Draft White Paper

REVIEW OF NEW SURROGATE DATA FOR ESTIMATING INTAKES OF URANIUM AT GENERAL STEEL INDUSTRIES

Contract Number 200-2009-28555

Prepared by

Robert Anigstein, William C. Thurber, and Harry J. Chmelynski
S. Cohen & Associates
1608 Spring Hill Road, Suite 400
Vienna, Virginia 22182

November 25, 2012

Disclaimer

This document is made available in accordance with the unanimous desire of the Advisory Board on Radiation and Worker Health (ABRWH) to maintain all possible openness in its deliberations. However, the ABRWH and its contractor, SC&A, caution the reader that at the time of its release, this report is pre-decisional and has not been reviewed by the Board for factual accuracy or applicability within the requirements of 42 CFR 82. This implies that once reviewed by the ABRWH, the Board's position may differ from the report's conclusions. Thus, the reader should be cautioned that this report is for information only and that premature interpretations regarding its conclusions are unwarranted.

S. Cohen & Associates: ***Technical Support for the Advisory Board on Radiation & Worker Health Review of NIOSH Dose Reconstruction Program***	Document Description: White Paper: Review of New Surrogate Data for Estimating Intakes of Uranium at General Steel Industries Effective Date: Draft – November 25, 2012 Revision No. 0 (Draft)
REVIEW OF NEW SURROGATE DATA FOR ESTIMATING INTAKES OF URANIUM AT GENERAL STEEL INDUSTRIES	Page 2 of 18
Task Manager: ______________________________ Date:__________ Robert Anigstein, PhD	Supersedes: N/A
Project Manager: ______________________________ Date:__________ John Stiver, MS, CHP	Reviewer: John Mauro, PhD, CHP

Record of Revisions

Revision Number	Effective Date	Description of Revision
0 (Draft)	11/25/12	Initial issue

NOTICE: This report has been reviewed for Privacy Act information and has been cleared for distribution. However, this report is pre-decisional and has not been reviewed by the Advisory Board on Radiation and Worker Health for factual accuracy or applicability within the requirements of 42 CFR 82.

Review of New Surrogate Data for Estimating Intakes of Uranium at General Steel Industries

1 Introduction

During Meeting 84 of the Advisory Board on Radiation and Worker Health on June 20, 2012, the Board tasked SC&A with reviewing NIOSH's use of surrogate data for estimating intakes of uranium at General Steel Industries (GSI). In fulfilling that task, Anigstein (2012) reviewed the surrogate data used by Allen and Glover (2007) and found that these data did not satisfy the Board's five criteria for the use of such data (ABRWH 2010). In response, Allen (2012a) reviewed measurements of airborne uranium activity concentrations at three additional work sites and concluded the original data used by Allen and Glover constituted a plausible upper bound. Both reports were discussed at the August 28, 2012, meeting of the ABRWH Work Group on TBD-6000. At the conclusion of the meeting, the work group requested that NIOSH look for surrogate data from sites that have handled the same types of uranium as GSI.

Allen (2012b) stated that "NIOSH broadened its search for data related to the handling of cold uranium metal." In this report, which was issued November 6, 2012, he reviewed additional measurements of airborne uranium activity concentrations. He compiled a list of 37 actual or implied measurements for seven individual operations at various work sites to use as a surrogate for uranium concentrations during uranium handling at GSI. He evaluated the use of these data against the Board's five surrogate data criteria and concluded that they satisfied the criteria. He then derived a value of 104 dpm/m^3 as the upper 95th percentile of these data, assuming they constituted a lognormal distribution, and assigned this value to the bounding airborne uranium concentration during uranium handling operations at GSI.

