p. 10].

Because no consideration was given to the multiple ingestion pathways through which workers could inadvertently take in radioactive material, the absence of bioassay testing has missed many exposures [Name redacted 2020a, PDF p. 10].

However, in 1999, as a result of new ICRP standards, it was found that insoluble and fecal monitoring was also needed [Name redacted 2020a, PDF p. 10].

The standards for which workers received monitoring was not consistent with ICRP standards, in that salaried workers were more closely monitored than hourly workers. Workers that performed the operations outlined in ICRP 78 were not monitored as frequently as salaried or office workers, who did not come in contact with radiological material. Consequently, the bioassay records for salaried workers returned higher values than the hourly workers [Name redacted 2020a, PDF p. 11].

…chronic levels of radiation exposure from uranium handling, while recognized, were not seen as a concern and, therefore, not given much attention in the Y-12 dosimetry program…Supervisors were typically given latitude to make decisions regarding which of their workers were provided badging, bioassay and respiratory protection, and how radiation jobs were performed…With the production exigencies of the Cold War, production was often the first priority and workers were kept at their contaminated workstations for almost the entire workday [Name redacted 2020a, PDF p. 13].

The machinists were required to work in cloth short-sleeved coveralls and without gloves, as wearing long sleeves and gloves was thought to be a safety hazard around rotating equipment. Some hourly workers wore long-sleeved shirts and chemical gloves taped to the long sleeves; but, other hourly workers wore short-sleeved coveralls [Name redacted 2020a, PDF p. 11].

Many of the hourly support workers, like janitors and laborers, were also only given short-sleeved cloth coveralls even though they were assigned to areas where known and unknown radioactive contaminants were present. Most of the shifts that required support workers to be in enriched areas were overtime shifts and dressing requirements were not consistently observed, instead deferring to the production schedule. They were required to handle these contaminants and work closely with that material, potentially breathing or ingesting it. They relied on the immediate employee supervisor to order bioassay testing and many were never bioassayed for their entire terms of employment at Y-12. Machinists could be bioassay monitored based on incident exposure; but, other hourly workers in the same area were not bioassayed unless their supervisor requested it [Name redacted 2020a, PDF pp. 11–12].

In 2000, when bioassay monitoring for certain designated workers was implemented, there was a policy that stated after three tests were returned above allowable levels, the worker would be removed from their work area for a designated period of time. However, this was not conducted equally across all process areas. Machinists who were working with depleted and binary uranium were not bioassay monitored, even though uranium oxide contamination was found in the work area [Name redacted 2020a, PDF pp. 12–13].

Inside air monitors were not placed in the work area properly using a smoke test, which created a "pig pen effect" where the monitor was placed away from the worker and in dead zones, assuming the worker would generate an aerosol to reach the monitors. This would not read concentrations where higher than expected levels occurred adjacent to the worker. In the process of machining uranium parts, there were daily uranium "chip fires" that generated uranium smoke that the machinist could not avoid inhaling. The usual practice was that a fire had to be large enough to warrant a visit by the fire department before attention would be given to the workers affected. Because of rotating shift workers, periods of days could elapse before those incidents were recorded in the log books for each machine. Policies regarding recording of uranium fires in log books was inconsistent across different buildings. If a machinist were to be in proximity to uranium dust or smoke from a uranium chip fire and their work location was not close enough to the air monitor, this exposure would go unrecorded, particularly when there is no bioassay monitoring available to that worker [Name redacted 2020a, PDF p. 16].

Machinists were also required to carry machined enriched, binary and depleted uranium parts of 70 pounds and less because the crane used was for heavier parts. These larger cranes prevented air monitors being placed over the machines and the monitors were placed away from the worker (see Sec 5 Internal Air Monitoring). Many times the size and weight of the part necessitated carrying it close to the body [Name redacted 2020a, PDF p. 12].

Supervisors determined if the employee needed a respirator and was in charge of the respirator cabinet for all hourly workers [Name redacted 2020a, PDF p. 12].

The NIOSH intake model does not treat the uncertainties inherent in bioassay measurements to detect intakes from urine samples after exposure to Type S uranium, as found in "high-fired" oxides. It also does not address the implication of a 48-hour absence from the workplace by the worker following a weekend before routine urine samples were taken: without an appropriate adjustment, this would lead to underestimation by the TBD model of a factor of 2-4 as a function of lung clearance type." When urine testing was implemented for employees determined to be exposure risks, they were forced to take the urine test kit home on the weekend and return it on Monday [Name redacted 2020a, PDF p. 13].

In 1989, the Department of Energy (DOE) changed procedures and required the summation of external and internal doses. Previous to that time, internal exposure was only assessed against an acceptable value (MPBB) and no reporting was required [Name redacted 2020a, PDF p. 5].

Neither NIOSH nor SC&A have addressed the evidence submitted that Y-12 did not monitor for internal dose prior to 1990.

The occupational radiation report states [sic] *submitted with the petition states,*

a - Monitoring not required.
b - In accordance with regulations, Internal Dose and Total Dose were not calculated prior to 1989.

NIOSH's document asserts that,

> *Thus, the presence of fecal sample results in an individual's monitoring records is a strong indicator that the worker was exposed to insoluble uranium compounds"*

NIOSH's assumption is incorrect because routine fecal sampling was not done before 1999. The "Y-12 Uranium Exposure Study" dated August 5, 1999 states,

> *Following the recent restart of operations at the Y-12 Plant, the Radiological Control Organization (RCO) observed that the enriched uranium exposures appeared to involve insoluble rather than soluble uranium that presumably characterized most earlier Y-12 operations. These observations necessitated changes in the bioassay program, particularly the need for routine fecal sampling* [Names redacted 2020b, PDF p. 3].

NIOSH Response:

NOTE: NIOSH acknowledges that consideration of the 48-hour absence from the workplace may impact the evaluation of bioassay data, and thus, the determination of internal dose under the EEOICPA program. NIOSH is not currently of the opinion that this issue impacts the feasibility of reconstructing internal dose for Y-12 workers in the class currently under evaluation. Nevertheless, this issue will be addressed during the resolution of SC&A comments to the Y-12 Technical Basis document, which is being done in a separate effort.

The petitioners assert that internal dose monitoring was not required at Y-12 until 1989, which they attribute to the SC&A site profile review document, SCA-TR-TASK-0007 [SC&A 2005].

