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SC&A Review of the SEC Petition Evaluation Report for Petition SEC-00247: Superior Steel Co.

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Table of Contents

Abbreviations and Acronyms

ABRWH, Board	Advisory Board on Radiation and Worker Health
AEC	U.S. Atomic Energy Commission
AWE	Atomic Weapons Employer
CATI	computer-assisted telephone interview
DOE	U.S. Department of Energy
EE	energy employee
ER	petition evaluation report
FY	fiscal year
NIOSH	National Institute for Occupational Safety and Health
NRC	U.S. Nuclear Regulatory Commission
ORAU	Oak Ridge Associated Universities
ORAUT	Oak Ridge Associated Universities Team
OTIB	ORAUT technical information bulletin
PFG	photofluorography
SEC	Special Exposure Cohort
SRDB	Site Research Database
SROO	Savannah River Operations Office
SSC	Superior Steel Co.
TBD	technical basis document

1 Executive Summary

On May 1, 2018, Special Exposure Cohort (SEC) Petition-00247 for the Superior Steel Co. (SSC) was submitted to the National Institute for Occupational Safety and Health (NIOSH). On November 16, 2018, NIOSH completed the SEC petition evaluation report (ER; hereafter referred to as the "NIOSH SEC ER" (NIOSH, 2018a)). On December 13, 2018, the Advisory Board on Radiation and Worker Health (ABRWH, Board) requested that SC&A review the ER. This report is provided to the Board in response to that request.

The ER concludes that doses experienced by the workers covered by SEC Petition-00247 can be reconstructed with sufficient accuracy and recommends denial of the SEC petition. This recommendation is based on data, methods, assumptions, and other sources of information described in the ER and available on the Site Research Database (SRDB).

Upon authorization by the Board, SC&A began its review of the ER with two objectives:

1. Provide information for use by the Board in determining whether doses can be reconstructed with sufficient accuracy, as defined in 42 CFR Part 83.

2. Provide a technical evaluation of the scenarios, data, assumptions, models, and other information provided or referenced in the ER for reconstructing doses.

With respect to the first objective, SC&A concludes that doses to workers covered by the SEC petition can be reconstructed in a scientifically sound and claimant-favorable manner. The Board will use this information, in part, as the basis for determining whether doses can be reconstructed with sufficient accuracy. With respect to the latter, SC&A found several deficiencies in the scenarios and assumptions described in the ER for reconstructing doses.

The following is a summary of SC&A's findings and observations:

- Finding 1: Failure to justify process similarities that support the use of the Vulcan Crucible billing rate
- Observation 1: New approach to bounding source term using contract billings
- Finding 2: 1955 survey distributions may not bound air concentrations
- Observation 2: Ratio of uranium to thorium may create consistency issues with other Atomic Weapons Employer (AWE) sites
- Observation 3: Storage time of material likely does not capture time on site
- Observation 4: Medical examination assumptions are inconsistent with other AWE sites

2 Introduction and Background

SEC Petition-00247 for the SSC was submitted to NIOSH on May 1, 2018, with the following proposed definition:

> All workers who worked in any area at the Superior Steel Co. facility in Carnegie, PA, during the period from January 1, 1952 through December 31, 1957

The original petition quoted NIOSH's 2005 exposure matrix for Superior Steel Co., ORAUT-TKBS-0034 (NIOSH, 2005a). NIOSH deemed the following quotes from that document sufficient to qualify for an SEC evaluation

- "Individual uranium urinalysis data are unavailable for Superior Steel Workers and none are known to exist."
- "No external dosimetry results are available for Superior Steel employees."

SEC Petition-00247 qualified for evaluation on August 6, 2018. The class evaluated by NIOSH remained virtually unchanged from the petitioner's requested class:

> All atomic weapons employees who worked in any area at Superior Steel Co. in Carnegie, Pennsylvania, during the period from January 1, 1952 through December 31, 1957. [NIOSH, 2018a, p. 4]

NIOSH's SEC ER was submitted on November 16, 2018, and presented to the ABRWH at its 126th meeting in Redondo Beach, CA, on December 12–13, 2018.

The NIOSH SEC ER concluded the following about the SSC facility:

> Based on its full research of the class under evaluation, NIOSH found no part of said class for which it cannot estimate radiation doses with sufficient accuracy. This class includes all atomic weapons employees who worked in any area at Superior Steel Co. in Carnegie, Pennsylvania, during the period from January 1, 1952 through December 31, 1957. [NIOSH, 2018a, pp. 39]

Following discussions of the SEC-00247 ER at the December ABRWH Meeting, SC&A, Inc. was tasked with reviewing the NIOSH SEC ER. This report presents the results of SC&A's investigation and review of the NIOSH SEC ER.