2 Definition of Cold Uranium Metal

Allen (2012b) defined cold uranium metal as metal that has not been physically heated. In fact, all uranium metal has been heated at some point in its metallurgical history. We presume that Allen was referring to intermediate or finished uranium mill products that had undergone some surface conditioning after high temperature processing to remove loose surface scale. For example, uranium slugs have a machined surface. Uranium ingots are produced by vacuum melting of derbies and therefore should have little oxide scale. Any dross resulting from the melting process would rise to the top of the melt and be subsequently removed when the cast ingot was cropped. The betatron slices produced at Mallinckrodt were sawed from these ingots (Westbrook and Bloom 2007). The sawed surfaces of the slices would tend to tarnish in air. The resulting thin oxide film prevents further oxidation of the bulk metal at room temperature (DOE 2001). The cylindrical surfaces would be those of the vacuum-cast ingots. Dingots would presumably have an oxidized surface resulting from the bomb reduction process. However, it is likely that most loosely adherent oxide would be removed during surface cleanup with a pneumatic chipping hammer (Westbrook and Bloom). It is also possible that aggressive handling of uranium metal shapes could actually abrade the metal causing particles to oxidize and become airborne. However, uranium metal is quite ductile, so the amount of material produced should be small.

NOTICE: This report has been reviewed for Privacy Act information and has been cleared for distribution. However, this report is pre-decisional and has not been reviewed by the Advisory Board on Radiation and Worker Health for factual accuracy or applicability within the requirements of 42 CFR 82.

3 Review of Airborne Uranium Activity Concentrations

In order to review Allen's (2012b) distribution of uranium activity concentrations, we performed an independent analysis of the data. We reviewed the seven source documents cited in his report and selected the data that, in our judgement, were most suitable for constructing a distribution to be used to derive a surrogate for uranium concentrations at GSI. We also reviewed other references pertaining to these work sites in order to gather more information about the processes that gave rise to these concentrations. Our evaluation of the data for each site is discussed below. The results of our analysis are presented in Table 1, which appears after the reviews of the source documents.

3.1 R. K. LeBlond Machine Tool Company

As described by Allen (2012a),

> A test was conducted at Leblond [sic] to evaluate a hole boring machine. Air samples were taken while boring a hole into a uranium billet with a rapid bore machine. Coolant was used while boring the hole but air samples were taken while loading the dry billet onto the machine. . . . The remarks section of the data sheet indicates there was no ventilation on the machine and very little air movement. Coolant used during the boring reduced any possible interference from nearby operations. Together, these issues make the Lebland [sic] samples the most directly relevant samples to the work at GSI.

Allen (2012b) included six of the breathing zone (BZ) samples measured at LeBlond in his data set. The first three were described as "operator hooking hoist to billet and placing billet into position on machine," while the next three were "operator removing billet from machine after billet had been bored and placing billet on scale" (Workum 1961). We agree that these measurements were appropriately included in the surrogate data set. However, we believe that six other samples should be included. These are described as "Operator operating controls of machine. No visible dust or fumes – oil splatters near end of operation." (Workum 1961) Although these samples were taken during the boring operation, the boring was performed under a continuous flow of liquid coolant that washed the chips down a pipe to the coolant tank. This prevented any significant contribution of material removed from the billet by the drill bit to the airborne activity. This second set of measurements produced values in the same range—"nd" to 15 dpm/m^3—as the first set; including these measurements doubles the number of data points for this facility.

3.2 Chambersburg Engineering Co.

According to Allen (2012a),

> At Chambersburg Engineering approximately 150 hot uranium slugs were forged into washers during a two day test. The slugs were dry heated and no ventilation was provided for the work. . . . The average air concentration while loading cold uranium slugs into a furnace was 69 dpm/m^3 while loading one slug every 15 minutes and increased to 77 while loading one slug every two minutes. The maximum air concentration while loading cold uranium into the furnace was

> 174 dpm/m^3. Air concentrations after heating and while forging were higher and it is possible some of that airborne contamination caused by this work interfered with samples taken while loading the furnace.

Rube (1957) included a summary of measurements of 19 BZ samples collected at seven individual locations during this operation. The highest concentrations—from 314 to 1268 dpm/m^3—were measured in the BZ of the impactor operator controlling the impactor at a 10-ft distance. As Rube reported, “The major portion of the dust generated from these operations drifted north toward the impactor control panel where the impactor operator stood while stamping the washers.” Although Allen (2012a) cited this reference and reproduced the data in his Figure 3, Allen (2012b) selected three samples from NLO 1957 that lists a subset of the data cited by Rube. These samples were collected at 5-min intervals in the BZ of the “operator working safety control on impactor, which is located 5′ west of impactor.” They had a range of 5–28 dpm/m^3.

