Draft

ADVISORY BOARD ON
RADIATION AND WORKER HEALTH

National Institute for Occupational Safety and Health

REVIEW OF THE JOSLYN MANUFACTURING AND SUPPLY COMPANY PETITION EVALUATION REPORT FOR SPECIAL EXPOSURE COHORT (SEC) PETITION 00200

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ABBREVIATIONS AND ACRONYMS

Advisory Board, ABRWH, or Board	Advisory Board on Radiation and Worker Health
AEC	U.S. Atomic Energy Commission
AM	arithmetic mean
AWE	Atomic Weapons Employer
bgs	below ground surface
BZ	breathing zone
CDC	Centers for Disease Control and Prevention
CFR	*Code of Federal Regulations*
Ci	Curie
cm^2	square centimeter
cpm	counts per minute
DOE	Department of Energy
DOL	Department of Labor
dpm $(\alpha)/m^2$	disintegrations per minute (alpha) per square meter
dpm	disintegrations per minute
DWA	daily weighted average
DWE	daily weighted exposure
EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
ER	Evaluation Report
ERDA	Energy Research and Development Administration
FUSRAP	Formerly Utilized Sites Remedial Action Program
g	gram
GA	general area
GM	Geometric Mean
GSD	Geometric Standard Deviation
HASL	Health and Safety Laboratory
IREP	Interactive RadioEpidemiological Program
m^3	cubic meter
MDC	minimum detectable concentration
MED	Manhattan Engineering District

mR	milli-Roentgen
mrem/yr	millirem per year
m/s	meter per second
NIOSH	National Institute for Occupational Safety and Health
ORAUT	Oak Ridge Associated Universities Team
ORNL	Oak Ridge National Laboratory
pCi	picoCurie
R	Roentgen
SC&A	S. Cohen & Associates
SEC	Special Exposure Cohort
SQRT	square root
SRDB	Site Research Database
SRQD	Site Research Query Database
TBD	Technical Basis Document
TIB	Technical Information Bulletin
TWA	time-weighted average
$\mu g/cm^3$	microgram per cubic meter

EXECUTIVE SUMMARY

During a meeting of the Advisory Board on Radiation and Worker Health (the Board) held in Oak Ridge, Tennessee, on December 10–12, 2012, SC&A was directed to perform a review of the NIOSH Evaluation Report (ER) for Joslyn Manufacturing and Supply Company Special Exposure Cohort (SEC) Petition 00200 (NIOSH 2012a). The petition was received on March 15, 2012, qualified on May 10, 2012, and the ER was issued on December 3, 2012.

The petition called for adding the worker class, defined as:

> *All employees who worked in any area of the Joslyn Manufacturing and Supply Company in Fort Wayne, Indiana, from 1944 through 1952.*

NIOSH redefined the class as follows:

> *All employees who worked in any area of the Joslyn Manufacturing and Supply Company in Fort Wayne, Indiana, from March 1, 1943 through December 31, 1952.*

In its evaluation, NIOSH recommended the following class be added to the SEC, including certain qualifications, as follows:

> *All Atomic Weapons Employees who worked in any buildings/area owned by the Joslyn Manufacturing and Supply Co. (or a subsequent owner) in Fort Wayne, Indiana, from March 1, 1943 through December 31, 1947, for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more other classes of employees included in the Special Exposure Cohort. ….*
>
> *However, NIOSH has identified sufficient information and air monitoring data that can be assessed using existing dose reconstruction methods defined in Battelle-TBD-6000 to support bounding internal dose for the period from January 1, 1948 through December 31, 1952.*

In its ER, NIOSH also makes the following statement:

> *Although NIOSH found that it is not possible to completely reconstruct radiation doses for the proposed class, NIOSH intends to use any internal and external monitoring data that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures). Therefore, dose reconstructions for individuals employed at Joslyn Manufacturing during the period from March 1, 1943 through December 31, 1947, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.*

This is an important qualifying statement, especially for workers who were present at Joslyn during the covered period, but are not within the cohort because they do not have one or more of the cancers covered by the SEC. The implications are that every effort will be made by NIOSH to reconstruct doses to all workers not within the cohort.

SC&A examined the petition, the NIOSH ER, and a number of supporting documents, primarily to assist the Board in assessing the degree to which NIOSH can "estimate radiation doses with sufficient accuracy" for those workers not covered by the class. NIOSH did not prepare a site profile for this site because of the limited site-specific data, which is the basis for the SEC, and the fact that data provided in TBD-6000 and other documents cited in the petition ER can be used to reconstruct worker doses for those time periods and claimants not covered by the SEC. This report presents the results of SC&A's investigations with regard to this matter. Our findings are summarized as follows:

Finding 1: The units of measure for the data from Klevin (1952) in Table 6-1 are cited as pCi/m^3, but the presented information is based on dpm/m^3.

Finding 2: The units of measure in Table 6-2 should be dpm/m^3, not pCi/m^3.

Finding 3: NIOSH should document the basis for assuming that 1948 is the starting date for the site surveys upon which TBD-6000 is based. The 1948 date needs to be affirmatively established in order to ensure that the TBD-6000 data are claimant favorable.

Finding 4: Table 7-1 needs to be corrected to assure that comparable units are used throughout, and that 1952 air concentrations from TBD-6000 are based on 2,200 work hours per year.

Finding 5: Typographical and calculational errors in Table 7-2 should be corrected.

Finding 6: The NIOSH approach for reconstructing internal doses due to metal-working operations at Joslyn for 1948 through 1952 appears reasonable for routine exposures. However, we have concerns that the exposure matrix does not adequately describe how the dose reconstruction methods in TBD-6000 are to be applied. In addition, as developed further under Finding 8, we have concerns regarding the degree to which the surrogate values in TBD-6000 adequately account for exposures associated with outdoor uranium pit burning and with incidents such as uranium chip fires.

Finding 7: To address uncertainty as to whether air concentrations are dependent upon production rates, NIOSH should consider using the 95th percentile values from TBD-6000 to reconstruct doses at Joslyn.

Finding 8: Though of short duration, the airborne uranium dust levels associated with uranium open pit burning and associated activities, such as shoveling the burn residue into containers, could contribute significantly to annual intakes of uranium. NIOSH needs to evaluate the degree to which outdoor open pit burning of uranium shards renders TBD-6000 incomplete as a surrogate dataset for Atomic Weapons Employer (AWE) facilities with limited

bioassay and air sampling data. NIOSH should do the same for uranium chip fires that may have occurred in the machining or scrap storage areas. A third area of concern is that there are no data for the frequent sweeping activities that likely generated considerable resuspension of uranium dust. The present intake matrix is incomplete in all three respects.

Finding 9: It would strengthen the report if the basis for the 90% coverage of the uranium source term was documented.

Finding 10: SC&A does not agree with some of the assumptions proposed by NIOSH in Section 7.3.1 of the ER. SC&A suggests that NIOSH consider prorating the dose values in Table 6-4 based on actual working time, such as days per month. At a minimum, the NIOSH approach appears to underestimate external exposure in 1948. In addition, there is no need to differentiate between rolling and machining operations, since the doses are the same. However, there is one caveat—the units of measure for the data listed in Table 6-4 as Metal Whole Body Dose should be mrem/yr, not mR/yr. This is an important consideration when converting whole-body dose to organ dose.

Finding 11: NIOSH should document the sources of information they propose to use regarding the relative radiological hazard from thorium.

These findings are described and discussed in detail in the main body of this report. Our primary concerns are that (1) NIOSH has not provided explicit instructions for performing dose reconstructions for the time period not covered by the SEC, (2) the possibility that open pit burning of uranium shards could contribute significantly to internal exposures to some workers, and (3) intakes from incidents such as uranium chip fires known to be frequent in the era under consideration were mentioned, but not quantitatively evaluated in the ER or in TBD-6000. The open pit burning and uranium chip issues are especially important, because they bear on the ability of using TBD-6000 as a surrogate for AWE facilities with limited bioassay and air sampling data.

1.0 INTRODUCTION

1.1 SCOPE AND PURPOSE OF SEC REVIEW

Based on recommendations by the National Institute for Occupational Safety and Health (NIOSH), a Special Exposure Cohort (SEC) was granted for Joslyn Manufacturing and Supply Company (Joslyn) for the time period from March 1, 1943, through December 31, 1947, because internal doses could not be reconstructed with sufficient accuracy. However, NIOSH also concluded that sufficient data and other information, primarily available from TBD-6000, can be used to reconstruct all doses from January 1, 1948, through December 31, 1952, which constitutes the remainder of the class evaluated by NIOSH. Therefore, the scope of this review is to evaluate the degree to which exposure to workers not covered by the SEC can be reconstructed, and the methods, data, and assumptions to be employed in those dose reconstructions.

In the course of its assessment, SC&A reviewed selected documents that were considered relevant to the petition, including the SEC Petition Evaluation Report (ER) and its supporting documents as provided in the NIOSH Site Research Query Database (SRQD) and notes compiled during worker interviews.