During its review, SC&A carefully evaluated documentation and statements contained in the following:

- Documentation in the SRDB maintained by NIOSH (see Sections 2–4)
- Computer-assisted telephone interview (CATI) reports
- SSC technical basis document (TBD) (ORAUT-TKBS-0034, Rev. 00 PC-1 (NIOSH, 2005b))

- Guidance documents used to support the petition, including Battelle-TBD-6000 (hereafter "TBD-6000" (NIOSH, 2011)) and ORAUT-OTIB-0006 (NIOSH, 2018b)

2.1 Site information

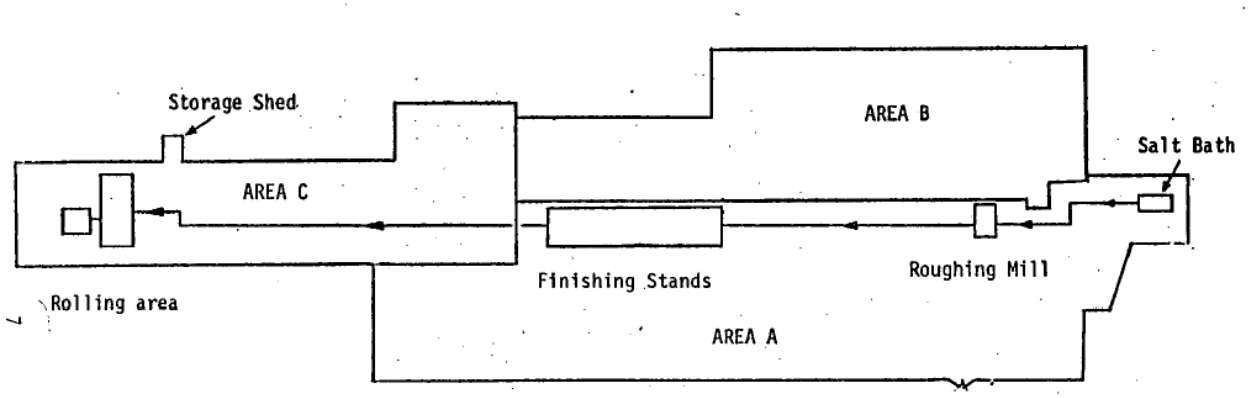
Superior Steel Co. was located in Carnegie, Pennsylvania, on a 25-acre site. A portion of the former SSC facility was utilized under contract with the United States Atomic Energy Commission (AEC) from June 27, 1952, to November 27, 1957, for the handling and milling of uranium metal. The contract was originated by the AEC's New York Operations Office but was transferred to the Savannah River Operations Office in October of 1954 (Mott, 1981). According to the Savannah River Operations Office, the official contract file was destroyed. There were seven known amendments or modifications to the contract. The total payments to SSC through fiscal year 1957 amounted to $356,849.00.

SSC was one of three principle contractors involved in the AEC's initial fuel element development program to fabricate, strip, and plate fuel elements for reactors (Young, 1985). The site's radiological source term included predominately natural uranium metals, with some metal oxides. Additionally, a single test milling of thorium was processed on the same equipment. This processing consisted of some combination of salt bathing, rolling, brushing, shaping, cutting, stamping, and coiling, depending on the desired end product.

Security inspection records indicate that SSC engaged in general work on rolling and possibly cladding the new type fuel elements. One of these records indicates that security inspections of the SSC facility were conducted in May and November in both 1954 and 1955, in June 1956, and in January 1957 (SPOO, 1979). This record also indicates an authority for receipt, storage, and transmittal of classified matter categorized up to and including Secret. Another entry in the document, dated November 19, 1957, apparently indicates withdrawal of authority for access to classified materials on or before that date. SSC was an accountable station for handling spent fuel material by November 1952.

Figure 1 presents a schematic of the operations conducted in 1955. Due to this treatment and handling, large quantities of radioactive uranium dust were generated during operation. Ventilation of this airborne material was provided to varying degrees during the operational life of the plant, although the system was probably not adequate to prevent contamination of the working environment. Fans were introduced at some point to reduce localized contamination surrounding the mill equipment (AEC, 1955a, 1955b; Klevin, 1953a). No details of the post-operative facility decontamination were located by either SC&A or NIOSH.

Figure 1. Operations schematic (Myrick & Clark, 1981)



The building that originally housed the uranium handling facilities was a large steel structure that at the time of operations divided into three basic areas: the former mill area (also known as area A), the former motor room (area B), and the former rolling area (area C), as pictured in Figure 1. Processes started in the salt bath and moved through the roughing mill, finishing strands, and rolling areas (SPOO, 1979).

Area A was approximately 24,000 square feet and originally contained the salt bath, roughing mill, brushing station, finishing stands and shear. Area A is the location where the majority of the uranium metal handling and shaping are believed to have occurred.

Area B was approximately 8,250 square feet and housed the former motor room and control panels for the mill. This area contained the large motors that provided power to the mill equipment in area A. Inside area B, the atmosphere was controlled to provide proper conditions for the motor, and it was considered the clean side of the mill.

Area C was approximately 12,000 square feet and was the location of the tail end of the mill process, where the metal was rolled for shipping or prior to further handling.

SC&A found no evidence that decontamination or decommissioning of SSC equipment or facilities was conducted at the conclusion of the AEC contract. However, NIOSH did uncover five known radiological surveys done in support of the clean-up efforts that took place at the site following operations, which are detailed in Table 6-3 of the NIOSH SEC ER.