NIOSH reviewed the cited document and did not locate such a finding. Based on NIOSH's Y-12 research, it is clear that bioassay analyses exist. NIOSH has access to nearly 400,000 sample results that were contained in the CER Dosimetry Database. These data were used to develop a co-exposure model for reconstructing internal dose from uranium exposure at Y-12 [ORAUT 2012]. During the dose reconstruction process, NIOSH uses individual bioassay data or, when necessary, co-exposure data. Co-exposure data are used to assign dose to unmonitored individuals who have a potential for internal exposure; this would compensate for any discrepancy in monitoring frequency between salaried and hourly employees. These same co-exposure data would also capture intake fluctuations from uranium fires, which were described as occurring frequently and often without coordinated fire department response.

In 1989, there was a major shift in internal monitoring requirements due to the implementation of DOE Order 5480.11 [DOE 1988]. This order required the *calculation of internal dose*. Prior to this, internal dose was not required to be calculated; rather, available bioassay data were used to determine the quantity of radioactive material present. This quantity was then compared to the applicable Maximum Permissible Body Burden [MPBB] limit (based on the radionuclide[s] involved) [Martin Marietta 1989b]. The changes in 1989 reflect how the collected bioassay data were assessed by Y-12 (i.e., the calculation of internal dose versus the calculation of the percent of MPBB present) and do not necessarily reflect the frequency of bioassay monitoring. Under EEOICPA, NIOSH uses neither DOE-calculated internal doses nor Maximum Permissible Body Burdens to determine the internal dose to an organ of interest. Rather, internal dose is calculated using either the individual's bioassay or estimates of intake detailed in NIOSH's co-exposure models.

ISSUE A4: Insufficient ambient external air monitoring for estimating site doses prior to 1983.

Relevant excerpts from the Y-12 petitioners' paper:

> *Ambient air monitoring at Y-12 prior to 1983 is insufficient for estimating environmental doses… Given the distance between the main production areas of Y-12 and the locations of these stations (HP-32 and Station 40), it is unlikely that these stations reflect the level of on-site ambient uranium. Consequently, these stations do not present a representative measure of air concentrations at Y-12 and cannot be used to estimate on site doses* [Name redacted 2020a, PDF p. 15].

NIOSH Response: The quote is from Section 4.3.1 of the Y-12 Occupational Environmental Dose TBD [ORAUT 2006]. Section 4.3.2 of that same document provides an alternative methodology for arriving at a claimant-favorable estimation of environmental internal dose. The methodology employs an empirical relationship developed by using on-site measured air

concentrations and estimated uranium release estimates. The approach circumvents the need for air-dispersion modeling by providing a direct relationship between uranium air concentrations and uranium releases.

ISSUE A5: Insufficient indoor air sampling until 1993, requiring particle size monitoring.

Relevant excerpts from the Y-12 petitioners' paper:

> *In the absence of bioassay, the air sampling of uranium particle size would be the only way to monitor that workers exposure level. There were no standards for air monitoring until NUREG 1400, Air Sampling in the Workplace, was published in September, 1993. It established guidelines for the placement of air monitors to represent inhaled air. Prior to this, particle size from a room monitor was the only way to know possible airborne exposures had occurred and workers in that space must then be tested further* [Name redacted 2020a, PDF p. 16–17].
>
> *Measured particle size values should be used over a default value of 5 um (as called for by 42 CFR Part 82), particularly at Y-12, where the particle size has been found to range from 1-10 um* [Name redacted 2020a, PDF p. 17].
>
> *Another example of a chronic source of "incidental" exposure of Y-12 workers is elevated airborne levels of uranium contamination due to failures of the building exhaust fans or, the incinerator…most of this elevated contamination was due to "backflow of air through the ducts at a time when the exhaust fans were off* [Name redacted 2020a, PDF p. 17].
>
> *In the buildings where processes were conducted using radiological material, the procedure for air monitoring was to weekly collect the filter papers from the monitors. Based on testimony of a Utility Operator responsible for recording the readings off those filters, there were certain buildings where the exhaust fans were turned off to reduce the amount of contaminated air reaching the outside. When the air monitor readings for those buildings were recorded, if there were any readings that were above allowed levels, those records were not forwarded to the DOE office in Washington, DC for review. There was a second set of records showing acceptable air level readings in those buildings that were sent off to Washington. At Y-12, the main objective was to reduce incident reports. This was irrespective of worker health and safety* [Name redacted 2020a, PDF p. 17].

NIOSH Response:

NOTE: NIOSH acknowledges that assumptions about particle size can impact the evaluation of bioassay data, and thus, the determination of internal dose under the EEOICPA program. NIOSH is not currently of the opinion that this issue impacts the feasibility of reconstructing internal dose for Y-12 workers in the class currently under evaluation. Nevertheless, this issue will be addressed during the resolution of SC&A comments to the Y-12 Technical Basis document, which has a more general scope and is being done in a separate effort.

NIOSH does not use Y-12 indoor air-monitoring data for internal dose reconstruction for EEOICPA claimants. Claimant dose-reconstruction methodology is outlined in general in ORAUT-PROC-0106, *Roadmap to Reconstructing Dose* [ORAUT 2020m]. Section 5.16 of that document identifies the hierarchy of data used in dose reconstruction as: (1) personal dosimetry data, (2) personal monitoring data, (3) co-exposure data, (4) area and environmental monitoring data, (5) source term data, and (6) radiation control limits. For Y-12 in particular, NIOSH has determined that there is sufficient personal monitoring and/or co-exposure data to perform dose reconstructions.

ISSUE A6: No known methodology to convert MPBB to E50 after adoption of DOE Order 5480.11 in 1989, making dose reconstruction before 1989 impossible.

Relevant excerpts from the Y-12 petitioners' paper:

> *Prior to January, 1, 1989, regulations in the DOE did not require computation of E50 and HT,50 values from bioassay and workplace monitoring data. From January 1, 1989, with the adoption of DOE Order 5480.11, sites were required to assess and record these values. Prior to 1989, records of intakes, if they exist, were likely to be expressed in fractions of a maximum permissible body burden (MPBB)." This order "…specified the uptakes of radionuclides be converted to internal dose and reposted using the AEDE methodology. With the implementation of the RadCon Manual in 1993, the methodology used to calculate and report internal dose was changed from the AEDE to the 50-year CEDE." "There is no simple and straightforward general method to convert MPBB values to E50 values. Sites should consider whether it is feasible and cost-effective to attempt to historically reassess doses prior to 1989. The DOE position on prior years' exposures records does not address doses due to intakes prior to 1989 or intakes at non-DOE facilities."* [Name redacted 2020a, PDF p. 17].