The purpose of this review is to provide the Advisory Board on Radiation and Worker Health (Advisory Board or Board) with an independent assessment of issues and concerns that surround the petition. Findings identified in SC&A's review are intended help the Board judge the feasibility of, and methods used to perform, dose reconstructions for Joslyn workers.

1.2 TECHNICAL APPROACH AND REVIEW CRITERIA

The approach used by SC&A to perform this review follows the protocols described in the draft reports prepared by SC&A entitled *Board Procedures for Review of Special Exposure Cohort Petitions and Petition Evaluation Reports,* Revision 1 (SC&A 2006b), and the *Report to the Working Group on Special Exposure Cohort Petition Review* (SC&A 2006a). The latter is a set of draft guidelines prepared by a Board-designated Work Group for evaluation of SEC petitions performed by NIOSH and the Board. The former is a set of draft procedures prepared by SC&A and approved by the Board for use by SC&A on an interim basis (ABRWH 2006, pg. 132). The procedures are designed to help ensure compliance with Title 42, Part 83, of the *Code of Federal Regulations* (42 CFR 83) and implement the guidelines provided in the report of the Work Group.

Key review criteria identified in the report of the Work Group include the following; the individual criteria have differing degrees of applicability, depending on the details of a particular SEC petition and ER:

- Timeliness
- Fairness
- Understandability

- Consistency
- Credibility and validity of datasets, including pedigree of the data, methods used to acquire the data, relationship to other sources of information, and internal consistency
- Representativeness and completeness of the exposure data with respect to the area of the facility, the time period of exposure, the types of workers, and processes covered by the data

The Work Group guidelines also recommend that NIOSH include in its SEC evaluation a demonstration that it is feasible to reconstruct individual doses for the cohort, including sample dose reconstructions.

SC&A's implementation of the SEC review process includes the following steps:

(1) Conduct a critical review of the petition and relevant reports, documents, and data that are enclosed and/or referenced in the petition/reports.

(2) Identify additional issues/concerns that emerged from SC&A's document review, which are independent of those stated in the petition.

(3) As part of the SEC review, develop a technical position for issues identified in the petition, as well as SC&A's independent findings.

SC&A's report with its findings will subsequently undergo a multi-step issues resolution process. Resolution includes a transparent review and discussion of draft findings with members of the Board's Work Group, petitioners, claimants, and interested members of the public. This resolution process is intended to ensure that each finding is evaluated on its technical basis in a scientifically sound and claimant-favorable manner.

In the past, SC&A's review of petition ERs included site visits, which included interviews with workers and other site experts, and data capture visits to obtain documents that might further our understanding of the dose reconstruction issues associated with a facility. In this case, NIOSH has performed such site visits, which included SC&A participation, and we do not recommend any additional site visits at this time. However, the need for additional site visits and data capture efforts might emerge during the issues resolution process.

1.3 BACKGROUND INFORMATION

Section 5 of the petition ER presents a detailed description of the operations that took place at Joslyn and the associated exposures. In summary, Joslyn Manufacturing, located in Fort Wayne, Indiana, was a steel mill that:

> *…performed tempering, hot rolling, quenching, straightening, cooling, grinding, waste burning, and abrasive cutting of natural uranium billets into metal rods for use in Hanford site nuclear reactors. Joslyn Manufacturing was instrumental in developing the procedures for rolling uranium metal rods. Joslyn also performed rolling operations after 1949 for the Chalk River reactor fuel assemblies.*

At the time of these Atomic Weapons Employee (AWE) operations, 25–75 out of a total staff of about 100 to 200 workers were employed in AWE operations. Apparently, the AWE operations began in June 1943 and continued well into 1951. In addition, thorium operations, which included rod straightening and rolling operations and centerless grinding, took place in 1946 and 1947, consistent with the affidavit submitted as part of the SEC petition.

During the early years, facilities like Joslyn performed the initial work that helped to establish the uranium and thorium metal handling technologies and techniques that were implemented on a large scale in the late 1940s and early 1950s at many AWE facilities and then throughout the weapons complex. In addition, it was the experience gained by Joslyn and other facilities, such as Simonds Saw, where our understanding of the health risks associated with uranium and thorium and the development of radiation protection programs began. Hence, it is understandable that it was not possible to reconstruct worker exposures during the early years of AWE operations at Joslyn. The fundamental concern of this report is whether sufficient operational data and experience became available in the latter years of the 1940s, such that doses to all workers could be reconstructed in a scientifically sound and claimant-favorable manner for the 1948–1952 time period.

Section 5.2 of the petition ER explains that the primary source of internal exposure was the inhalation and, to a lesser extent, the ingestion of uranium oxide dust produced during the handling of uranium. The uranium burning pits (outdoors) were another source of internal exposure, as was the handling of thorium. It appears that the uranium handled at Joslyn was entirely natural uranium; i.e., Joslyn did not handle enriched or recycled uranium. This is a reasonable assumption, given the time periods that the AWE work was performed. However, the petition evaluation report would benefit from a discussion of this issue.

External exposures at Joslyn included the conventional pathways; i.e., working in close proximity to large quantities of uranium metal rods and billets, standing on contaminated surfaces, and submersion in airborne clouds of uranium dust.

There was also the potential for internal and external exposure to relatively small amounts of thorium and the possibility of medical x-rays as a condition of employment. Neutron exposures were unlikely, because there was no enriched uranium (i.e., no fission neutrons) and no uranium in the form of nitrates or fluorides, which would have had the potential to produce alpha/n reactions.

The petition ER also explains that no bioassay or whole-body count data were collected for Joslyn workers, but a limited amount of air sampling data and surface smear data related to uranium operations were recovered and summarized in the petition ER. The implications are that if internal doses are to be reconstructed for Joslyn workers that might have been exposed to either uranium or thorium, surrogate data would be required, with adequate justification.

In addition, there are no external exposure personnel monitoring data for Joslyn workers, but information is available describing the types and quantities of uranium and thorium handled at Joslyn. Hence, in principle, bounding estimates of the external radiation fields experienced by workers could be developed using source term data. As will be seen, there was also the potential for exposure to medical x-ray examinations as a condition of employment. Specifically, Section 7.3.3 of the SEC ER indicates that medical x-rays were required as a condition of employment, but that it was not possible to determine whether the examinations were performed onsite or offsite, stating the following:

> *NIOSH has no further data regarding if medical X-ray examinations may have been performed onsite versus offsite. Per ORAUT-OTIB-0079, Guidance on Assigning Occupational X-ray Dose Under EEOICPA for X-rays Administered Off Site* [ORAUT 2011], *NIOSH has determined that it is applicable to reconstruct occupational medical X-ray exposures for Joslyn Manufacturing and Supply Co. workers during the period from March 1, 1943 through December 31, 1952.*

The implications of this statement are that reconstruction of external doses at Joslyn should include medical x-rays.

2.0 REVIEW OF METHODS FOR RECONSTRUCTING INTERNAL DOSES

For the time periods not covered by the SEC, the petition ER uses TBD-6000 protocols to reconstruct internal exposures. These protocols are based on a compendium of data reported primarily by Harris and Kingsley (1959). Accordingly, this section of our report focuses on two issues; (1) were the operations at Joslyn beginning in 1948 (i.e., the period not covered by the SEC) understood well enough, and (2) are there sufficient confirmatory data, such that judgments could be made that TBD-6000 protocols can be used as a surrogate for the data that are lacking at Joslyn, and if so, does the ER make use of those protocols in a manner that is scientifically sound and claimant favorable?

2.1 RECONSTRUCTION OF INTERNAL DOSES – APPLICABILITY OF TBD-6000

This section addresses the applicability of TBD-6000 data to Joslyn during the period January 1, 1948, through December 31, 1952. Section 5.1 of the petition ER describes the uranium fabrication operations, noting that:

> *Joslyn Manufacturing and Supply Company, also known as Joslyn Stainless Steel Company, Fort Wayne Steel Corporation, and Slater Steel, performed tempering, hot rolling, quenching, straightening, cooling, grinding, waste burning, and abrasive cutting of natural uranium billets into metal rods for use in Hanford site nuclear reactors. Joslyn Manufacturing was instrumental in developing the procedures for rolling uranium metal rods. Joslyn also performed rolling operations after 1949 for the Chalk River reactor fuel assemblies.*
>
> *Natural uranium billets were received by rail at Joslyn Manufacturing, unloaded by an overhead crane onto carts, and stored in a storage area. The billets were taken, as needed, from the storage area to the tempering area, pre-heated in one of eight small natural-gas-atmosphere electric furnaces to a specified temperature, and moved to the rolling mills (an 18-inch roughing stand, 12-inch intermediate mill, and a 9-inch finishing mill were used) where passes occurred (Army Corps, 2005, PDF pp. 6–7). Time was allowed for the rolls to cool between passes in order to prevent the metal from exceeding a specified temperature.*
>
> *The grinding process was carried out in two widely separated parts of a large shed. The first operation consisted of grinding uranium rods. This process was carried out in a small shed constructed inside a larger shed. The fumes and dust from this smaller shed were vented into the atmosphere of the larger shed. The second operation was a rough cut on the uranium rods inside of the smaller shed. The rods were cropped and moved to the threading area, where they were milled and machined to contract specifications (Army Corps, 2005, PDF p. 7).*

SC&A has reviewed the available documentation and finds that this description generally reflects uranium operations at Joslyn. However, it does not appear that centerless grinding was conducted in the 1948–1949 period. Piccot (1949) describes operations after completion of rolling, noting that:

> *After rolling the rods were placed on a roll conveyor, and moved for a distance of approximately 80' outside the building where they were stamped for identification. After stamping the rods were moved from the conveyor and placed over a cooling pit on cross bars for 10 minutes, quenched in a water tank and allowed to cool and removed by jeep to the next operation or to the freight car for shipping*.