3 Sources of Exposure

3.1 Uranium exposures

The primary AWE operations performed at the SSC site consisted of salt bathing, rolling, brushing, shaping, cutting, stamping, and coiling of uranium metal. Records indicate that natural and enriched uranium were processed at the site. Since the AWE operations were conducted after 1952, it is assumed that small quantities of primarily alpha- (plutonium-239, thorium-232, thorium-228 and neptunium-237) and beta- (technetium-99) emitting radionuclides may have been present in the uranium metal from recycling. The majority of AWE rolling campaigns at SSC were with natural uranium; however, a single rolling campaign is known to have contained six slabs of 1.5 percent enriched uranium. This campaign was witnessed by the 1953 HASL study and included additional slabs of natural uranium.

3.2 Thorium exposures

On March 13, 1956, SSC applied for a "source material license to receive, possess, use, and transfer thorium" (Reardon, 1956). In this application, the site requested the license cover four ingots of thorium that Babcock & Wilcox Company had Source Material License C-3465 to possess. In this application, SSC stated:

> The work to be performed includes test runs on rolling and cutting similar to that which was done by the applicant for the Atomic Energy Commission. It is hoped that only one ingot will have to be rolled for the test. However, application is made for a license for four (4) ingots in case rolling one ingot does not yield sufficient information.

Additionally, the site indicated that air sampling would be done during these tests to quantify air concentrations under ordinary plant conditions. They indicated the results of this sampling would be used to design and install ventilation and air concentrations needed for rolling large quantities of thorium (Reardon, 1956). To date, the results of this air sampling have not been located.

The site was licensed on March 27, 1956, to receive thorium to support non-AEC development studies for Babcock & Wilcox Company (SSC, 1956a; AEC, 1956a). This was a short-term license that expired on April 1, 1957, and allowed the site to possess up to 700 pounds of thorium. Shortly thereafter, on April 30, 1956, the license was amended to include forging, roll cogging, finish rolling, and cutting unlimited quantities of thorium metal for the Babcock & Wilcox Company with an expiration date of April 30, 1958 (after the AWE-covered period) (SSC, 1956b; AEC, 1956b).

In the communication regarding the license amendment, there is reference to completed thorium test rolling. It is believed that the rolling referenced is the only thorium rolling completed, though the site does indicate approximately 45,000 pounds of thorium metal from the Babcock & Wilcox Company was estimated to be the first quantity of material shipped to SSC. No documentation has been located indicating this or other shipments occurred. According to the U.S. Nuclear Regulatory Commission (NRC), the SSC AEC license expired in 1958. Records indicate that there was no inspection of the facility to support the termination of this license. No

evidence of thorium contamination at the site was found by the multiple studies done to quantify contamination following the covered operations period.

SC&A notes that the current exposure matrix for SSC (ORAUT-TKBS-0034) does not address potential thorium exposures at the site. During the course of the SEC evaluation, NIOSH located proof that thorium milling occurred on site and included this information in the NIOSH SEC ER.

4 Internal Exposures

At the time the contract was initiated, the physical characteristics of uranium metal and the measures required for protecting workers from the hazards of working with it were well documented. Therefore, the technical supervision practiced by the AEC during the 1940s was not enforced on the contract (DOE, n.d.). There are no indications of AEC involvement in monitoring the personal health of workers at the SSC facility where uranium metal was processed. Each of the HASL studies recommended process changes to improve exposure conditions; however, evidence suggests that the site did not implement the majority of these recommendations.

4.1 Internal uranium exposures

To bound internal uranium exposures, NIOSH makes several key assumptions using the results of the four HASL studies. In the following subsections, SC&A evaluates each of the assumptions.

4.1.1 Rolling mill time

The exact amount of time that rolling was done at SSC is unknown; however, NIOSH estimates this time based on the billing totals of the site's contract with the AEC. On page 30 of the SEC ER, NIOSH states:

> According to contract information, the total amount paid to Superior Steel Co. through fiscal year (FY) 1957 was $356,849 (SROO, [1979, PDF pp. 23–24]). Superior Steel Co. had a cost-plus-fixed-fee contract that included payments for equipment upgrades (SROO, [1979, PDF pp. 23–24]). Based on the annual payments for FY 1954 through FY 1957, the year with the maximum payment was FY 1956 at $217,246. However, the payments for the other three years were all consistently in the range of $40K to $55K. Based on the rolling data presented in Table 7-1, NIOSH sees no indication that the production rate for FY 1956 was significantly different than the other years under evaluation. The highest payment in the other three years was for FY 1957 at $54,632. NIOSH assumes that the entire payment for FY 1957 was associated with mill work. NIOSH considers it reasonable to conclude that the Superior Steel Co. hourly billing rate was similar to that of Vulcan Crucible for a 1949 AEC contract (SRDB 11996, PDF p. 99), at $132 per mill hour. Assuming $132 per mill hour billing rate, the number of Superior Steel Co. mill hours would be approximately 414 mill-hours for FY 1957. NIOSH will assume 500 mill-hours per year as a bounding estimate for AEC-related uranium rolling operations during the AWE period under evaluation. This estimate of mill-hours is comparable to the rolling information in Table 7-1. An additional 250 pre-rolling hours and 250 post-rolling hours (total of 500 hours) will be assumed by NIOSH to account for time the material was stored onsite before and after any rolling operations.