NIOSH Response: NIOSH is aware of the changes in internal dose reporting requirements that were implemented in 1989. As a result of this change, DOE sites (such as Y-12) shifted focus from tracking the quantity of radioactive material contained within individuals against a nuclide-specific limit (termed the Maximum Permissible Body Burden (MPBB) to the calculation of an internal dose value based on the material present. However, NIOSH uses neither site-calculated internal dose nor MPBB values to reconstruct internal dose for the EEOICPA program. The NIOSH process employs claimant-favorable assumptions related to exposure conditions and material composition. These assumptions allow for sufficiently accurate dose assessments using available individual bioassay records. Note that although it is problematic to calculate a committed effective dose equivalent directly from an MPBB value alone, consideration of additional information (e.g., the radionuclide involved and the exposure conditions) would allow such calculations to be performed.

ISSUE A7: Inadequate or non-existent worker monitoring of radionuclides other than uranium.

Relevant excerpts from the Y-12 petitioners' paper:

> *The internal dose TBD is incomplete in its review of the historic dose contribution of radioisotopes other than uranium. These radionuclides include 3H, 90Sr, 99Tc, 210Pl* [sic: 210Po], *228Th, 232Th, 239Pu, 241Pu, 237Np, 233U and 241Am…site experts indicated in interviews that radionuclides processed or worked with at the Y-12 plant included 3H, 232U, 233U, 237Np, 238Pu, 239Pu, 240Pu, 228Th, 232Th, and 241Am* [Name redacted 2020a, PDF p. 19].
>
> *Currently, some of these unmonitored doses are added into the dose reconstruction equation; however, the entire list is not included there* [Name redacted 2020a, PDF p. 19].

NIOSH Response: The provided excerpt is documented as Finding 4 in SC&A's 2005 review of the Y-12 Site Profile. The sentence following the provided excerpt provides additional clarity on the nature of the listed radionuclides:

> *Some of these radionuclides were associated with research and development activities, while others were handled in production, either as a source material or as a contaminant, e.g., from recycled uranium* [SC&A 2005, PDF p. 16].

NIOSH is currently evaluating the need to update the Y-12 Occupational Internal Dose Technical Basis Document, ORAUT-TKBS-0014-5 [ORAUT 2012], to address this comment; however, NIOSH is not of the opinion that the issue impacts the ability to reconstruct internal dose in a claimant-favorable manner.

ORAUT-TKBS-0014-5, Section 5.1.2 currently states:

> *When claim information indicates that a Y-12 worker was involved with research activities involving the calutron, cyclotron (accelerator), fusion work, or plutonium [except in the case of recycled uranium (RU) exposure, which is addressed in this section], consideration must be given to possible exposure to radionuclides other than uranium* [ORAUT 2012, PDF p. 10].

ORAUT-TKBS-0014-5, Section 5.2.4.1 provides guidance on the inclusion of internal dose from nuclides introduced by the recycling of uranium (i.e., Tc-99, Th-228, Np-237, Pu-238, and Pu-239) [ORAUT 2012]. Section 5.3.2 of the TBD also contains guidance on the interpretation of a claimant's non-uranium bioassay measurements for application to the following nuclides:

- uranium-233/232: Section 5.3.2.1, PDF pp. 28–29
- plutonium: Section 5.3.2.2, PDF p. 29
- tritium: Section 5.3.2.3, PDF p. 29
- americium, strontium, and technetium: Section 5.3.2.4, PDF pp. 29–30

ORAUT-RPRT-0090 provides additional information on the feasibility of reconstructing exposures for workers involved with research activities involving the calutron, cyclotron (accelerator), fusion work, or plutonium [ORAUT 2018].

It should be noted that individual dose reconstruction efforts are not limited by the information contained in the site profile document. Rather, claimant-favorable assumptions are used to interpret data and exposure conditions that are not specifically addressed. When necessary, NIOSH can request additional information from the Y-12 site and locate necessary information within the documentation previously obtained either from the site or from other NOCTS claimants.

ISSUE A8: Noncompliance with ALARA, 10 CFR 835, DOE Order 5480.11, DNFSB Recommendations 90-2 and 91-1, ICRP 30, 54 and 78, eventually requiring a cessation of operations from 1994–1998.

Relevant excerpts from the Y-12 petitioners' paper:

> *Upon conducting a review of the implementation plans for DOE Order 5480.11 during April 7-8, 1993, "Senior DOE Oak Ridge Field Office (DOE-ORO) and Martin Marietta Energy Systems (MMES) radiological controls managers stated the opinion that many DOE Radiological Control Manual mandatory requirements are "good management practices"*

which will not necessarily be implemented at the Y-12 Plant due to insufficient resources…" [Name redacted 2020a, PDF p. 20–21].

…There are numerous instances where Y-12 is not in compliance with DOE Order 5480.11, the DOE Radiological Controls Manual, or consensus standards…The MMES Y-12 Plant Radiation Protection Upgrades Manager stated that the organization and budget to implement the Radiological Control Manual will be severely limited in FY94…Some of the areas in which MMES is farthest from being in full compliance with the requirements of these instructions include contamination control, training and occurrence reporting [Name redacted 2020a, PDF p. 21].

The Defense Nuclear Facilities Safety Board submitted Recommendation 94-4, Deficiencies in Criticality Safety at Oak Ridge Y-12 Plant, to Victor H. Reis, Assistant Secretary for Defense Programs, on September 27, 1994. In the accompanying staff report, it was stated that, "Although Y-12 has made some improvements over the past two years, activities at the plant still do not comply with DOE Order 5480.19, Conduct of Operations Requirements for DOE Facilities. The DNFSB staff has identified many conduct of operations deficiencies during reviews at Y-12. The DNFSB has pointed out this fact to both DOE Oak Ridge and Martin Marietta Energy Systems (MMES) senior management. Although the Y-12 management appears willing to change the existing operational culture, they clearly have not implemented the changes effectively… The DNFSB staff believes this is a clear indication of an institutional culture that lacks the appropriate level of rigor and formality associated with conduct of operations…Despite the DNFSB Recommendations, site specific reporting requirements, publicly-issued trip reports, and numerous staff reviews…recent events indicate that the personnel at the Oak Ridge Y-12 Plant still have not integrated several fundamental concepts supporting sage operations into their daily routines. These fundamental concepts include providing adequate procedures…, ensuring the workforce is properly trained, expecting compliance with requirements, and conducting nuclear facility operations formally. All these concepts are necessary in a integrated, systems engineering-based health and safety management strategy required of a modern DOE defense nuclear facility [Name redacted 2020a, PDF p. 22–23].