Piccot describes the next operations as follows:

> *After quenching, the rods are bundled (6 to a bundle) and are carried to the cut-off machine, called cutamatic, which is located in the cold finishing department. The rough ends were cropped while a heavy flow of coolant was used over the cutting tool and the rod end to minimize sparking hazard.*
>
> *The treading was done on a Pratt & Whitney 15" lathe with a continuous flow of coolant over the cutting point.*

The added information from the contemporaneous report of Piccot (1949) indicates that:

- Some of the operations were conducted outdoors
- Cutting and machining operations were accomplished with heavy coolant flow
- Transfer of the uranium shapes was typically done via cranes, overhead trolleys, and roll conveyors, which would result in lower dust generation than if the uranium shapes had been dragged across the floor

All of these factors would contribute to lower dust generation during product handling.

Table 6-2 of the ER identifies 19 job descriptions or work areas for which daily weighted average (DWA) exposures were measured by the Health and Safety Laboratory (HASL) during a 1952 survey of air concentrations at Joslyn (Klevin 1952).

TBD-6000 characterizes both uranium rolling and uranium machining based on data collected by Harris and Kingsley (1959) at unspecified Atomic Energy Commission (AEC) sites. An excerpt from the section on *Rolling* in Harris and Kingsley (1959) is included below:

> *The usual sequence of operations involved in the process of rolling is as follows:*
>
> (1) *A uranium billet or slab is heated to a suitable temperature in a furnace (normally about 1170° F). Gas-fired, lead-bath, salt-bath, and induction furnaces have been used. The choice of a furnace can be very important from the standpoint of worker health and dust-control ventilation. This will be discussed more fully below.*

(2) *The billet is removed from the furnace and conveyed to a roughing roll for lengthening into shapes (rods or slabs) or rough dimension. Several passes are usually made through the roughing roll.*

(3) *The roughed shape is then passed through one or more finishing rolls, either manually or automatically.*

(4) *The finished section is dragged or conveyed to shears for cutting into the desired number of sections for handling and further processing.*

(5) *The rods or strips are then dragged or conveyed to another area where they are quenched or air cooled and stamped for identification and accountability.*

(6) *After stamping, they may be descaled and straightened, bundled, weighed, recorded, packed, stored, and shipped.*

All these operations may be performed manually, or many of them can be done automatically.

Most of these operations are potentially capable of releasing large quantities of uranium dust to the plant atmosphere. This is due to the rapid surface oxidation of uranium at the temperatures used in heating and rolling (about 1200° F). The oxide scale thus formed is readily removed during any handling. This oxidation is not confined to the heating and rolling operations; on the contrary, the oxide forms continuously and spontaneously flakes off the metal at temperatures above 600° F. Any vigorous working of the metal produces a temperature rise which may initiate oxide formation, flaking, and subsequent air-borne contamination.

As indicated above, the type of furnace used can strongly influence the rate of oxide formation. When a gas-fired, air-atmosphere furnace is used, there is so much oxidation in the furnace during heating that large quantities of uranium are deposited on the furnace floor and therefore lost for further processing. In addition, during removal of the billet from the furnace, conveyance to the rolls and introduction to the rolls, oxidation continues. Needless to say, this oxide scale tends to contaminate the air. Thus, ventilation and other control methods are necessary to reduce air-borne concentrations to satisfactory levels. These will be discussed below.

It is clear that the rolling process, as described by Harris and Kingsley (1959), is very similar to the process as practiced at Joslyn. Unlike Harris and Kingsley, Piccot (1949) makes no mention of dragging the product across the floor.

Table 2-1 compares the job descriptions evaluated at Joslyn by HASL (Klevin 1952) with those included from Harris and Kingsley (1959) in TBD-6000.

Table 2-1. Comparison of TBD-6000 and Joslyn Job Descriptions

Job Description	Included in Joslyn Survey (Klevin 1952)	Included in TBD-6000	Comments
18" Rough Roll East	Yes	Yes	TBD-6000 Table 7.3
18" Rough Roll West	Yes	Yes	TBD-6000 Table 7.3
Roller Foreman	Yes	No	TBD-6000 Table 7.3 (Supervisor)
Ass't Foreman	Yes	No	TBD-6000 Table 7.3 (Supervisor)
Furnace Heaters	Yes	Yes	TBD-6000 Table 7.3 (Gas-fired furnace)
Recorder	Yes	No	TBD-6000 Table 7.3 (Laborer)
12" Rough Roll East	Yes	Yes	TBD-6000 Table 7.3
12" Rough Roll West	Yes	Yes	TBD-6000 Table 7.3
Drag Down (Billet)	Yes	No	TBD-6000 Table 7.3 (Laborer)
9" Finishing Roll East	Yes	Yes	TBD-6000 Table 7.3
9" Finishing Roll West	Yes	Yes	TBD-6000 Table 7.3
Quench Tank	Yes	Yes	TBD-6000 Table 7.3 (Spray cooling)
Draggers	Yes	Yes	TBD-6000 Table 7.3
Rod Stamper	Yes	Yes	TBD-6000 Table 7.3
Rod Bundler	Yes	No	TBD-6000 Table 7.3 (Laborer)
Lathe Operator	Yes	Yes	TBD-6000 Table 7.5
Centerless Grinder	Yes	Yes	TBD-6000 Table 7.5
Grinder (portable)	Yes	Yes	TBD-6000 Table 7.5
Cutomatic	Yes	No	TBD-6000 Table 7.5 (Operator)

It can be seen from this table that nearly all of the same jobs are included in both sources, indicating that scope of the job coverage in TBD-6000 adequately embraces the jobs performed at Joslyn. It should be remembered that TBD-6000 does not use the individual job data, such as the rod stamper or quench tank operator, but rather considers all of the rolling-related jobs for which data are available and selects from that group the job with the highest dust exposure. This exposure defines the generic operator for rolling. As shown in Table 7.3 of TBD-6000, the highest exposures are attributed to the roughing roll operator, whose exposure then defines the generic rolling operator. In the case of machining operations, the generic operator is defined by exposures to the centerless grinder operator (see Table 7.5 of TBD-6000). TBD-6000 also provides a methodology for estimating exposures to generic supervisors, laborers, and clerical staff. These estimates can be used where specific job descriptions are not listed in TBD-6000; for example, a rod bundler can be assumed to be a laborer. For many of the rolling-related job descriptions in Harris and Kingsley (1959), the authors present data for manual operations with no controls; manual operations with controls, such as salt-bath heating; and automated operations. The rolling operation values for use in TBD-6000 were conservatively selected as the manual with no controls data. Similarly, for the machining operations, Harris and Kingsley include data both with and without ventilation, but conservatively, only the latter were included in TBD-6000.

In terms of coverage of comparable operations, data in TBD-6000 effectively capture the operations at Joslyn. The specific data selected from the source document (Harris and Kingsley 1959) are conservative choices and thus can be used to make bounding dose calculations as required by 42 CFR §83.13(c)(1) for the period in which those measurements were taken. However, as discussed in Section 2.5 below, NIOSH has yet to show that the Harris and Kingsley data are representative of the operational period at Joslyn from January 1, 1948, through December 31, 1952. In addition, as discussed in Section 2.6 below, uranium pit burning is not explicitly addressed in TBD-6000, and there is a need to demonstrate that the default data in TBD-6000 bound the contribution to exposures associated with uranium open pit burning.

2.2 AVAILABLE JOSLYN DATA FOR INTERNAL MONITORING

Table 6-1 of the ER summarizes the available site-specific data on air concentrations at Joslyn. This section presents a review of that data. However, as a preface to this review, we remind the reader that the interview record of July 2012 indicates that workers swept up scale and dust every half hour, which could generate considerable dust for short periods of time (not unlike outdoor uranium pit burning). There are no measurements for air dust concentrations due to this important activity. This is an important limitation in the Joslyn air sampling data. It is also important to note that it is not apparent that TBD-6000 and its supporting documentation provide quantitative dust data that could apply to the frequent sweeping operations at Joslyn. Harris and Kinsley do note the importance of housekeeping to dust control, but do not provide data that would be applicable to manual sweeping (pp. 92–93). The issue of uranium dust arising from chip fires also needs to be addressed. See Section 2.6 below for further elaboration of these issues.