The August 16, 1948, contract stipulates a rate of $132 per mill hour to roll uranium billets into rods. In the context of the Energy Employees Occupational Illness Compensation Program Act, "surrogate data" refers to the use of exposure data from one site for individual dose

reconstruction for workers at another site. Use of this value does not technically meet this criterion in that it is using billing rates rather than exposure data; since the data are being used to ultimately bound worker exposures, SC&A believes it is important to qualify the use of these data against the Board's five surrogate data criteria.

1. Hierarchy of Data: Since there are no individual monitoring data at SSC and the original contract was destroyed, SC&A finds no hierarchy-of-data issues.

2. Exclusivity Constraints: Only a single value is being applied in the ER and comes from contract information for the site, so there are no concerns of quality or completeness. SC&A believes this criterion is not applicable to the way the data are being used in the NIOSH SEC ER.

3. Site or Process Similarities: One of the main criteria for judging the appropriateness of the use of surrogate data is the similarity between the site where the data were generated and the site where the surrogate data are being utilized. According to the surrogate data criterion, "The application of any surrogate data to an individual dose reconstruction at a site should include a careful review of the rationale for utilizing that source of data."

   Finding 1: Failure to justify process similarities that support the use of the Vulcan Crucible billing rate.

   SC&A questions the selection of Vulcan Crucible and Steel as a data source used to support the SEC petition. Although the site was also an AWE that processed uranium metal, no rational is given for why the site's mill-hour billing rate is a reasonable substitute to SSC other than this is the site used in the TBD. It is unclear to SC&A what the impacts of process conditions, final mill product, and mill throughput have on final mill costs. Additionally, no information was provided to support the selection of this billing rate over other uranium processing facilities' rates. In a cursory search for other facilities' billing rates, SC&A identified Joslyn Manufacturing Company had a mill rate of $88 per mill hour in 1948 (SRDB Ref. ID 11996, PDF p. 131). Use of this billing rate would increase the estimated number of mill hours by over 200 hours and is not bounded by the NIOSH "bounding" estimate of 500 hours per year.

4. Temporal Considerations: The Vulcan Crucible contract originated in 1948 (SRDB Ref. ID 11996, PDF p. 99), several years prior to the SSC 1953 contract. SC&A is unaware of significant process changes in uranium milling that occurred during that timeframe that would be expected to significantly impact billing rates.

5. Plausibility: SC&A finds that the use of a billing rate of $132 per milling hour to be reasonably plausible in the context of the site. Use of this value with the FY 1957 total billings of $54,632 results in an estimated 414 mill hours a year, and NIOSH rounds this value to 500 in order to be bounding. This is equivalent to the assumption of a single 10-hour billing day per week, assuming 50 weeks per year.

   SC&A does note that the SEC bounding assumption of 500 hours per year is in conflict with the TBD bounding assumption of 800 hours per year. Although the NIOSH SEC ER does indicate the intent to revise the TBD in section 7.2.2, no justification is given for the

nearly 40 percent reduction in mill hours, despite both documents using the same references to justify the assumption. SC&A finds the TBD rate to be higher than is supported by the site documentation.

Observation 1

To SC&A's knowledge, bounding the source term has not been done based on contract billing in combination with another site's billing rate in the manner that it is being done here. Although SC&A understands the rational for use of the data in this way, SC&A believes the Board needs to weigh in on the acceptability of this use. The closest similarity SC&A was able to identify was the use of contract billings to estimate employee work hours at General Steel Industries.