We do not believe that the Chambersburg measurements should be included in the surrogate data set since, contrary to Allen’s (2012b) statement that NIOSH “broadened its search for data related to the handling of *cold* uranium metal [italics ours],” the uranium was hot during the forging operation. The operator working the safety control, whose readings were included in Allen’s data set, was only 5 ft from the machine, while the operator at the control panel, whose readings were excluded, was 10 ft away. Since these samples were collected during the hot forging operation, as were the rest of the samples at this facility, there is no basis for selecting them for the surrogate data set in preference to other samples which had higher readings.

3.3 Tocco Induction Heating Division, Cleveland

According to EECAP (2012),

> Tocco Induction Heating in Cleveland, Ohio had a contract with National Lead of Ohio (Fernald) to develop induction heating coil equipment for heating uranium fuel cores. Tocco performed operational tests of these units at its Cleveland Ohio facility, which took place during 1967-1968. The company received 2000 pounds of natural uranium machined fuel cores and 5600 pounds of depleted uranium machined fuel cores from NLO for testing.

NLO (1968) provided data on air samples collected at Tocco on February 16 and June 6, 1968. The February data were from “8″ normal slugs – no ventilation” and include two BZ samples, described as “loading uranium slugs on run in table,” that Allen (2012b) properly included in the surrogate data set. There were four additional samples, collected slightly later the same morning, for “8″ normal slugs – no ventilation, smoke and or fumes could be seen when the slug hit the oil bath.” These samples, with measurements that ranged from 12 to 113 dpm/m^3, were described as “working controls west of the oil bath.” Allen appropriately excluded them from the data set.

The June data were from “normal & depleted slugs being heat treated.” These data include 12 BZ samples. The time sequence of the sampling casts additional light on the processes that took place. Three samples “loading slugs at loading tray – heating,” were collected between 10:26 and 10:28 o’clock; three “loading slugs – no heat,” were collected at 11:15–11:17. Six samples

NOTICE: This report has been reviewed for Privacy Act information and has been cleared for distribution. However, this report is pre-decisional and has not been reviewed by the Advisory Board on Radiation and Worker Health for factual accuracy or applicability within the requirements of 42 CFR 82.

were from “unloading slugs from conveyor and putting in box,” three of which were collected at 11:45–11:50 and the rest at 1:05–1:09. Allen (2012b) included the first six samples, which ranged from “nd” to 37 dpm/m^3, in the surrogate data set, but excluded the last six, with measurements of 59–320 dpm/m^3. Given the time sequence and the measured values, it is most likely that these latter measurements were made after the uranium was heated, and were thus properly excluded.

We agree that the measurements on the first six samples in June data should be reflected in the surrogate data set. However, the tests included slugs made of depleted uranium, which would have produced the same airborne *mass* concentrations (e.g., µg/m^3) as natural uranium, but lower activity concentrations. Since, according to EECAP (2012), Tocco received 5,600 lb of depleted uranium and 2,000 lb of natural uranium, and since the February tests were of natural uranium, we made the claimant-favorable assumption that all the June data are from depleted uranium. We recalculated these activity concentrations, multiplying each value by 1.887, the ratio of specific activities of natural to depleted uranium, and substituted the revised values in the surrogate data set.

3.4 Feed Materials Production Center, Fernald, Ohio

According to Ross et al. (1963),

> Air dust samples were collected during the week of August 19, 1963, for the purpose of evaluating the air dust levels generated during the reduction of 1.25% enriched UF_4 to uranium metal. During the sample period complete ventilation for the reduction area was provided by G37-5011 dust collector. The primary duct to the breakout enclosure was closed to allow maximum ventilation at the breakout table.

Ross et al. (1963) tabulated 17 sets of BZ samples—the concentrations for each set were presented as high, low, and average, with no indication of how many samples comprised each set. Only three of these data sets referred to uranium metal: those labeled “breaking out derby,” “cleaning derby,” and “removing derby from breakout table.” Allen (2012b) included these data in the surrogate data set, utilizing the high, low, and average values as if they represented three individual measurements.