The most comprehensive dataset for Joslyn was developed by the AEC Health and Safety Division, based on a survey conducted in January 1952 (Klevin 1952). Only very limited data were available for prior years. Operations surveyed included rolling, centerless grinding, cutting, and lathe operations. Both breathing zone (BZ) and general area (GA) air samples were collected and daily weighted exposures (DWE) were calculated for 19 job descriptions covering 66 workers. Table 6-1 of the ER presents the range, geometric mean (GM), average, geometric standard deviation (GSD), and 95th percentile for each type of operation (to the extent permitted by the data). In developing the statistics reported in Table 6-1, NIOSH recalculated all of the individual sample results to verify the information in Klevin (1952) and Piccot (1949). This resulted in minor adjustments to some samples, so the data in Table 6-1 are not directly traceable to the source documents. Rather, the results are traceable to an Excel® spreadsheet (AIR CORECTIONS final.xlsm), which was developed by NIOSH from Klevin (1952) and Piccot (1949).

Samples producing less than 1 count per minute (cpm) were treated as non-detects by Klevin (1952). However, NIOSH assigned values to these samples, based either on assuming a value of 1 cpm if no background information was available (e.g., for rolling) or the net value of gross cpm minus background cpm if data were available in Klevin 1952 (e.g., centerless grinding). This approach is claimant favorable, as compared to treating these values as non-detects. NIOSH also calculated the minimum detectable concentration (MDC) for each sample where sufficient data were available. Table 2-2 below compares the concentrations calculated by NIOSH for the "non-detects" with the MDCs for centerless grinder BZ samples. In general, the values calculated for the non-detects were similar to the MDCs, adding credibility to the NIOSH approach.

Table 2-2. Comparison of MDCs and Calculated Centerless Grinder BZ "Non-Detect" Samples

Sample No. (Klevin 1952)	Calculated Concentration (dpm/m^3)	MDC (dpm/m^3)
O406	20	29
O407	22	27
O408	52	28
O411	36	34
O413	62	21
O415	12	21
G191	44	22
G193	40	23
G194	15	23
G195	22	31
G196	21	30
G198	54	31
G199	36	30
O400	4	31

However, it is important to note that the units for the data from Klevin (1952) in Table 6-1 of the ER are incorrectly stated as pCi/m^3 instead of dpm/m^3. While this may be a simple typographic error, it can significantly distort comparisons with other datasets.

Finding 1: The units of measure for the data from Klevin (1952) in Table 6-1 are cited as pCi/m^3, but the presented information is based on dpm/m^3.

Daily weighted exposures for various job descriptions are listed in Table 6-2 of the Joslyn ER. These data are not directly traceable to Klevin 1952, but include minor adjustments made by NIOSH during recalculation of the Klevin data, as described above. The units in Table 6-2 of the ER are also incorrectly stated as pCi/m^3.

Finding 2: The units of measure in Table 6-2 should be dpm/m^3, not pCi/m^3.

2.3 URANIUM AIRBORNE LEVELS

NIOSH notes in Section 7.2.1.1 of the petition ER that: "Battelle-TBD-6000, Appendix B utilizes data (Christofano [and Harris], 1960) which were collected starting in 1948 as a foundation for its methodologies." This statement is not correct; Christofano and Harris (1960) deal with uranium refining operations, not metal working operations, which are described by Harris and Kingsley (1959). Furthermore, Appendix B is not relevant, dealing, as it does, with Birdsboro Steel and Foundry. Harris and Kingsley (1959) are silent on the period covered by their surveys of metal fabrication operations. However, Christofano and Harris indicate that the time period covered by surveys at uranium refining operations was from 1948 through 1958. It is reasonable to assume that reported surveys of both uranium refining and metal working operations were contemporaneous and both reports shared a common author (W.B. Harris). The start date for the metal working surveys is critical, since it establishes the time after which NIOSH concludes that bounding dose reconstructions can be performed. This issue needs to be explored further by NIOSH, because it could impact the dates selected for the time period covered by the SEC.

Finding 3: NIOSH should document the basis for assuming that 1948 is the starting date for the site surveys upon which TBD-6000 is based. The 1948 date needs to be affirmatively established in order to ensure that the TBD-6000 data are claimant favorable.

2.4 EVALUATION OF BOUNDING RESIDUAL PERIOD INTERNAL DOSES

In Section 7.2.2 of the ER, NIOSH confirmed from two sources that no residual radioactive period was specified. Information in an August 2008 NIOSH document, *Report on Residual Radioactive and Beryllium Contamination at Atomic Weapons Employer Facilities and Beryllium Vendor Facilities,* supports the determination that residual contamination at Joslyn is not an issue that needs to be addressed (see Attachment A). Based on our review of this material, we concur with NIOSH with respect to this matter.

2.5 METHODS FOR BOUNDING OPERATIONAL PERIOD INTERNAL DOSE AT JOSLYN

Table 7-1 of the ER compares DWEs for Joslyn workers (based on Table 6-2 of the ER) with comparable job categories for workers based on Tables 7.3 and 7.5 of TBD-6000 (Battelle 2006). For example, according to Table 7.3 of TBD-6000, exposures for a roughing mill operator range from 1,620 to 13,700 dpm/m^3. This range of exposures is directly traceable to Table 2 of Harris and Kingsley (1959). In Table 7.3 of TBD-6000, these values are used to calculate a GM of 4,710 dpm/m^3 (GM = SQRT [1,620 x 13,700]). TBD-6000 further assumes that to convert this exposure to a DWA, the GM should be multiplied by an exposure factor of 0.75; thus, the DWA is 3,533 dpm/m^3. As stated in Section 7.1.2 of TBD-6000:

> *The daily weighted average for the operator's*[sic] *is assumed to be the measured air concentration for the roughing roll operator, with a 75% weighting factor assuming that 25% of the operator's time was spent away from the high concentration.*

Thus, one would expect to see a value of 1,591 pCi/m^3 (3,533 dpm/m^3 ÷ 2.22dpm/pCi) as the first entry in column 4 of Table 7-1, rather than the listed value of 1,472 pCi/m^3. NIOSH explained that the value of 1,472 pCi/m^3 was back-calculated from data in TBD-6000 based on the assumption of 2,400 hours worked per year. It is our understanding that, for the period 1951 through 1955, the correct assumption is 2,200 work-hours per year. In addition, as discussed above, we believe that the data in column 2 of Table 7-1 are in units of dpm/m^3, not pCi/m^3. Thus, Table 7-1 is actually not making comparisons in comparable units, and the TBD-6000 values are understated by about 9%.

Finding 4: Table 7-1 needs to be corrected to assure that comparable units are used throughout, and that 1952 air concentrations from TBD-6000 are based on 2,200 work hours per year.

To facilitate our review and make necessary comparisons, Table 2-3 here presents a reconstruction of Table 7-1 of the ER, correcting the problems described above.

Table 2-3. Reconstruction of Table 7-1 of the Petition Evaluation Report

Joslyn Work Area/Job Description	TWA (dpm/m^3)	TBD-6000 Equivalent Description	GM* (dpm/m^3)	95% (dpm/m^3)	AM (dpm/m^3)	Is TBD-6000 limiting?
18" Rough Roll East	3,322	Rolling Operator	3,533	49,883	12,901	yes
18" Rough Roll West	375	Rolling Operator	3,533	49,883	12,901	yes
Roller Foreman	725	Rolling Supervisor	326	4,603	1,190	yes
Ass't Foreman	725	Rolling Supervisor	326	4,603	1,190	yes
Furnace Heaters	16	Rolling General Labor	651	9,192	2,377	yes
Recorder	16	Rolling General Labor	651	9,192	2,377	yes
12" Rough Roll East	605	Rolling Operator	3,533	49,883	12,901	yes
12" Rough Roll West	570	Rolling Operator	3,533	49,883	12,901	yes
Drag Down (Billet)	310	Rolling General Labor	651	9,192	2,377	yes
9" Finishing Roll East	16,542	Rolling Operator	3,533	49,883	12,901	no
9" Finishing Roll West	5,791	Rolling Operator	3,533	49,883	12,901	yes
Quench Tank	155	Rolling General Labor	651	9,192	2,377	yes
Draggers	831	Rolling General Labor	651	9,192	2,377	yes
Rod Stamper	242	Rolling General Labor	651	9,192	2,377	yes
Rod Bundler	128	Rolling General Labor	651	9,192	2,377	yes
Lathe Operator	12	Machining Operator	5,480	77,372	20,010	yes
Centerless Grinder	100	Machining Operator	5,480	77,372	20,010	yes
Grinder (portable)	277	Machining Operator	5,480	77,372	20,010	yes
Cutomatic	191	Machining Operator	5,480	77,372	20,010	yes

GM is a DWA value (GM × 0.75) from Tables 7.3 and 7.5 of TBD-6000. AM and 95th percentile calculated from GM* assuming GSD = 5.*

Inspection of the reconstructed table indicates that, for every job description, except *9" Finishing Rolling East*, the average (or expected value) of the DWA airborne dust loadings associated with TBD-6000-equivalent job descriptions is greater than the DWE at Joslyn. The value for the *9" Finishing Rolling East* lies at the 83rd percentile of the TBD-6000 distribution, so this value would be subsumed in a dose reconstruction based on the full TBD-6000 distribution for rolling, or would be less than the 95th percentile if a constant value is used in dose reconstruction.