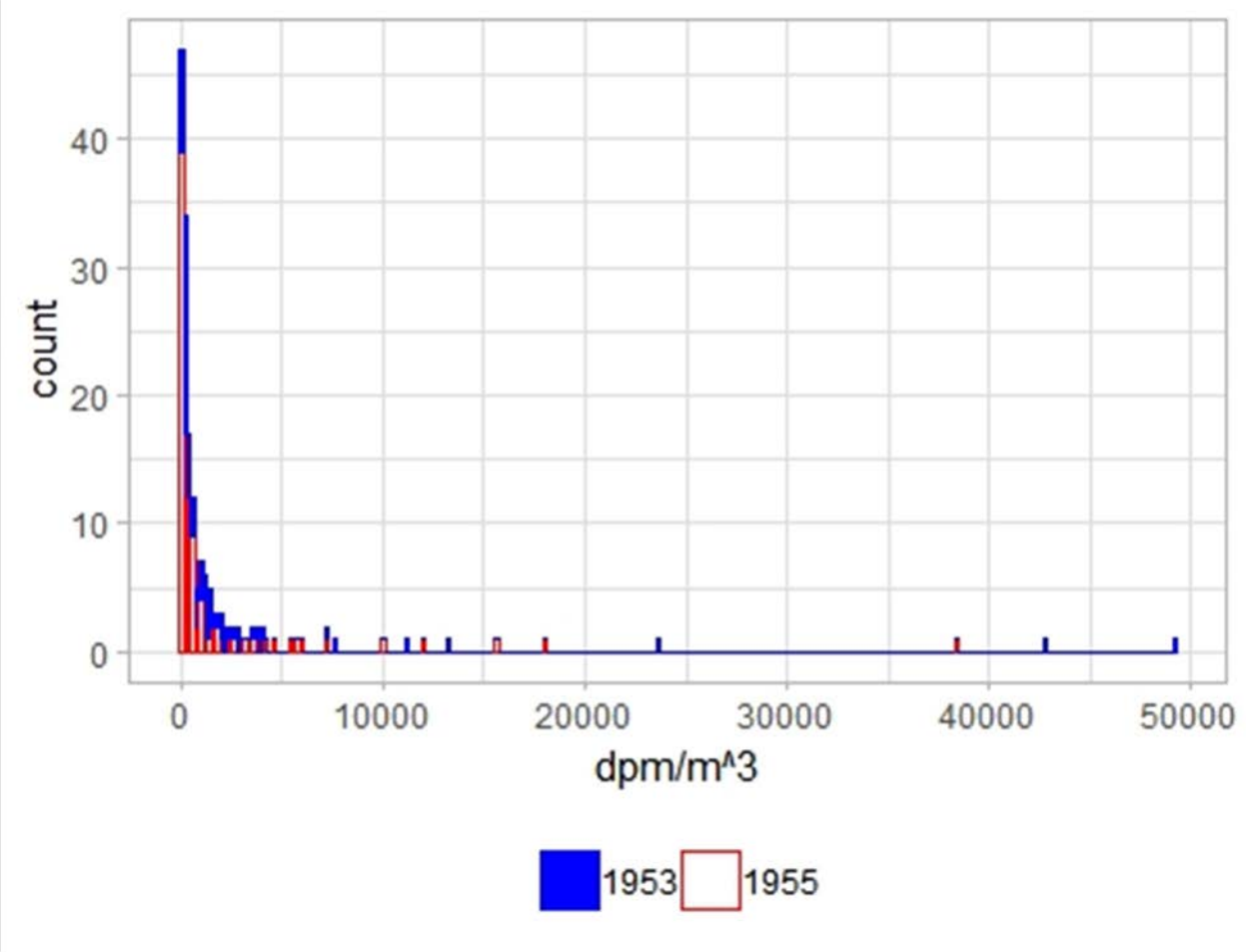
4.1.2 Air concentration

Section 7.2.2 of the NIOSH SEC ER indicates that NIOSH intends to use breathing zone and process air sampling data from the HASL monitoring to establish exposures for workers. NIOSH will split the exposure periods into two groups based on evidence of process controls implemented. The first group ranges from the start of operations and goes through May 8, 1955, the day before the May 9 rolling. The second group starts May 9, 1955, and goes through the end of operations on December 31, 1957. These dates are based on the HASL monitoring performed on site.

The geometric mean associated with the 1953 air data is statistically higher than for the 1955 air data. Therefore, NIOSH concludes that they represent separate exposure distributions. NIOSH's review of post-operations reports indicate that the site instituted improvements to the engineering controls after evaluation of lessons learned from each HASL-attended rolling (AEC, 1955a, 1955b; Klevin, 1953a, 1953b). NIOSH found no specific dates of implementation for these process improvements. Consequently, NIOSH intends to use the more claimant-favorable 1953 data for exposures up until the May 9, 1955, rolling date. NIOSH intends to use the 1955 data for exposures starting on May 9, 1955, and continuing through the end of AWE operations on December 31, 1957.

To inspect this claim, SC&A evaluated the air sampling results. All air sampling results from the four HASL studies were included in this investigation. In most instances, three samples were taken at each location. When a minimum, maximum, and average were reported, SC&A used the number of samples and the reported values to calculate the unreported values. When four samples were taken, the missing values were assumed to be the highest equivalent value that could result in the stated average. SC&A located 17 breathing zone samples and 144 general air samples. Figure 2 shows the results of this analysis. The histogram shows that the 1955 and 1953 samples follow a similar distribution that is visually indistinguishable other than the presence of additional samples in 1953.

Figure 2. HASL air monitoring uranium distribution by year of sampling (AEC, 1955a, 1955b; Klevin, 1953a, 1953b)



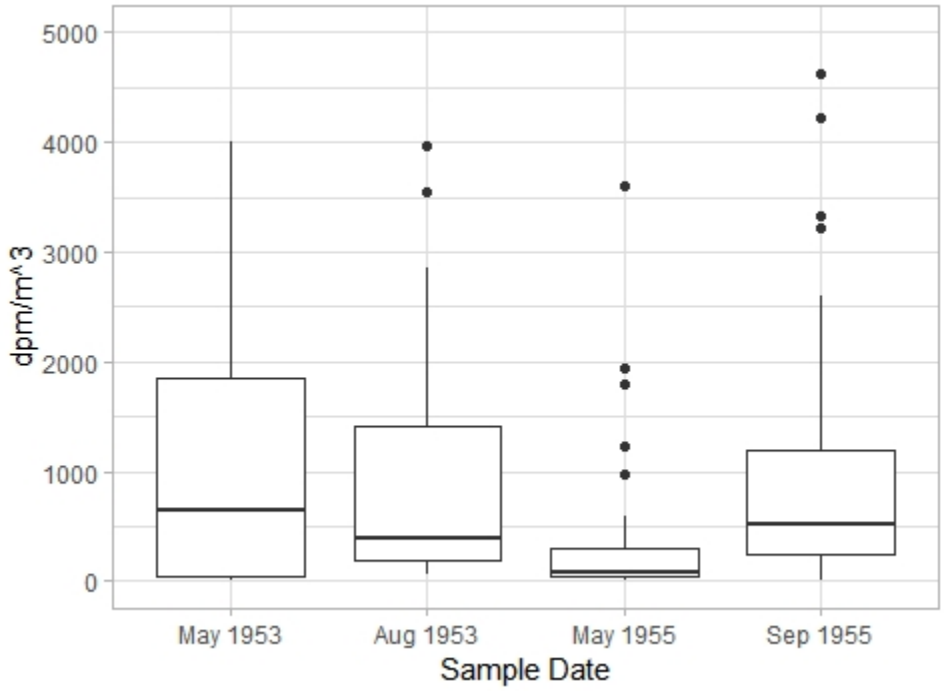
SC&A further split the data by date of survey, the results of which are shown in Figure 3. Although the May 1955 results have a visibly lower distribution, the reductions in air concentrations were not maintained in the September 1955 results. The September 1955 study notes that, between the May and September samplings, the site implemented a process change that included slab brushing. According to that study, brushing the slab oxides resulted in a considerable amount of U_3O_8 airborne contamination and exposed the bare metal to air oxidation throughout the rest of the milling. This process change resulted in the increased air concentrations seen in the September 1955 study.