In Memorandum for Distribution, Radiological Control Technical Positions Regarding Use of Personal Nuclear Accident Dosimeters and Internal Audits, February 18, 2011, it is stated, "On November 22, 1996, Lockheed Martin Energy Systems (LMES) requested, for the Y-12 facility, an exemption from 10 C.F.R. 835.1304(b)(4), which at the time required "Personal nuclear accident dosimeters worn by all personnel who enter locations in which installed criticality alarm systems are required." The requirement for installed criticality alarm systems was specified in DOE O 420.1A, chapter 2, October 24, 1996, which required

installed criticality alarm systems "to cover occupied areas in which the expected dose exceeds 12 rads in free air." The exemption request listed eight locations at the Y-12 facility outside the security fence, which met the requirement for needing an installed criticality alarm system, and accordingly, PNADs for all individual entering those locations. On April 10, 1997, DOE granted an Exemption Decision to LMES to allow the site to establish PNAD zones based on criteria other than that specified in 10 C.F.R. 835.1304(b)(4) and to take advantage of existing physical boundaries and access points, such as security fences. In recognition of this implementation difficulty, on December 23, 1996, DOE published a Notice of Proposed Rulemaking (NOPR) in the Federal Register. The NOPR explained DOE's intent to amend 10 C.F.R. 835. One of the purposes of the amendment was to revise 10 C.F.R. 835.1304 to eliminate confusion regarding the coverage of the personal nuclear accident dosimetry provisions and remove the reference to "all personnel" to provide flexibility in implementing the personal nuclear accident dosimetry provisions. DOE issued a final rule on November 4, 1998, revising the requirement to simply indicate that the nuclear accident dosimetry system must include personal nuclear accident dosimeters. This approach was to allow for flexible implementation on a site- and facility-specific basis [Name redacted 2020a, PDF p. 19–20].

In 1994 [sic: 1989], *when the DOE Order 5480.11 was enacted, many non-ALARA compliant practices were modified, curtailed or eliminated. "Y-12 continued to allow eating, drinking and smoking in radiological areas until 1988-89, and did not practice egress monitoring (DOE 1986, DNFSB 1993)"* [Name redacted 2020a, PDF p. 19–20].

One practice was to require workers with no current work assignment to gather and wait in a designated area, until their next assignment was determined. These waiting areas were adjacent to actual process areas where uranium machining was and other processes were performed. There were usually coffee pots, donuts and other edibles, as well as, dishes and cutlery, in these waiting areas where they were exposed to uranium and other unidentified particulates that were generated by process work nearby. If there was an area where known radionuclides were present, either by work activity or accidental spillage, the area would be roped off; but, workers were required to access those areas, while awaiting work assignments, on scheduled breaks, etc. [Name redacted 2020a, PDF p. 21].

NIOSH Response: The identified issues provide a clear understanding of historically poor radiological practices that fall short compared to current standards. Recent interviews with former Y-12 employees have confirmed practices such as lack of controls on eating in work areas and the lack of contamination monitoring prior to the implementation of more-stringent radiological controls in the late 1980s. Although these earlier practices may have resulted in enhanced opportunities for Y-12 worker exposures via ingestion routes, this fact does not

preclude NIOSH from completing dose reconstructions for Y-12 claims. Available internal monitoring data are evaluated in a claimant-favorable manner, considering all possible lung-clearance classes. NIOSH is currently evaluating the impact of assumptions regarding ingestion exposure in conjunction with its assessment of SC&A's review of the Y-12 Technical Basis Document [SC&A 2005]. Once this assessment is complete, the Y-12 Technical Basis Document will be revised, as appropriate. In addition, the fact that some ancillary workers (e.g., parts expeditors) may not have been placed on bioassay monitoring programs does not prevent NIOSH from reconstructing internal dose using the co-exposure data published in ORAUT-TKBS-0014-5.

Although the issues related to compliance with DOE complex-wide criticality monitoring standards represent a weakness in the implementation of such standards, these same issues do not impact the validity and availability of the site personnel radiation monitoring program records. Criticality safety monitoring is intended to augment existing monitoring practices so that immediate actions may be taken in the event of a criticality accident. Despite the site's substandard implementation of these monitoring augmentations, NIOSH still has access to sufficient routine and special-request external and internal monitoring data to perform dose reconstructions. The dialogues and negotiations between Y-12 site contractors and the DNFSB and DOE regarding PNADs were independent of the established monitoring programs upon which NIOSH relies for data for its EEOICPA dose-reconstructions efforts.

ISSUE A9: Gross lack of worker records.

Relevant excerpts from the Y-12 petitioners' paper and presentation:

> *Neither NIOSH nor SC&A have addressed the evidence submitted that Y-12 did not monitor for internal dose prior to 1990* [Names redacted 2020b, PDF p. 3].
>
> *The Y-12 Plant payroll records were maintained at the central location housed at K-25 and were later moved to a warehouse in Oak Ridge, TN; but, FOIA requests for those records do not include searching that location, only the central archive at the NNSA facility in Albuquerque, NM* [Name redacted 2020a, PDF p. 23].
>
> *The Y-12 Plant management has not prioritized the ability of current and former workers to access their own work records and this lack of documentation has made accurate dose reconstruction impossible* [Name redacted 2020a, PDF p. 24].
>
> *This, then, makes the EEOICPA claimant overly dependent upon dose reconstruction assumptions made by NIOSH. Those assumptions, in most cases, do not resemble, in any*

credible manner, the actual work experience and therefore, radiological exposures of the claimant, resulting in denied EEOICPA claims for legitimate workplace exposures that are "at least as likely as not" to have caused a workers cancer [Name redacted 2020a, PDF p. 24].

NIOSH Response: The assertion that Y-12 did not monitor for internal dose prior to 1990 is addressed in the NIOSH response to Issue A3.

NIOSH has access to a significant quantity of bioassay data (nearly 400,000 sample results) that were contained in the CER Dosimetry database. This internal monitoring dataset was used to develop a co-exposure model that is available for reconstructing internal dose from uranium exposures at Y-12 [ORAUT 2012]. Table 1 below reproduces Table 6-1 from the SEC-00250 ER, which presents a summary of the CER dosimetry database measurements from 1977 to 1988. The CER dosimetry database only extends through 1988; therefore, the associated co-exposure study only covers through 1988 as well. Although post-1988 data are available from Y-12, the Y-12 co-exposure study has not yet been updated to account for these later data. Table 2 below provides summary data on the urine sample and lung count frequency taken from currently-available Y-12 quarterly health physics summary reports for 1989–1992.