Table 7-2 of the ER provides a comparison of centerless grinding air concentrations based on 1951 sampling (Chipman 1943) at Joslyn with equivalent results from TBD-6000. The table contains several data entry and typographical errors, including the *Table 7-1 Finding* discussed above. Table 2-4 below presents a reconstruction of Table 7-2 of the ER. This table makes the necessary changes and adds comparable Joslyn data from 1952, which allows the reader to also make a year-on-year comparison of dust levels from centerless grinding at Joslyn to those in TBD-6000.

Finding 5: Typographical and calculational errors in Table 7-2 should be corrected.

Table 2-4. Reconstruction of Table 7-2 of the Petition Evaluation Report Comparing Joslyn Air Concentrations from Centerless Grinding to TBD-6000 Defaults

Joslyn Work Area/ Job Description	GM	95%	AM	TBD-6000 Equivalent Description	GM*	95%	AM
Centerless grinding 1951 BZ (oper.)	944	2,927	1,096	machining operator 1951–1955	5,480	77,372	20,010
Centerless grinding 1952 BZ (oper.)	42.4	297	93.6	machining operator 1951–1956	5,480	77,372	20,010

* This is the GM of DWA values for centerless grinding. The 95th percentile and the arithmetic mean were derived from the DWA values for the GM assuming a GSD of 5.

It is important to understand the information in this table in order to judge the degree to which TBD-6000 can be used to place a plausible upper bound on the airborne uranium dust concentrations that might have been experienced by AWE workers at Joslyn. First, the GM values reported for Joslyn for 1951 and 1952 were derived based on taking the GM of the BZ samples for personnel performing centerless grinding while they were performing centerless grinding. Given these GM values, the 95th percentile values and the arithmetic mean values for Joslyn workers were derived assuming a lognormal distribution with a standard deviation of 5. The GM mean values reported in Table 2-3 for TBD-6000-equivalent operations are actually the GMs of DWAs, not BZ values, as reported in Harris and Kingsley for workers involved in centerless grinding operations. It turns out that the term "machining operator," as employed in TBD-6000, is a general term and applies to a broad range of operations, including centerless grinding. Inspection of the data reported in Harris and Kingsley (1959) reveals that the data used by NIOSH to characterize the dust loading experienced by generic machining operators were actually data for centerless grinding operations. This was deliberately done by NIOSH to ensure that the exposures to any personnel defined as machining operators are not underestimated. From this perspective, NIOSH selected the appropriate TBD-6000 job category for use as a bounding surrogate for activities at Joslyn. Given this understanding, the TBD-6000 values are GM values of DWAs, while the GM values for Joslyn are for the individual BZ samples. The implications are that if one were able to convert the Joslyn BZ values to DWA values, the dust concentrations would be substantially lower, because DWA values include exposures during a given work day that occur while the activity is going on (in this case, centerless grinding), and also the activity during a given work day when the activity is not going on. Again, the implications are that the TBD-6000 values are bounding.

Section 7.2.4 of the ER states:

> *NIOSH concludes that there are site specific data and existing dose reconstruction methods available in Battelle-TBD-6000 to support reconstructing internal radiation doses with sufficient accuracy for the period from January 1, 1948 through December 31, 1952.*

Based on our review, including reconstruction of key Tables 7-1 and 7-2 above, SC&A concurs with this general NIOSH conclusion; however, with certain qualifiers.

Finding 6: The NIOSH approach for reconstructing internal doses due to metal-working operations at Joslyn for 1948 through 1952 appears reasonable for routine operational exposures. However, we have concerns that the site profile does not adequately describe how the dose reconstruction methods in TBD-6000 are to be applied. In addition, as developed further under Finding 8, we have concerns regarding the degree to which the surrogate values in TBD-6000 adequately account for exposures associated with outdoor uranium pit burning, chip fires, and floor sweeping.

In its review of other petition ERs, SC&A has concurred with a NIOSH conclusion that a bounding calculation can be performed, but has indicated that the approach suggested by NIOSH is not appropriate, or that NIOSH did not specify in detail how a bounding approach would be conducted. A similar situation exists at Joslyn, where NIOSH states that internal doses can be calculated using methods and assumptions in TBD-6000. The logic underlying the NIOSH conclusion appears to be based on the following premises and conclusion:

- TBD-6000 is a vetted document appropriate for use at AWE sites where site-specific data are limited or unavailable
- Air concentration data from Joslyn are lower than data from comparable operations characterized in TBD-6000
- Therefore, TBD-6000 can be used to bound internal exposures at Joslyn

As described in Section 7.2.3 of the ER, a dose reconstructor would use the GM values from Table 7-3 and a GSD of 5 as input into the IREP internal dose calculations. The highest observed air concentration at Joslyn is contained within this distribution, as shown above. However, as also noted, the available air concentration measurements were made during periods of only limited production. Therefore, it is not obvious that use of the full distribution from TBD-6000 in reconstructing doses at Joslyn is sufficiently conservative and claimant favorable.

Finding 7: To address uncertainty as to whether air concentrations are dependent upon production rate, NIOSH should consider using the 95th percentile values from TBD-6000 to reconstruct operational doses at Joslyn.

2.6 DATA ADEQUACY CONCERNS: URANIUM WASTE BURN PITS AT JOSLYN MANUFACTURING SITE, CHIP FIRES, AND FLOOR SWEEPING

2.6.1 Burn Pits

In the Joslyn SEC ER, NIOSH describes the practice of burning uranium waste in outdoor pits onsite during the late 1940s. This information came primarily from U.S. Army Corps of Engineers 2005 assessment of the Joslyn site (Army Corps 2005) and from interviews with several former Joslyn workers performed in July 2012 (NIOSH 2012b). Section 5.2.1 of the ER summarizes the uranium waste burning practices:

> *There is evidence that an outdoor area was used to burn waste. According to former worker reports, uranium wastes/residues from machining uranium rods were collected and dumped on the ground each day and were gone when the workers returned the next day. The work experience at Joslyn of these former workers began in 1948 and continued beyond the end of covered operations at the site. These workers could not give any testimony regarding operations prior to 1948. These workers related that they learned much later from a co-worker that the co-worker was in fact responsible for burning these scraps and wastes at the end of the day* [NIOSH 2012b].
>
> *For accountability purposes, efforts were made to collect the residual cuttings and dust using steel pans to collect shavings and trimmings and by brushing the steel floor plates before, during, and after cutting work. The practice at Joslyn was to burn the waste material so that it would be in the less combustible oxide form for shipment back to the AEC. NIOSH is aware that former workers report that burning operations were performed outdoors by one individual* [NIOSH 2012b]. *These former workers reporting on burn operations had work history at the site beginning in 1948 through covered operations.*

NIOSH references the Kehoe et al. 1950 report, which discusses the practice of "dry burning" of uranium waste:

> *The most expeditious and least expensive method for the disposal of uranium scraps by conversion to oxide is by direct dry burning in air. For a quantity not exceeding 5#, the scrap may be spread out on a steel plate in an open area and burned to oxide by the flame of an oxy-acetylene torch. The worker should be protected by a welders face shield and a metal fume respirator. The scrap should be raked to insure that all the metal goes to oxide.*

NIOSH does mention that waste burning outdoors, as opposed to indoors, does greatly reduce the airborne concentrations, as compared to indoor burning, but as indicated in Section 2.6 of this report, even outdoors, these activities could produce substantial airborne dust loadings. In addition, it is not known if the individuals responsible for burning the uranium scrap waste wore respiratory protection.