Finding 2: 1955 survey distributions may not bound air concentrations.

SC&A finds insufficient evidence to support splitting the data into pre- and post-1955 survey distributions. Evidence suggests that the May 1955 sample results may not be representative of the typical working air concentrations at the site because they represent a theoretically small point in time where engineering controls reduced airborne contamination. The reductions in air concentrations seen by the introduction of man-cooling fans and additional ventilation appear to have been largely offset by the introduction of slab brushing in the September 1955 survey. Lacking evidence of additional engineering controls implemented after the introduction of slab

brushing, SC&A does not believe that limiting the post-1955 distribution to just 1955 data bounds potential air concentrations in later years.

Figure 3. HASL air monitoring distribution by sampling date (AEC, 1955a, 1955b; Klevin, 1953a, 1953b)



Note: The y-axis was limited to values from 0 to 5,000 for visual clarity. This resulted in some values being omitted from the visualization.

Potential exposure to contaminants in recycled uranium will be assigned based on guidance in TBD-6000. Based on the time periods that the site processed uranium and historical documentation, this is a reasonable assumption.

4.1.3 Resuspension factor and post-rolling surface contamination

There are no known swipe samples to quantify surface contamination following rolling at the site. NIOSH proposes post-rolling surface contamination levels be determined assuming that 500 uranium mill hours of contamination from the 1955 HASL studies was deposited on the surface of the facility at a rate of 0.00075 meters per second (m/s). As discussed in sections 4.1.3 and 4.1.4, SC&A has concerns regarding how the 500-mill-hour time is derived and the use of 1955 study air concentrations, which would also impact surface contamination calculations. Use of surface deposition velocity of 0.00075 m/s for uranium handling facilities is well established in TBD-6000. SC&A notes that, after rollings, surfaces were washed with water, leaving only minimal surface contamination (AEC, 1955b). SC&A finds the use of a deposition velocity of 0.00075 m/s in this instance to be reasonable and claimant favorable.

NIOSH intends to apply a resuspension factor (RF) of 1E-5/m to the post-rolling surface contamination levels to determine post-rolling airborne contamination levels. An RF is the ratio of the airborne radionuclide concentration per unit air volume divided by the surface

concentration per unit area. It is generally reported in units of m^{-1} (e.g., pCi/m^3 per pCi/m^2). The concept of an RF has been studied extensively, with RF values ranging from 10^{-10} m^{-1} to 10^{-2} m^{-1} reported. NUREG-1720, "Re-evaluation of the Indoor Resuspension Factor for the Screening Analysis of the Building Occupancy Scenario for NRC's License Termination Rule" (NRC, 2002), found a 90th percentile RF of 8.7×10^{-7} m^{-1} for a normal fit and 9.6×10^{-7} m^{-1} for a lognormal fit. However, the study cited applies to decommissioned facilities where all contaminated surfaces had been cleaned and washed.

SC&A's review of the literature indicates that the surfaces were hosed down with water following rolling operations in at least some instances. Following this spraying, only minimal surface contamination was found (AEC, 1955b). It is not known if this was part of regular operations or done in response to the HASL studies identifying high air concentrations. As such, SC&A believes that the use of a resuspension factor of 1E-5 /m is appropriate and claimant favorable for the conditions modeled by the SEC.

4.1.4 Prorated labor hours

Section 7.2.2 (page 31) of the NIOSH SEC ER states that,

> The 95th percentile uranium alpha air exposures will be assigned to all operator and laborer job categories. The post-rolling slab stamping work, performed by hand, represents work likely associated with the laborer category, and resulted in some of the higher air data results. NIOSH has not found justification to assume that the exposures for the operator and laborer categories were different. Consequently, laborers will be assigned the same exposure as operators based on a NIOSH analysis of the air data. Supervisor and administrative exposures will be prorated based on guidance in Battelle-TBD-6000 to account for differences in occupancy time in the production areas.

SC&A supports the use of reduced occupancy times for supervisors and administrative positions in conjunction with the 95th percentile uranium alpha air exposures.