We have several objections to the use of these data. First, the operations were performed with maximum ventilation, which does not correspond to working conditions in the GSI betatron shooting room. Second, the uranium is enriched, while most if not all the uranium handled at GSI was natural. Third, the operation “cleaning derby” implies some disturbance of the surface that could have been more aggressive than merely handling and transferring uranium metal. Fourth, we do not agree with assigning the average value as a third datum.

Some of these issues could be resolved by adjusting the reported values. The measured activity of the 1.25% enriched uranium could be adjusted to correspond to natural uranium. The operation “cleaning derby” could be omitted, leaving two sets of data. Since most of the BZ data at other sites surveyed by NLO personnel consist of three sets of readings over a short time span at a given location, we could use the three reported values—high, low, and average—to calculate the presumed third value and enter it, along with the high and low values, in the data set. However, we do not know how to account for the maximum ventilation, which does not represent conditions at GSI. We therefore excluded the Fernald data from the revised surrogate data set.

3.5 Weldon Spring

3.5.1 Dingot Handling

Reyland (1960) described a dust study performed on a dingot lathe at the Weldon Spring Plant. Two BZ samples were collected during the removal and installation of a dingot on the lathe by means of an overhead hoist; this operation is similar to the dingot handling at GSI. Allen (2012b) appropriately included these readings in the surrogate data set.

"Uranium Dust Study . . ." (1961) describes the operation of the dingot machining station that was located at the Weldon Spring Plant. "A dingot grab and bridge crane combination is used for moving the dingots from the storage area to the lathes. The dingot is centered on the lathe table and secured in the chuck." These operations were performed before a fume hood was moved into place, so there was presumably little or no forced ventilation during this time. Table I, "Measured Uranium Dust Concentrations at the Dingot Machining Station – 301 Metal Plant," includes concentrations measured during "installation and removal of dingot in lathe." The measurements are listed as $2.1–3.0 \times 10^{-11}$ µCi/cm^3; the table also lists the average concentration as 76 µg/m^3. A footnote lists the assumed conversion factor of 3×10^6 g/Ci of natural uranium.[1]

Allen (2012b) included these measurements in the surrogate data base. He apparently divided the average concentration—76 µg/m^3—listed in the table by the conversion factor to derive the average value of 2.533 µCi/cm^3, and converted all three values (the average, and the low and high ends of the range) to dpm/m^3. We observe that dividing the average dust concentration by the conversion factor and rounding to one decimal place yields 2.5×10^{-11} µCi/cm^3, which is the rounded average of the range of readings. It would appear strange for the report to list a range in µCi/cm^3 and an average in µg/m^3—it is more likely that the author simply averaged two readings and converted to µg. We therefore believe it is not correct to use the average as a third value and have eliminated it from the revised surrogate data set. We retained the high and low values in the surrogate data set.

3.5.2 Core Outgassing

"Core Outgassing" (1960) describes the heating of uranium slugs in a vacuum furnace. The α air activity concentrations include only one BZ sample measured before the slugs were heated in the furnace. The other BZ samples were taken after the furnace was unsealed and the operator was exposed to the hot slugs. Unlike the data selected from other sources, Allen (2012b) selected three general air samples from this document for inclusion in the surrogate data set. These data are inconsistent with the rest of the surrogate data set. We excluded them from the revised data set and added the single BZ sample in their place.

[1] The currently accepted value is 4.6×10^6 g/Ci.

NOTICE: This report has been reviewed for Privacy Act information and has been cleared for distribution. However, this report is pre-decisional and has not been reviewed by the Advisory Board on Radiation and Worker Health for factual accuracy or applicability within the requirements of 42 CFR 82.

3.6 Mallinckrodt[2]

Mallinckrodt (1957) lists α air concentration measurements during dingot machining, including three BZ samples collected while the worker was setting up the dingot for machining on a lathe. Allen (2012b) appropriately included these results in the surrogate data set.