As part of their discussion of the burn pits, NIOSH describes the radiation surveys that were performed in the area of the burn pits. In 2004, Radiation Safety Services Incorporated (RSSI) took borehole readings in the former burn pit area. Section 4.5 of the ER states:

> *This survey included the advancement of soil borings (Borings A - D) in the EastWest Bay (Building 8) and in the former burn pit area outside immediately to the north of Building 8 (P-l through P-6). Borehole count rates showed elevated readings at depths 3-10 ft below ground surface (bgs) in the burn pit area, and at depths 4-9 ft bgs in the Processing Building (Building 8). The highest isotopic uranium concentrations were in a sample from Borehole D (4-8 ft bgs interval) which had uranium-235 at 2.07 pCi/g and uranium-238 at 73.5 pCi/g. Uranium-235 was less than 1 pCi/g in the other eight samples for which data were reported, and less than 10 pCi/g for uranium-238.* [Army Corps 2005]

SC&A reviewed all of the Joslyn documents referenced by NIOSH in the ER, as well as publically available U.S. Army Corps of Engineers documents, and were able to confirm all the information presented by NIOSH regarding waste burning activities. SC&A did conduct a query of the Joslyn documents on the Site Research Database (SRDB) using the search terms "burn," "burning," and "burn pit," but no documents resulted from that query. However, the available evidence is sufficient to make a conservative assumption that waste pit burning did occur, as indicated by the fact that Army Corps 2005 and Joslyn worker interview report (NIOSH 2012b) both discuss the burn pits; both documents are located in the database. Therefore, estimation of intakes from exposure at the burn pits is critical.

Some outdoor burning results were reported for the Melt Plant Building at Hanford in Adley et al. 1952. Both an open hearth furnace and a graphite burner were located outside the Melt Plant Building. The open hearth furnace was used to burn crucible heels, floor sweepings, used gloves, and some material from a chip recovery process conducted in another building. The graphite burner was used for burning broken and discarded crucibles and stopper rods. Operations associated with a graphite burner produced less dust than operations associated with the open hearth furnace. The operation that resulted in the highest dust concentrations was shoveling the residue from the open hearth burning into barrels or buckets. In some cases, the burned material was sifted through a coarse screen before being loaded into a container. Adley et al. (1952) note that while these operations were very dusty, they were of brief duration. They characterized the air concentrations for three operations:

- Operation A – burning in open hearth furnace
- Operation B – loading oxide from open hearth furnace into buckets and barrels
- Operation C – graphite burning

Air sampling results are summarized in Table 2-5 (Adley et al. 1952, Table V), where the GM values were calculated using the same procedure used in TBD-6000.

Table 2-5. Atmospheric Concentrations of Uranium at Hanford Melt Plant Outdoor Burning Operations

Operation	Number of Samples	Range of Uranium Concentrations		GM Uranium Conc.
		10^{-5} µg/cm^3	dpm/m^3	dpm/m^3
A	9	1.4 to 260	21 to 3,950	288
B	3	3,930 to 6,370	59,700 to 96,800	76,000
C	2	1.4 to 9.8	21 to 149	56

The measured airborne uranium concentrations for Operation B are significantly higher than any of the values from TBD-6000 used in evaluating Joslyn exposures. However, it is difficult to make a direct comparison. Table 7.5 of TBD-6000 cites the **DWA** from centerless grinding of uranium to be 5,480 dpm/m^3. While Adley et al. (1952) note that Operation B was of "brief duration," it is not possible to estimate what the actual DWA might have been. If the operator's exposure other than shoveling oxide was minimal, then exposure during shoveling would need to have not exceeded about 30 minutes per day for a comparable DWA. As discussed below in Section 4.0, which summarizes worker interviews, it appears that uranium pit burning was a daily occurrence, and exposures from this activity could have been as high as 30 minutes per day.

2.6.2 Chip Fires

The Joslyn ER mentions the possibility of uranium chip fires:

> *The biggest generator of uranium dust associated with machining was probably the ignition of small chips and turnings that were generated during machine operations (*[Battelle 2006]*, PDF p. 16). At Joslyn, due to the pyrophoric nature of the uranium, a heavy flow of coolant was used over the cutting/grinding surfaces to minimize sparking. These measures would have also reduced the airborne concentrations to some degree. While the rolling operations were generally open in the mill buildings, the grinding and cutting operations were to be ventilated through the use of a small shed enclosure within the larger building. The grinder had an overhead hood connected to a fan and discharge was into the inside of the larger shed. During MED/AEC surveys the air concentrations around the centerless grinder were still found to be unacceptable and apparently this ventilation was not sufficient to meet the standards in effect at the time.* [NIOSH 2012a, pp. 23–24]

Beyond the likelihood that chip fires may have been the "biggest generator of uranium dust associated with machining," there is the problem of other chip/turnings fires resulting from machining operations; this is discussed in Harris and Kingsley (1959, pp. 111–113). However, neither TBD-6000 nor Harris and Kingsley (1959) contain actual data on air dust concentrations resulting from such fires. It would appear, therefore, that quantitative data relating to chip fires other than routine ignition in the process of machining need to be added to the exposure matrix provided in the ER for Joslyn in order for it to be complete.

2.6.3 Sweeping

As mentioned in Section 2.2 above, workers swept up the floors in operational areas every half hour. This likely resulted in considerable airborne dust. Neither the Joslyn ER (NIOSH 2012a) nor TBD-6000 contain quantitative data on such operations. Harris and Kingsley discuss the importance of housekeeping in reducing airborne dust and provide an example of the reduction in airborne dust resulting from installation of grating. However, this example is not quantitatively relevant to the problem at hand, which would be to estimate airborne dust intakes of workers performing the sweeping. This is another item that needs to be added to the intake exposure matrix in the ER for it to be complete.

Finding 8: Though of short duration, the airborne uranium dust levels associated with uranium open pit burning and associated activities, such as shoveling the burn residue into containers, could contribute significantly to annual intake of uranium. NIOSH needs to evaluate the degree to which outdoor open pit burning of uranium shards renders TBD-6000 incomplete as a surrogate dataset for AWE facilities with limited bioassay and air sampling data. NIOSH should do the same for uranium chip fires that may have occurred in the machining or scrap storage areas. A third area of concern is that there are no data for the frequent sweeping activities that likely generated considerable resuspension of uranium dust. The present exposure matrix in the ER is incomplete in all three respects.

3.0 REVIEW OF METHODS FOR RECONSTRUCTING EXTERNAL DOSES

3.1 EVALUATION OF BOUNDING PROCESS-RELATED EXTERNAL DOSES

NIOSH states that the information in Table 5-1 of the ER covers 90% of the uranium processed at Joslyn.

Finding 9: It would strengthen the report if the basis for the 90% coverage of the uranium source term was documented.

NIOSH determined that about 1,127,000 lbs of uranium were processed during the covered period (from 1943 through 1952). Data supporting this throughput estimate is included in Tables 5-1 and 6-3 of the ER. NIOSH further determined that the monthly production rate was 90 tons, based on a 1948 report (Monthly Report Apr 1948). Using this information, it was estimated that uranium rolling at Joslyn occurred over 190 days during the covered period, or about 1.6 days per month on average. NIOSH estimated that an additional 95 days were spent doing centerless grinding of the uranium rods. Thus, the total time for uranium exposure was about 2.5 days per month. Based on this approach, NIOSH concluded that:

> *This estimate of exposure duration can be used to calculate external dose from uranium metal to workers, using the methods and assumptions in Battelle TBD-6000.*

While SC&A believes that it is possible to calculate bounding external doses from uranium exposures based on TBD-6000, we have several reservations about the NIOSH approach outlined in the previous paragraph. These reservations include:

- No basis is provided in the ER for assuming 95 days for centerless grinding.
- It is likely that centerless grinding work would typically be contemporaneous with uranium rolling, and it might not be appropriate to add grinding time and rolling time to determine total exposure time. This matter should be addressed in the ER.
- Table 5-1 shows that more than 50% of the total uranium processing occurred in 1948, so it is inappropriate to average external exposure over 10 years. Instead, NIOSH should consider varying annual external exposures with annual production.
- The monthly production rate of 90 tons was based on expectations during the time of maximum throughput at Joslyn (i.e., March through June 1948). Throughput at other times over the 10-year period was much lower. Exposure times during periods of low throughput may be higher than predicted from long-term averages.

Finding 10: SC&A does not agree with some of the assumptions proposed by NIOSH in Section 7.3.1 of the ER. SC&A suggests that NIOSH consider prorating the dose values in Table 6-4 based on actual working time, such as days per month. At a minimum, the NIOSH approach appears to underestimate external exposure in 1948. In addition, there is no need to

differentiate between rolling and machining operations, since the doses are the same. However there is one caveat—the units of measure for the data listed in Table 6-4 as Metal Whole Body Dose should be mrem/yr not mr/yr. This is an important consideration when converting whole body dose to organ dose.

In Section 7.3.1, NIOSH also discusses their ability to reconstruct external doses from thorium. NIOSH provides plausible estimates of the mass of thorium processes and the processing duration. It is stated in this section that, "NIOSH also has information regarding the radiological hazard associated with thorium relative to uranium." However, the nature of, and references to, this information on relative hazards is not provided.

Finding 11: NIOSH should document the sources of information they propose to use regarding the relative radiological hazard from thorium.

3.2 METHODS FOR BOUNDING OPERATIONAL PERIOD EXTERNAL DOSE AT JOSLYN

Photon Dose

NIOSH states that:

> *The monthly exposure duration described in Section 7.3.1 of 2.5 days/month provides an annual exposure potential of 30 days/yr for worker exposures.*

As described above, this approach would significantly understate external exposure in 1948 (see Finding 10).