4.2 Internal thorium exposures

To bound internal thorium exposures, NIOSH makes several key assumptions. In the following subsections, SC&A evaluates each of the assumptions.

4.2.1 Rolling time

NIOSH assumes that the thorium test rollings all occurred within a single 10-hour workday. This is based on knowledge of the quantities of uranium SSC was able to roll in a day. As documented in the HASL reports, the site was able to roll over 30 slabs of uranium in a day. SSC was only licensed to possess four ingots of thorium. SC&A finds no reason to suspect that amount of material took longer than 10 hours to roll.

4.2.2 Air concentrations

There are no known air monitoring results corresponding to the time thorium was milled on site. NIOSH intends to use the 1955 HASL studies' gross alpha air sampling results to develop a mass dust load associated with the rolling process. They state they will assume the same mass loading

for thorium as uranium. A method similar to this approach was applied in the Bridgeport Brass DCAS-PER-061 evaluation, which SC&A reviewed in 2017. The Bridgeport Brass evaluation, however, assumed that the thorium-232 mass intake was 10 percent of the uranium mass intake. The NIOSH SEC ER modified this approach by instead assuming a one-to-one relationship so that uranium mass intakes were equal to thorium intakes. This is a more claimant-favorable assumption that results in a higher thorium intake than the 10 percent assumption.

Observation 2

There is a sound basis to use some fraction of the uranium concentration as the basis for the thorium concentration; however, SC&A notes that use of a one-to-one ratio could be important for consistency. This ratio is considerably more claimant favorable than the 10 percent assumption. The approach used here could establish a precedent that might require NIOSH to revisit previous ERs that use a lower ratio.

For the reasons noted in finding 1, SC&A does not support isolating the 1955 HASL studies from the 1953 studies. SC&A notes that resolution of that issue will have a direct impact on the thorium internal dose reconstruction.

4.2.3 Resuspension factor and prorated employment times

NIOSH intends to use the same resuspension factor and prorated employment for thorium as was discussed for uranium internal exposures in sections 4.1.3 and 4.1.4 above. SC&A supports the use of these values as specified in previous sections.

5 External Exposures

SC&A did not locate any external monitoring data for the SSC site and found no indication that external personnel monitoring was performed at SSC during the AWE operations period under evaluation.

The principal sources of external radiation doses for employees of SSC were direct exposure from being in proximity to the uranium and thorium ingots, exposure from contaminated surfaces, and submersion in air contaminated with dust generated via the processing of such.

5.1 External uranium exposures

The vast majority of the uranium work performed was associated with natural uranium. The only enriched uranium material identified by NIOSH was the rolling of six ingots of enriched to 1.5 percent uranium-235 on May 9, 1955. The enriched uranium rollings were a small portion of the overall material rolled in that campaign, and even less significant compared to the total amount of normal uranium rolled during SSC's AWE operational period.

The NIOSH SEC ER indicates that NIOSH intends to use the guidance from TBD-6000 to bound estimated exposures from "1) submersion in contaminated air; 2) contaminated surfaces; 3) whole-body penetrating radiation emitted from uranium metal surfaces; and 4) non-penetrating radiation emitted from uranium metal surfaces."

For AWE sites (such as SSC) that handled uranium metals, TBD-6000 presents methods for bounding estimation of worker doses from rolling operations with uranium metal. SC&A confirmed that this document is applicable to SSC. The NIOSH SEC ER indicates that NIOSH will use the methods specified in TBD-6000 with the following site-specific assumptions (NIOSH, 2018a, p. 35):

- 500 hours per year of external dose associated with rolling operations in Battelle-TBD-6000;
- 500 hours per year of external dose associated with submersion in rolling operations airborne contamination, based on dose conversion factors in EPA-FGR-12;
- 500 hours per year of external dose associated with storage of on-site material based on external 1-meter dose rates in Battelle-TBD-6000; and
- 2,000 hours per year of external dose associated with submersion in post-rolling airborne contamination and direct exposure associated with post-rolling surface contamination, based on Dose Conversion Factors in EPA-FGR-12.

Regarding bullets 1 and 2, SC&A notes that finding 1 and observation 1 both directly relate to the assumption of 500 mill hours per year. Resolution of those issues directly impacts the assumption of external dose from rolling and submersion in rolling operations airborne contamination.

Regarding bullet 3, NIOSH indicates in section 7.2.2 of the SEC ER that an additional 250 pre-rolling hours and 250 post-rolling hours will be assumed to account for time the material was stored on site before and after any rolling operations.

Observation 3

SC&A finds this storage time assumption to be inadequate to capture the length of time material was likely found on site. If the site milled uranium metals for 500 hours per year, then it is reasonable to assume a 10-hour milling once per week. For the 250 pre-rolling and 250 post-rolling hours assumption to hold true, uranium metals would have to arrive on the day before rolling and be shipped off site the day following rolling. Table 7-1 in the NIOSH SEC ER shows that the site regularly had more than a single day's rolling in inventory. Additionally, during the April 2019 Board meeting, the petitioner indicated that scrap material was stored on site for extended periods of time post rolling.