Table 1. Summary of Available CER Data

Year	No. of Urine Samples	No. of Individuals Monitored by Urine Sampling	Percent of Individuals Monitored by Urine Sampling	No. of Lung Count Measurements*	No. of Individuals Monitored by Lung Counting* **	Percent of Individuals Monitored by Lung Counting*
1977	3475	664	12%	1411	1061	20%
1978	3409	689	12%	1512	1173	21%
1979	3504	840	14%	1794	1362	23%
1980	3985	952	15%	1798	1366	22%
1981	4842	1004	16%	2091	1588	26%
1982	5836	1211	18%	3051	2264	33%
1983	5504	1313	19%	3149	2471	35%
1984	6389	1356	19%	3087	2350	33%
1985	6265	1296	17%	2960	2216	28%
1986	6629	1125	15%	2430	1674	23%
1987	6164	1043	15%	2131	1709	24%
1988	5559	1359	19%	3028	2130	29%
Total	**61561**	**3675**	**30%**	**28442**	**4801**	**40%**

Source: Y-12 SEC-00250 evaluation report, Table 6-1 [NIOSH 2019, PDF p. 34]

* Cited value is for all lung counts performed (i.e., not limited to U).

** NOTE: The values in Columns 3 and 6 represent the number of unique individuals monitored during each specific year. The Total value in the last record in Column 6 does not represent the sum of the values in that column. It represents the actual number of unique individuals monitored from 1977-1988.

Table 2. Summary of 1989–1992 Urine and Lung Count Data

Year	No. of Urine Samples*	No. of Lung Count Measurements**
1989	1562	3000
1990	2930	3086
1991	11558	2574
1992	10890	441
Total	**26940**	**9101**

Sources:

* [Martin Marietta 1993, PDF p. 10]

** 1989–1991: [Martin Marietta 1987–1991]
1992: [Martin Marietta 1992–1993]

The data presented in ORAUT-TKBS-0014-5 (which covers the period ending December 31, 1988) indicate a downward trend in intake quantities over time [ORAUT 2012, Appendix B, Table B-1]. This is consistent with the summary of uranium urinalysis data for 1987-1992 presented in the Quarterly Plant Health Physics Report for fourth-quarter 1992, which indicates a downward trend in the number of individuals exceeding the site administrative control level for uranium [Martin Marietta 1992b, PDF p. 10]. Therefore, NIOSH can use the co-worker data provided in ORAUT-TKBS-0014-5 to provide a bounding estimate of uranium intake for unmonitored individuals from 1989 through 1994 [NIOSH 2019, PDF p. 43].

NIOSH has reviewed a DOE "reasonable search protocol" document, which outlines the record sources accessed and records retrieved by DOE when gathering records for EEOICPA claimants. Included in those records are "HR Information – ORACLE System and Legacy Database." This record set is described as follows:

> *Searches are conducted by retrieving information from these two databases. The ORACLE database provides employment history from January 1998 to present. The Legacy database provides employment history from August 1990 to December 1997. Prior to 1990, hard copy records are stored on-site and searched alphabetically* [DOE 2010].

In summary, NIOSH has access to a significant amount of internal monitoring data and uses that data along with claimant-specific information and claimant-favorable assumptions to reconstruct internal dose for Y-12 workers.

SECTION B: ISSUES RAISED IN PETITIONERS' PRESENTATION

ISSUE B1: NIOSH did not address complex-wide deficiencies in monitoring program.

Relevant excerpts from the Y-12 petitioners' presentation:

1. *Annual reports to workers documenting their exposures to radiation incomplete.*
2. *Repeated failures to perform in vivo bioassays as required.*
3. *Failure to perform special, follow-up bioassays in a timely manner.*
4. *Radiological worker restrictions not implemented in a timely manner.*
5. *Failure to perform termination bioassays and, subsequently, failure to issue reports of terminated worker exposures.*
6. *Collection of routine bioassay samples incomplete.*
7. *Analysis of bioassay samples not performed for all radionuclides to which workers were exposed.*
8. *Workers enrolled in incorrect routine bioassay program.*
9. *Job-specific Radiation Work Permit (RWP) required bioassay samples not collected and processed.*
10. *Routine and special bioassay samples not collected and processed as required.*
11. *Dose assessments and subsequent dose assignment for workers with intakes of radioactive material not completed.*
12. *Bioassay program not consistently implemented across a contractor site.*
13. *Decision Levels in use did not appropriately reflect current quantitative capability of the site laboratory.*
14. *Inconsistent application of bioassay requirements for similar work activities.*
15. *Untimely performance of worker dose assessments.*
16. *Untimely radio-analytical processing of bioassay samples.*
17. *Internal dose assessments not accurate.*

18. *IDEP procedure reviews and subsequent revisions not performed.*
19. *Bioassay sample submission not verified as required* [Names redacted 2020b, PDF p. 4].

NIOSH Response: The 19 cited issues originated in a July 1999 memorandum from the DOE Office of Enforcement [DOE 1999]. They are a compilation of issues identified across the DOE complex. To investigate the pertinence of these issues to Y-12, NIOSH reviewed DOE's Occurrence Reporting and Processing System (ORPS) reports and Noncompliance Tracking System (NTS) reports for Y-12 to identify any events or circumstances related to these 19 issues.

DOE uses ORPS reports as a method to provide timely notification to the DOE complex of events that could adversely affect the following: public or DOE worker health and safety, the environment, national security, DOE's safeguards and security interests, functioning of DOE facilities, or the Department's reputation. Reports include basic occurrence specifics (e.g., location, date/time, and description of the occurrence) as well as immediate actions taken, an evaluation of causes, a facility manager evaluation, environment impacts, employee safety and health impacts, programmatic impacts, codes and standards impacts, lessons learned, and corrective actions.

DOE's NTS is a database for DOE contractors to voluntarily report noncompliance with DOE nuclear safety requirements, worker safety and health regulatory requirements, and identify actions to correct the conditions and prevent a recurrence. Similar to ORPS reports, the NTS documents noncompliance specifics (e.g., location, date/time, description of the issue) as well as assessing impacts on standards, environment, safety and health, along with causes, assessment results, tracking status, and corrective actions. Any associated ORPS reports are also noted.