Beta Dose

NIOSH states that:

> *The assumptions, based on annual dose by job category and dose relations as described in Battelle-TBD-6000 for estimating beta dose to metal workers will be used to bound the dose for the workers at Joslyn by applying the annual exposure duration of 30 days/yr as suggest*[ed] *in the photon subsection above.*

As described above, this approach would significantly understate external exposure in 1948 (see Finding 10).

4.0 SC&A REVIEW OF JOSLYN PETITION EVALUATION REPORT WORKER INTERVIEWS

A NIOSH team (which included representatives from NIOSH, Advanced Technology and Laboratories International, Inc., and Oak Ridge Associated Universities) and SC&A conducted an SEC Outreach meeting on July 25, 2012, in Fort Wayne, Indiana, during which [redacted] former workers at the Joslyn facility were interviewed (NIOSH 2012b). The [redacted] workers all began work at the plant in 1948 or 1949, and one stated working there for 43 years (i.e., ending around 1992). Two of the workers had filed claims with the Department of Labor (DOL), but had not yet received compensation determinations.

The interviewers asked about protective equipment and personal radiation monitoring equipment provided when the workers handled uranium. The workers recalled that they were only given cotton gloves when working with uranium, and that they wore their own street clothes, which they were responsible for laundering off-site, at all times in the plant. Although shower facilities were provided, they were only used occasionally; in any event, they wore the same clothes home. One of the workers described wearing what might have been a type of radiation monitor once at the beginning of the worker’s tenure, but none afterwards. No other personal protective or monitoring equipment was provided.

The interviewers asked if the workers could recall any special medical testing related to their employment, such as an annual chest x-ray or urinalyses. The workers could only recall an x-ray machine being brought onsite for chest x-rays for a short time.

The interviewers were interested in whether there were radiation sources at Joslyn other than associated with the uranium processing, and asked if there were onsite non-destructive test facilities, such as those using x-ray instruments, to inspect the uranium. The workers had no knowledge of such facilities.

The workers described the uranium handling and processing in the facility. The uranium was first received by rail and placed in a fenced and guarded holding area. Uranium rods were heated in batch furnaces, rolled in the rolling mill, sent to the straighteners, and then to the centerless grinders (which produced copious sparks and wastes that were collected for later disposal). Following that, cutters, which also generated sparks and waste, were used to reduce the length of any uranium bars that were too long. Rods were also inspected in an inspection shop. After uranium rod processing was finished, the rods were loaded into a closed and guarded railroad car, which would then leave the site. Different rolls (in the rolling mill) would be used to process uranium or steel. The plant was busy, so there was a lot of overtime, with a typical work week of about 48 hours.

The workers recalled that there were no access controls and people were free to go anywhere in the facility. Likewise, there was no employee cafeteria, and workers were free to eat wherever they wanted (usually, though, not at their work sites). They were also free to smoke anywhere, even at their work stations.

The interviewers were particularly interested in dust generation and waste handling and control. The workers noted repeatedly that the different processes generated a lot of dust that was inhaled and scale and other waste that fell to the floors. They noted that the rolling mill produced a great deal of scale and dust that they swept up and put into 5-gallon buckets about every half-hour. The buckets were taken outside full at the end of the day and brought back empty the next day. Although none of the workers interviewed had ever done so themselves or personally observed the activity, they reported that coworkers burned the waste outdoors each night on a steel plate. The workers could not recall any other (uncontrolled) fires at the facility.

The mill floor consisted of steel plates covering a dirt floor and the centerless grinders sat on a steel grating (the floor under the grating was swept periodically). The grinders operated with liquid coolant running over the uranium and the waste and coolant were collected in bins below the grinders. Canvas tents were placed over both the rolling mill and centerless grinders (when processing uranium), with air being drawn out into the surrounding buildings. One of the workers mentioned that, on cold days, other workers would gather in the centerless grinder tent to get warm.

5.0 USE OF SURROGATE DATA

Based on the information presented in this report, one can make a determination regarding whether or not the use of TBD-6000 surrogate data at Joslyn for routine operational intakes is consistent with the surrogate data guidelines developed by the ABRWH (ABRWH 2010). The appropriateness of each of the five surrogate criteria are discussed below.

1. Hierarchy of Data. *It should be assumed that the usual hierarchy of data would apply to dose reconstructions for that site (Individual worker monitoring data followed by co-worker data followed by workplace monitoring data such as area sampling followed by process and source term data.) This hierarchy should be considered when evaluating the potential use of surrogate data. Surrogate data should only be used to replace data if the surrogate data have some distinct advantages over the available data and then only after the appropriate adjustments have been made to reflect the uncertainty inherent in this substitution.*

There were no bioassay data and only limited air sampling data available at Joslyn Steel for the 1948–1952 period, including a few samples in 1951 and an extensive survey by HASL in 1952 (NIOSH 2012a, Table 6-1). In terms of hierarchy of data, generic air sampling data from TBD-6000 site was substituted for limited air sampling data at Joslyn for the 1948–1952 period. The GM and 95th percentiles for the Joslyn rolling date (Klevin 1952) and the TBD-6000 rolling data (Battelle 2006, Table 7-3) are compared below:

Table 5-1. Comparison of Breathing Zone Samples during Rolling

Source	GM (dpm/m^3)	95th Percentile (dpm/m^3)
Joslyn	776	22,500
TBD-6000	4,710	66,500

Comparison of the two sources indicates that use of the more conservative TBD-6000 data is an appropriate adjustment to reflect uncertainties in the surrogate data substitution for rolling.

Similarly, for centerless grinding, the highest dust loadings at Joslyn were experienced in 1951 (see Table 2-3 above), while the generic TBD-6000 values are also based on centerless grinding as being highest amongst the various operations reported. The Joslyn samples are BZ samples, while the TBD-6000 samples are DWA samples. The two sources are compared in Table 5-2.

Table 5-2. Comparison of Air Samples during Machining

Source	GM (dpm/m^3)	95th Percentile (dpm/m^3)
Joslyn	944 (BZ)	2,927 (BZ)
TBD-6000	5,480 (DWA)	77,300 (DWA)

The generic TBD-6000 values are significantly higher than the measured Joslyn values, particularly when considering that the TBD-6000 values are based on DWAs. Comparison of the two sources indicates that use of the more conservative TBD-6000 data is an appropriate adjustment to reflect uncertainties in the surrogate data substitution for machining.

Piccot (1949) can be used to provide added perspective on the applicability of TBD-6000 air concentrations to the situation at Joslyn. Piccot reported on a radiation contamination survey conducted by HASL in 1949 after major rolling operations had ceased at Joslyn, but little decontamination had been done. The highest observed count was 30,000 dpm alpha measured with a Zeuto instrument. Since the Zeuto Mark 1, Model 10, Type A instrument had a 100 cm^2 window, a measurement of 30,000 dpm is also 30,000 dpm/100 cm^2 or 3E+06 dpm/m^2 (http://national-radiation-instrument-catalog.com/new_page_116.htm). Per TBD-6000 (Section 3.4.2), the surface contamination (dpm $(\alpha)/m^2$) is equal to the air concentration (dpm/m^3) times 1944 m.[1] Using the GM value of 4,710 dpm/m^3 from Table 7.3 of TBD-6000, the surface concentration would be 9.17E+06, about three times as high as the highest value measured at Joslyn. This provides further support to the reasonableness of using TBD-6000 rolling data as a surrogate for Joslyn rolling data.

2. Exclusivity Constraints. *In many cases, surrogate data are used to supplement the available monitoring data from a site. In those cases, the surrogate data is* [sic] *usually used to justify certain assumptions about the distribution or range of possible exposures or assumptions about the source terms. In those cases, no special justification is necessary beyond the usual scientific evaluation. This is akin to the Type II use described above. However, in other situations, there are no or very little monitoring data available. In those cases, the use of the surrogate data as the basis for individual dose reconstruction would need to be stringently justified. This judgment needs to take into account not only the amount of surrogate data being relied on relative to data from the site but also the quality and completeness of that surrogate data.*

As discussed above, there were limited site data at Joslyn for the period 1948–1952. The fact that TBD-6000 has been carefully vetted by a Work Group of the ABRWH is indicative of stringent justification of that document as a source of surrogate data. The selected surrogate data from TBD-6000 were based on the sampling work of HASL, which is regarded to be of high quality. The TBD-6000 data are composites from a number of sites and were selected from the source document (Harris and Kingsley 1959) using the most conservative groups of measurements. Consequently, the quality and quantity of the data used should satisfy this criterion.

3. Site or Process Similarities. *One of the key criteria for judging the appropriateness of the use of surrogate data would be the similarities between the site (or sites) where the data were generated and the site where the surrogate data are being utilized. 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.*

[1] This assumes settling at a terminal velocity of 0.00075 m/s for 30 days.