5.2 External thorium exposures

Between March 27, 1956, and April 20, 1956, SSC conducted one test rolling operation with up to 700 pounds of thorium metal to perform development studies for its non-AEC commercial client, Babcock & Wilcox Company. As non-AEC work, the external exposures associated with the commercial thorium rolling operations can be assigned only during the AWE-evaluated period through December 31, 1957. Non-AEC-related exposures are not considered during an AWE site's designated residual radiation period.

Evidence suggests that only this single test rolling of thorium occurred on site. Based on thorium licensing restrictions at the time it occurred, it is assumed that a maximum of 700 pounds (lb) of thorium metal was rolled during the test. The initial license application indicates it may have been as little as one ingot (~160 lb) of thorium. An extensive literature search did not locate any evidence of additional thorium being received or shipped from the site.

The NIOSH SEC ER indicates that NIOSH intends to do MCNP modelling of thorium metal-related exposures in accordance with TBD-6000 guidance. To bound external thorium dose, NIOSH (2018a, p. 35) intends to use the following assumptions:

- 10 hours of external dose associated with thorium rolling operations in 1956 will be calculated using MCNP and guidance in Battelle-TBD-6000;
- 10 hours per year of external dose associated with submersion in rolling operations airborne contamination in 1956 will be calculated based on Dose Conversion Factors in EPA-FGR-12;
- 190 hours per year of external dose associated with storage of onsite thorium material based on MCNP calculations at 1 meter (190 hours assumes exposure to thorium for all of the 19 workdays between March 27, 1956 and April 20, 1956);
- For the remainder of 1956 (post-March 27, 1956) and all of 1957, external dose associated with submersion in post-rolling airborne contamination and

direct exposure associated with post-rolling surface contamination, will be assigned based on Dose Conversion Factors in EPA-FGR-12.

Regarding bullets 1 and 2, SC&A finds the assumptions to be valid and consistent with evidence of only a single thorium rolling during AWE operations. Based on known volumes of uranium rollings that occurred in a day, the assumption that test rolling occurred in a single day is justified. It is unlikely that this quantity of material took longer to roll than 10 hours; therefore, SC&A believes this assumption is bounding.

Regarding bullet 3, SC&A finds the assumption that a worker might be exposed to external dose from the storage of thorium for 10 hours per day for the 19 workdays between the start of thorium operations and the request for an amended license to be claimant favorable. Additionally, the assumption that this exposure occurred at a distance of 1 meter from the source builds in an additional layer of claimant favorability. It is unlikely any energy employees (EEs) were in that close proximity to a thorium source for the entirely of that 19-day window. SC&A is satisfied that this assumption bounds the exposures to all workers.

Regarding bullet 4, SC&A finds this assumption to be consistent with evidence that suggests that no thorium work occurred following the initial test rolling. The exact date this rolling occurred is unknown. NIOSH's assumption that the rolling occurred on the first day possible is claimant favorable because it maximizes the length of time an EE could potentially be subjected to post-rolling airborne and direct thorium.

5.3 Occupationally required medical x-ray

SC&A reviewed the extensive literature and found no evidence that medical examinations were performed at SSC. Additionally, the limited number of CATI reports that were conducted with EEs of SSC did not indicate examinations were performed.

Lacking evidence documenting if occupationally required examinations were performed on site, the SEC evaluation identified that a pre-employment, annual, and termination examination would be assigned to all EEs. This is consistent with the recommendations already in place in the TBD. Both documents recommend that ORAUT-OTIB-0006 guidance should be followed to assign dose to these potential examinations.

SC&A finds that the recommendations to assign pre-employment, annual, and termination scans to EEs at SSC to be claimant favorable. Although neither the TBD nor NIOSH SEC ER specifically address photofluorography (PFG) scans, SC&A notes that it would be inappropriate to assign PFG scans to workers at SSC. PFG scans were a means of screening large populations; it is unlikely that a PFG would have been in place at a facility the size of SSC.

Observation 4

Despite the claimant favorability of the assumption, SC&A questions the decision to assume annual medical examinations in spite of a lack of evidence. In recent years, the Board has made a concerted effort to improve consistency between sites. It is unclear if all AWE sites with no evidence of examinations receive the same claimant-favorable assumptions.

6 Interview Evaluation

No interviews were conducted to directly support this SEC evaluation. During the December 13, 2018, Board meeting, Board members questioned why no additional interviews were conducted as part of the SEC evaluation. NIOSH responded to this question with a response paper, *Superior Steel SEC Petition: Responses to ABRWH Questions*, dated January 10, 2019. NIOSH indicated that "since more than 60 years have passed, which in NIOSH's experience limits the availability of EEs for interviews, it was decided to forgo interviews" (NIOSH, 2019, p. 4). NIOSH also indicated that of the 35 claims completed for SSC, only three of the claims had living EEs.

SC&A reviewed the NIOSH/OCAS Claims Tracking System records and located 35 SSC claims where the EE worked during the time period being evaluated by the NIOSH SEC ER. Of those claims, SC&A identified that three claims did not have survivors listed. SC&A reviewed these CATI reports and found that all three had no knowledge during that time of any radioactive materials being handled on site. SSC had roughly 100 employees at a given time. The covered employment period began 67 years ago. These facts limit the potential pool of surviving EEs who might be available for interview. SC&A concurs that it is unlikely new information would be obtained from pursuing an additional round of interviews in support of this SEC petition evaluation.

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