Results of NIOSH's review of the ORPS and NTS reports are as follows:

- NIOSH obtained a listing of all 2,849 ORPS reports specific to the Y-12 site between 1990 and 2019 [DOE 2019a]. This listing contained the ORPS report number along with a descriptive title. This listing was initially reviewed for any possible indications of occurrences with potential relevance to dose reconstruction feasibility for the SEC-00250 class under evaluation. Based on this initial review, NIOSH identified 74 titles for which complete reports were obtained for a more detailed analysis. These reports and the complete ORPS title listing were re-reviewed for relevance regarding the petitioner- identified issues. NIOSH's analysis did not locate any information that would substantiate any of the 19 DOE complex-wide, petitioner-specified issues as being germane to the Y-12 site.

- NIOSH obtained a listing of all 221 NTS reports specific to the Y-12 site between 1996 and 2019 [DOE 2019b]. This listing contained the NTS report number along with a descriptive title. This listing was initially reviewed for any possible indications of occurrences with

potential relevance to dose reconstruction feasibility for the SEC-00250 class under evaluation. Based on this initial review, NIOSH identified eight titles for which complete reports were obtained for more detailed analysis. These reports and the complete NTS title listing were re-reviewed for relevance regarding the petitioner-identified issues. NIOSH's analysis identified one instance [DOE 2019c] related to the failure to collect routine bioassay samples. The issue was identified on January 18, 2000 and was based on a review of calendar year 1999 bioassay sample participation. The issue reads as follows:

> *During 1999, some employees were transitioned from the Management and Operation (M&O) contractor at the Y-12 Site, Lockheed Martin Energy Systems, (LMES) to the Management and Integration (M&I) contract under Bechtel Jacobs Company (BJC). The transition required that Y-12 Site Radiation Work Permit (RWP) information be transferred from the LMES manual (non-electronic) system over to the BJC electronic system to schedule bioassay samples. Incompatibilities between LMES system and the BJC system resulted in a backlog of documents awaiting manual log-ins into the BJC electronic RWP system. As a result, bioassay samples for some transitioned employees were not collected by BJC in a timely manner [DOE 2019c, PDF p. 2].*

The immediate corrective action was to obtain bioassay samples from all available individuals and to place those individuals on a routine (scheduled) bioassay program until electronic RWP records were updated. Based on the stated corrective actions, NIOSH has concluded that the information in this specific instance does not represent a condition that would challenge its ability to reconstruct internal dose at Y-12.

ISSUE B2: The evidence from DOE, DOE Contractor and ORAU acknowledge that the Y12 bioassay methods were non-existent or inaccurate.

Relevant excerpts from the Y-12 petitioners' presentation:

> *The evidence from DOE, DOE Contractor and ORAU acknowledge that the Y12 bioassay methods were non-existent or inaccurate* [Names redacted 2020b, PDF p. 11].
>
> *How can dose be reconstructed or co-worker models be developed with sufficient accuracy when the accuracy of the records themselves are, at best, suspect* [Names redacted 2020b, PDF p. 11].

NIOSH Response: Section 5.4 of the Y-12 Internal Dose TBD [ORAUT-TKBS-0014-5] summarizes both the *in vitro* and *in vivo* bioassay methods used at Y-12 [ORAUT 2012]. NIOSH reviewed the section text to identify any discussions that could be construed as related to the accuracy of Y-12 bioassay sample-analysis methods.

NIOSH identified one such discussion in SC&A's 2005 review of the Y-12 TBD [SC&A 2005, PDF pp. 51–53]. SC&A's review documented issues related to the uncertainty associated with individual bioassay sample results.

NIOSH has documented Y-12 uranium bioassay data usability in the currently-approved SEC evaluation reports (SEC-00186 covering 1948–1957; and SEC-00250 covering 1958–1994).

The recent SC&A review of the SEC-00250 ER [SC&A 2020b] identified one open issue related to the uranium co-exposure data (i.e., consideration of Monday morning sampling). This issue is still open; however, the issue's resolution will impact only how the existing co-exposure data are applied (i.e., adjusted for the worker's time off prior to sample collection); the issue does not impact the accuracy of the co-exposure data itself.

ISSUE B3: The values in the "Total" row of Table 6-1 from the SEC-00250 Evaluation Report (ER) cannot be reproduced [NIOSH 2019, PDF p. 34].

Relevant excerpts from the Y-12 petitioners' presentation:

> *Statistics for monitored workers don't add up* [Names redacted 2020b, PDF p. 12].
>
> *Expert statistician Professor, Dr. Chris Barker could not reproduce the calculations from this NIOSH Table* [Names redacted 2020b, PDF p. 12].

NIOSH Response: Regarding Table 6-1 in the SEC-00250 ER, it is not possible to determine the value for each annual "Percent of Individuals Monitored by Urine Sampling" (Column 4) and "Percent of Individuals Monitored by Lung Counting" (Column 7) using only the data available within that table. As noted in the ER, these percentages were derived by dividing the number of unique individuals monitored by urine sampling or lung counting for a given year (provided in Columns 3 and 6) by each respective year's number of unique individuals monitored for external dose (provided in ER Table 6-4, Column 3).

The explanation for the inability to add (or average) each year's percentage of individuals monitored by urine sampling or lung counting to arrive at the percentages listed in the "Total" row is provided in the following table footnote:

> *The Total value in the last record in Column 6 does not represent the sum of the values in that column. It represents the actual number of unique individuals monitored from 1977-1988* [Names redacted 2020b, PDF p. 12].

NOTE: This same explanation also applies to Column 4; however, the footnote inadvertently fails to note this.

ISSUE B4: Independent analysis of monitoring frequency is inconsistent with NIOSH-reported values.

Relevant excerpts from the Y-12 petitioners' presentation:

> *Petitioners compiled their own statistics using CEDR [CER] and DOE's Occupational Radiation Exposure Reports for years 1981-1988 and found that no more that 14% of workers who had external monitoring received internal monitoring. (CEDR [CER] statistics compiled by Energy Employees Claimant Assistance Project)* [Names redacted 2020b, PDF p. 13].

NIOSH Response: The petitioners provided a table to present their calculated percentage of externally monitored workers who also received internal monitoring. Results were provided for each year for 1981–1988. The petitioners determined the presumed number of workers receiving internal monitoring using data presented in DOE's "Annual DOE Occupational Radiation Exposure Reports." The numbers were pulled from "Table B.5" within each of the annual reports. Although the title of this table varies slightly over the years, each year's table presents a "distribution of annual whole-body doses" for each contractor within the Oak Ridge Field Organization. The Annual DOE Occupational Radiation Exposure Reports are available online at: https://www.energy.gov/ehss/listings/annual-doe-occupational-radiation-exposure-reports.