Section 2.1 above presented a comparison of rolling operations at the two sites and showed them to be generally similar. Some of the process steps used at Joslyn appear to be less prone to dust generation than the generic process described by Harris and Kingsley (1959), upon which TBD-6000 is based. However, the issues discussed in Section 2.6 remain:

(1) It is not apparent that the data supporting TBD-6000 include consideration of open pit burning

(2) The frequency and air dust concentrations due to chip fires need to be addressed

(3) The intakes from resuspended contamination due to frequent floor sweeping need to be estimated

In view of these three items, it appears that the values for intakes derived from or based on TBD-6000 might not be bounding for all workers at Joslyn.

4. Temporal Considerations. *Consideration also needs to be given to the period in question, since working conditions and processes varied in different periods. Surrogate data should belong in the same general period as the period for which doses are sought to be reconstructed unless it can be demonstrated that the working conditions, procedures, monitoring methods, and (perhaps) legal requirements were comparable to the period in question.*

As discussed under Finding 3, NIOSH needs to document that the TBD-6000 data cover the relevant period from 1948 through 1952. The source document (Harris and Kingsley) for the TBD-6000 data was published in 1959, but is not clear over what period the data were collected. While it is likely that the data are relevant for the 1948–1952 time frame, this point should be further investigated. The temporal considerations criterion provides the decision-maker with some latitude, noting that surrogate data "should belong in the same general period as the period for which doses are sought to be reconstructed."

5. Plausibility. *The plausibility criterion equates plausibility with the reasonableness of the assumptions made regarding surrogate data. The plausibility determination should address issues of:*

- *Scientific plausibility. Are the assumed models (e.g., bioassay, concentration gradients) scientifically appropriate? Have the models been validated (where feasible) using actual monitoring data collected in a similar situation?*

- *Workplace plausibility. Are the assumed processes and procedures (including monitoring) plausible for the facility in question? Have all of the factors that could significantly impact exposure been taken into account? Is adequate information available about the facility in order to be able to make a fair assessment?*

With regard to scientific plausibility, as described previously, internal exposures were based on actual monitoring data collected under similar situations by a respected measurement laboratory.

With regard to workplace plausibility, we described in Section 2.1 that the processes and procedures that underlie the TBD-6000 data are generally comparable and slightly more conservative than the processes at Joslyn. We have also noted that the methodology used in TBD-6000 was to select from air concentrations measured for several job descriptions. The particular operation (such as rolling or machining) that resulted in the highest exposure was employed and applied to all the operators involved in the rolling or machining operation. Given this methodology, it is reasonable to assume all of the factors that could significantly impact exposure have been taken into account. Adequate information is available about Joslyn to make a fair assessment of workplace plausibility. For example, Piccot (1949) provides a detailed contemporaneous description of the operations and equipment used at Joslyn.

It is our opinion that use of surrogate data from TBD-6000 for dose reconstruction at Joslyn satisfies the ABRWH criteria for routine operational intakes. However, the three issues discussed in Section 2.6 need to be addressed before the intake matrix provided in the ER can be considered complete.

6.0 REFERENCES

42 CFR Part 83, 2004. *Procedures for Designating Classes of Employees as Members of the Special Exposure Cohort Under the Energy Employees Occupational Illness Compensation Program Act of 2000*; Final Rule; May 28, 2004; SRDB Ref ID: 22001.

ABRWH 2006. *Transcript of the 38th Meeting of the Advisory Board on Radiation and Worker Health, held at the Marriott Metro Center, Washington, DC, on June 16, 2006*. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

ABRWH 2010. *Criteria for Use of Surrogate Data*. Draft. Prepared by ABRWH Work Group on Use of Surrogate Data. May 2010.

Adley, F.E., W.E. Gill, and R.H. Scott, 1952. *Study of Atmospheric Contamination in the Melt Plant Building*, U.S. Atomic Energy Commission Report HW-233352 (Rev.), April 4, 1952.

Army Corps 2005. *Preliminary Assessment Joslyn Manufacturing Site Fort Wayne Indiana;* U.S. Army Corps of Engineers Buffalo District. August 23, 2005. SRDB Ref ID: 112928.

Battelle 2006. *Site Profiles for Atomic Weapons Employers that Worked Uranium and Thorium Metals*, Battelle-TBD-6000, PNWD-3738 Rev. 0, Rev. F0; Battelle; December 13, 2006; SRDB Ref ID: 30671.

Chipman, J., 1943. *Rolling of Billets Supplied by Union Carbide and Carbon Company*, correspondence to R.L. Doan from J. Chipman, Joslyn Manufacturing Company. June 30, 1945. SRDB Ref ID: 11036, PDF p. 244.

Christofano, E., and W. Harris, 1960. *The Industrial Hygiene of Uranium Refining*. Reprinted November 1960; SRDB Ref ID: 15774.

Harris, W.B. and I. Kingsley 1959. *The Industrial Hygiene of Uranium Fabrication.* American Medical Association Archives of Industrial Health, May 1959, Vol. 19, pp. 540–565; SRDB Ref ID: 15779.

Kehoe, E.J., F.I. Brannigan, and M. Eisenbud, 1950. *Fire protection precautions for handling uranium turnings, chips, borings, sawdust and powder*. U.S. Atomic Energy Commission, New York Operations Office. March 1, 1950. SRDB Ref ID: 90891.

Klevin, P.B., 1952. *Joslyn Manufacturing and Supply Company Occupational Exposure to Radioactive Dust*; March 25, 1952; SRDB Ref ID: 9664.

Monthly Report, Apr 1948. *Monthly Status and Progress Report for April 1948*; submitted by Office of New York Directed Operations; May 5, 1948; SRDB Ref ID 11036.

NIOSH 2012a. *SEC Petition Evaluation Report SEC-00200*, Joslyn Manufacturing. National Institute for Occupational Safety and Health, Cincinnati, Ohio. December 3, 2012.

NIOSH 2012b. *Documented Communication SEC-00200 – Worker Outreach Meeting for Joslyn Manufacturing and Supply – Unredacted Draft Minutes*. July 25, 2012, 09:45 am. SRDB Ref ID: 118494.

ORAUT 2011. *Guidance on Assigning Occupational X-ray Dose Under EEOICPA for X-Rays Administered Off Site*, ORAUT-OTIB-0079, Rev. 00; Oak Ridge Associated Universities Team, Cincinnati, Ohio. January 3, 2011; SRDB Ref ID: 89563

Piccot, A.R., 1949. *Residual Contamination Survey at Joslyn Steel Co.*; August 22, 1949, SRDB Ref ID: 11036, PDF pp. 46–50; SRDB Ref ID: 9663, PDF pp. 6–14.

SC&A 2006a. *Report to the Working Group on Special Exposure Cohort Petition Review,* Draft. SC&A, Inc., McLean, Virginia. January 16, 2006.

SC&A 2006b. *Board Procedures for Review of Special Exposure Cohort Petitions and Petition Evaluation Reports,* SCA-TR-TASK5-0002, Rev. 1. SC&A, Inc., McLean, Virginia. June 12, 2006.

ATTACHMENT A: RESIDUAL RADIOACTIVITY EVALUATIONS FOR INDIVIDUAL FACILITIES

FACILITY NAME: Joslyn Manufacturing and Supply Co.
Ft. Wayne, Indiana

ALSO KNOWN AS: Joslyn Stainless Steel Co.

TIME PERIOD: 1944–1952

FACILITY DESCRIPTION: DOE Office of Health, Safety and Security Website:
Joslyn rolled uranium rods from billets for use by the MED and the AEC in weapons production.

DISCUSSION:
The billets were received by rail. Work was conducted under MED/AEC constant supervision, and scraps and ash generated were retained by MED/AEC personnel for uranium accountability. Small furnaces were used to heat the material. Three mills and straightening, cutting, threading, and grinding equipment were used in the operation. An outdoor area was used to burn waste. Documentation reviewed indicates that there was a comprehensive radiological survey performed at the end of AEC activities (1949), for the purpose of identifying contamination levels for a facility cleanup. While no post-decontamination surveys are available for review, description of the removal of equipment and handling of accountable materials at the end of the operations, in conjunction with the conditions identified in subsequent DOE preliminary FUSRAP surveys (1976) indicates that residual contamination did not exist beyond the listed period.

INFORMATIONAL SOURCES:
The sources of information reviewed included:

- DOE Office of Health, Safety and Security Website
- Residual Contamination Survey at Joslyn Steel, August 22, 1949
- DOE Report (ORNL); Preliminary Survey of Joslyn Stainless Steel Company, Fort Wayne, Indiana; March 1980
- ERDA Memorandum; Thornton to Kennedy; Subject: ERDA Resurvey Program: Joslyn Stainless Steel Company, Fort Wayne, Indiana; March 10, 1977.

EVALUATION FINDINGS:
Documentation reviewed indicates that there is little potential for significant residual contamination outside of the period in which weapons-related production occurred.