Table B.5 in each Annual DOE Occupational Radiation Exposure Report presents the distribution of reported whole-body doses, which represent external exposures, not the number of workers receiving internal monitoring. Furthermore, in the timeframe under discussion (1981–1988), contractors were only required to report those individuals for whom monitoring was required (i.e., those with the potential to exceed 10% of the quarterly or annual occupational exposure guidelines). Contractors were not required to report those for whom monitoring was simply provided.

There is no practical avenue to arrive at the number of workers internally monitored by using any of the data in the DOE annual reports. Petitioner attempts to calculate that number by using these data will produce an inaccurate result. Note that the number of internally monitored workers plays no direct role in individual dose reconstructions for the EEOICPA project. NIOSH calculations use actual Y-12 internal monitoring results (to which petitioners have no access).

ISSUE B5: Petitioner not provided an opportunity to review interview summary prior to use.

Relevant excerpts from the Y-12 petitioners' presentation:

> *Actual account was that the supervisor would manipulate the survey instrument and recheck the worker if the original body count resulted in a positive reading. When the supervisor "found" skin contamination after the body count, the original body count was considered invalid and removed from the worker's record* [Names redacted 2020b, PDF p. 14].
>
> *The Petitioner was also interviewed. Neither the Petitioner nor the Former Worker did not receive a draft copy of the interview before NIOSH included it in their presentation. They were unable to offer corrections or clarifications or received notice that it has gone through the DOE classification review process before today's meetin*g [Names redacted 2020b, PDF p. 14].
>
> *NIOSH/ORAU has violated one of the most fundamental tenets of the program. A worker's interview will not be discussed until the worker had the opportunity to correct or clarify a statement* [Names redacted 2020b, PDF p. 14].

NIOSH Response: As a standard practice, NIOSH sends the interview notes to the interviewee for corroboration before incorporation into the formal record. The NIOSH HP included a brief summary of the main points of the two interviews in the presentation to the Y-12 WG because it is customary to inform the WG of ongoing efforts, and it was felt, possibly erroneously, that the petitioner would want to have the interview content be part of the discussion; one interviewee objected. Due to procedural requirements that take some time (i.e., DOE clearance of interview notes), the interview notes had not yet been sent to the interviewees before the WG meeting; however, they were sent as soon as it was possible to do so. NIOSH asked the two cited interviewees to review the draft NIOSH notes from their respective interviews. NIOSH incorporated their comments into the interview records. The formal interview transcripts are now available as [ORAUT 2020f, k], and no statements contradict the content mentioned in the presentation [ABRWH 2020, PDF p. 22]. The standard practice (i.e., forwarding draft interview summary notes to interviewees and incorporating their comments) has been applied to subsequent interviews.

ISSUE B6: SC&A's report confirms issues raised by the petitioners.

Relevant excerpt from the petitioners' presentation:

NOTE: The findings below were paraphrased by the petitioners from SCA-TR-TASK1-007, Section 1.2, Summary of Findings [SC&A 2005]; some context was lost in the process. These findings were presented by the petitioners in a slide show at the 2020 WG meeting [Names redacted 2020b].

Finding 1: Routine bioassay sampling among support workers who had access to multiple areas onsite was not implemented prior to 1994.

Support services workers included janitors, laborers, security, maintenance personnel, crafts, pipefitters, boilermakers, and welders.

They were routinely exposed to high-enriched and depleted uranium, insoluble ("high-fired") uranium oxides, thorium, and transuranic contaminants.

They cleaned up contaminated plant areas, serviced machining equipment and lathes, and fixed piping and pressure vessels.

Workers had free access to all operational areas and no records were kept of work or building assignments.

Finding 2: Issues with RadCon regarding which workers were badged and which results were recorded.

Line supervisors made all badging decisions for groups and individuals; production took precedence over safety.

Historic discrepancies in recording badge readings in which all film badges reading "below the minimum detectable [were directed to be] recorded as the average of the minimum detectable reading and zero, instead of being recorded as the minimum detectable."

Finding 3: Internal dose TBD does not adequately address the potential for missed dose due to historic bioassay practice at Y-12, which applies an incomplete and flawed intake model.

No assessment of dosimetric implications of Y-12 workers continuously exposed to low-level chronic uranium exposures and having this exposure

effectively treated as operational "background" radiation for health physics purposes.

The ingestion exposure pathway is not considered, despite this being a likely route of exposure.

Co-worker dose assignments do not consider shortcomings of the uranium urinalysis database, variability in material types, bioassay technique uncertainties, and sampling methodology.

NIOSH's use of a 50th percentile intake rate to calculate doses for unmonitored workers is not considered claimant-favorable.

Uncertainties in bioassay techniques and detection limits used to quantify internal dose are significant issues in dose reconstruction and are not fully addressed in the TBD.

Finding 4: Internal dose TBD incomplete in dose contribution of radioisotopes than uranium.

Radionuclides included: 3H, 90Sr, 99Tc, 210Po, 228Th, 232Th, 239Pu, 241Pu, 237Np, 233U, and 241Am. Thorium, 233U, and transuranic handling are of particular importance to the TBD.

Finding 5: Unsubstantiated assumptions were employed on nuclear track Type A emulsion (NTA) film to characterize worker exposure due to limited availability of neutron spectral measurements.

Neutron radiation sources were not adequately defined for all potential neutron exposure conditions, including spontaneous fission neutrons, moderated (alpha, neutron) sources in solutions/compounds, subcritical and critical assemblies, and moderated neutrons from the 86-inch cyclotron.

NTA may seriously underestimate the true neutron dose.

Finding 6: No credit is given for radiological hazards from operations of radiation-generating devices.

There is no discussion of how film badge response to low-energy X-rays may impact recorded dose.

The 86-inch cyclotron was used for isotope development; however, there is no discussion of the internal dose associated with the isotopes generated from this operation.

Other accelerators are not included.

Finding 7: There is not enough depth on the varying and changing nature of Y-12 operations and work environments to provide dose reconstructors with the specific knowledge needed for specific group or individual dose reconstructions.

Finding 8: The Occupational Environmental Dose TBD omits important exposure pathways.

The inadvertent ingestion of radioactively contaminated soil and inhalation of radionuclides other than uranium are not fully addressed.

Y-12's proximity to the ORNL facility that handled irradiated thorium, radioactive lanthanum, and plutonium was near enough to cause exposure to outdoor Y-12 workers from its airborne emissions.

No data are furnished regarding activity median aerodynamic diameter (AMAD) or chemical form of airborne uranium.

The empirical approach used to derive atmospheric dispersion factors for reconstructing outdoor exposures of unmonitored workers is based on unstated premises.

There is questionable validity in deriving outdoor inhalation exposures to uranium using atmospheric dispersion factors when actual airborne uranium concentrations are available at outdoor receptor locations.

Finding 9: Frequent "incidental" sources of workplace radiation exposure were not monitored.

Uranium chip fires occurring many times per shift exposed everyone in the work area to an acute intake of uranium fumes.

Exhaust fans were inoperative, causing a back-flow of contaminated air through the ductwork.

Finding 10: Extremity and skin doses are not given enough consideration.

Depleted-uranium metal-handling has been associated with high beta radiation fields, leading to elevated hand and arm exposures of material handlers.

232Th has beta-emitting progeny that present a radiological hazard for direct handling.

NIOSH Response:

Issues 1 through 10 above appear to have originated in Section 1.2 (Summary of Findings) of SCA-TR-TASK1-007 [SC&A 2005], which was a 2005 review of the Y-12 Site Profile document set (aka the Y-12 Technical Basis Documents [TBDs]). NIOSH is in the process of evaluating the validity of the identified issues in light of the evolution of program documents since the time of SC&A's 2005 review and will provide either closure documentation or identify necessary actions needed once that evaluation is completed.

SECTION C: ISSUES RAISED BY SC&A

ISSUE C1: SC&A is unable to verify the Pu-241 production end date based on the citation provided.

Relevant excerpt from the 2020 Y-12 WG meeting transcript:

> *But I found on Page 18 of that* [SEC-00251] *Evaluation Report* [NIOSH 2018], *it says that plutonium-241 separations began in 1953 and continued through 1973, and provided a reference, which is SRDB 89989 from 1998* [ORNL 1998]. *And so I dug up that document and it is dated 1998. But I can't find other dates listed in there to verify that date range of activities with plutonium-241.*
>
> *I might be misreading the information there, so maybe some clarification I think would be helpful from NIOSH. Because if the operations with plutonium-241 ended in 1973. Then they may not be necessarily relevant to an SEC discussion* [ABRWH 2020, PDF pp. 37–38].

NIOSH Response: Through its efforts to confirm the 1973 end of the Pu-241 calutron work, NIOSH located the following four statements:

- The last three Pu calutron runs were Series bc, bh, and bl [ORNL 1998, PDF p. 4].

- During the Series bc run of December 1973, 97.79% Pu-241 was extracted [ORNL 1980, PDF p. 61].

- During the Series bh run of November 1974, Pu-244 was extracted [ORNL 1980, PDF p. 66].

- During the Series bl run of May 1979, Pu-242 and Pu-244 were extracted [ORNL 1980, PDF p. 70].

Using the above four statements, NIOSH deduced and confirmed that the Pu-241 calutron end-of-production date of 1973 cited in the SEC-00251 ER is accurate.

SECTION D: ADDITIONAL INTERVIEWS WITH Y-12 EMPLOYEES

Following the September 2020 Work Group meeting, a series of interviews were held with individuals identified by the petitioner/petitioner representative as having additional information for NIOSH consideration. The petitioner and petitioner representative identified 20 interview candidates. Of these, thirteen individuals were interviewed, and seven could not be contacted or declined to be interviewed. One of the thirteen interviewees did not respond to NIOSH requests for review of the NIOSH-generated interview summary; consequently, the formal documentation of that interview is unavailable for subsequent use [ORAUT 2020a,b,c,d,e,f,g,h,i,j,k,l].

Issues mentioned in the petitioner-issued document, *Analysis of Working Conditions, Worker Exposures and Monitoring, 1980–1994, Y-12 Plant, Oak Ridge, TN*, such as poor contamination-control practices, lack of contamination monitoring, and the role of supervision in assigning individuals to the bioassay and respiratory protection programs were identified during the course of the 13 interviews.

Several interviewees recalled significant program changes occurring in the very-late-1980s–1990 period. These changes included:

- stricter controls regarding eating, drinking, and smoking in proximity to contamination areas [ORAUT 2020h,i]; and

- increased requirements for protective clothing, increased work-area monitoring, and more robust contamination control efforts [ORAUT 2020b,h,i,j,l].

Also noted were the changes to respirator use requirements. Previously, direct supervisors determined the need for, and maintenance of, respirators for hourly workers. Post 1989, this determination was directed by health physics department employees and documented on

Radiation Work Permits (RWPs). Improvements to respirator contamination monitoring, cleaning procedures, and exchange frequencies were also implemented during the 1989–1990 time frame [ORAUT 2020i].

The information garnered from these interviews confirms some of the issues raised in the petitioners' paper [Name redacted 2020a], particularly those related to contamination-control practices and the programmatic changes implemented during the early 1990s. However, no additional response is provided because the issues raised are already considered within this response paper.

One interviewee indicated that urinalysis records might be missing based on a recollection of sample kits sent home compared to the available sample records (the associated individual employment period was 1965–1969 at ORNL and 1969–2011 at Y-12). NIOSH reviewed the individual's work history and title (engineer). Based on the available information, there would be a low potential for internal exposure. Lack of sampling for individuals with a low potential for internal exposure is consistent with Y-12 program documentation (see below) and NIOSH is not of the opinion that this is related to record-keeping deficiencies.

Changes to the urinalysis program in 1972 reduced the number of program participants for departments whose employees averaged less than 10% of the plant action level [Union Carbide 1972, PDF pp. 2–3]. Clarification on the selection of participants for the urinalysis program was published in a 1989 plant bulletin, stating:

> *Your potential for intake of uranium determines the frequency of your participation in the uranium urinalysis program. For example, an engineer whose potential for exposure to uranium is very small is not included in the routine uranium urinalysis program. Maintenance workers who have a low potential for exposure are on a quarterly urinalysis program. Chemical operators who work daily with uranium have the greatest potential for intake, and they submit samples each month. Workers with only a slight possibility for exposure to uranium, such as machinists in depleted uranium areas, are on a random sampling program.* [Martin Marietta 1989c]

The way that the urinalysis participants were selected results in the selection of individuals with the highest potential for internal exposure. These data form the basis for the co-exposure study, which is then used for unmonitored individuals who had a potential for internal exposure.

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