3.7 Results and Conclusions

Table 1 presents a summary of our analyses of data from the individual work sites. All activity concentrations listed by Allen (2012b, Attachment 1) are included. Data on measurements that we excluded from our revised surrogate data set are listed in blue and struck out. Data that we added are listed in red and underlined. There were 37 concentrations in Allen's original data set; our revised surrogate data set includes 28 readings. We have performed a statistical analysis of Allen's data, using the regression of order statistics (ROS) method to fit the data to a lognormal distribution, and confirmed the upper 95th percentile value of 104 dpm/m^3. The best fit of these data, which include six nondetect readings, yields a value of R2 = .8781. A similar analysis, based on the best fit of our revised data set to a lognormal distribution, results in a 95th percentile of 66.4 dpm/m^3. Our adjusted data set, including eight nondetect readings and one low-value outlier that is not part of the curve fit, yields R^2 = .946. The goodness of fit of the revised data is further confirmed in that the empirical 95th percentile value, calculated by a nonparametric analysis, is 66.9 dpm/m^3, which is within 1% of the previous value. This method makes no assumption about the form of the underlying distribution. The details of the analyses are presented in Appendix A.

The revised data set thus provides a better fit to a lognormal distribution and more closely satisfies the surrogate data criteria, as discussed below. However, Allen's (2012b) data yield a more claimant-favorable surrogate value.

4 Evaluation of Surrogate Data

The ABRWH Work Group on Use of Surrogate Data (2010) issued five "criteria that need to be considered in determining whether the specific use of surrogate data for individual dose reconstruction is scientifically sound and appropriate for that particular application." We have applied these criteria in reviewing the use of Allen's (2012b) data and our own revised data set to derive surrogates for the uranium handling operations at GSI. Following the statement of each criterion is an evaluation of how well the use of these surrogate data conforms to that criterion.

[2] Allen (2012b) attributed these data to Weldon Spring while in fact, Plant 7W, where the data were collected, was located at the Mallinckrodt Chemical Works in St. Louis (Westbrook and Bloom 2007).

NOTICE: This report has been reviewed for Privacy Act information and has been cleared for distribution. However, this report is pre-decisional and has not been reviewed by the Advisory Board on Radiation and Worker Health for factual accuracy or applicability within the requirements of 42 CFR 82.

Table 1. Airborne Activity Samples[a]

Site	Form	α activity (dpm/m^3)	Reference	Description
LeBlond	billets	9	Allen 2012b	Operator hooking hoist to billet and placing billet into position on machine
LeBlond	billets	nd[b]	Allen 2012b	
LeBlond	billets	nd	Allen 2012b	
LeBlond	billets	15	Allen 2012b	Operator removing billet from machine after billet had been bored and placing billet on scale
LeBlond	billets	nd	Allen 2012b	
LeBlond	billets	nd	Allen 2012b	
LeBlond	billets	nd	Workum 1961	Operator operating controls of machine. No visible dust or fumes – oil splatters near end of operation
LeBlond	billets	nd	Workum 1961	
LeBlond	billets	15	Workum 1961	
LeBlond	billets	9	Workum 1961	
LeBlond	billets	9	Workum 1961	
LeBlond	billets	1	Workum 1961	
Chambersburg	slugs	~~24~~	Allen 2012b	Operator working safety control on impactor, which is located 5' west of impactor
Chambersburg	slugs	~~5~~	Allen 2012b	
Chambersburg	slugs	~~28~~	Allen 2012b	
Tocco	slugs	53	Allen 2012b	8″ normal slugs – no ventilation: Loading uranium slugs on run-in table
Tocco	slugs	22	Allen 2012b	
Tocco	slugs	~~5~~	Allen 2012b	Loading slugs at loading tray – heating
		9.44	Adjusted for DU	
Tocco	slugs	~~37~~	Allen 2012b	
		69.83	Adjusted for DU	
Tocco	slugs	~~5~~	Allen 2012b	
		9.44	Adjusted for DU	
Tocco	slugs	~~24~~	Allen 2012b	Loading slugs – no heat
		45.30	Adjusted for DU	
Tocco	slugs	nd	Allen 2012b	
Tocco	slugs	~~19~~	Allen 2012b	
		35.86	Adjusted for DU	
Fernald	derby	~~45~~	Allen 2012b	Breaking out derby
Fernald	derby	~~50~~	Allen 2012b	
Fernald	derby	~~34~~	Allen 2012b	
Fernald	derby	~~60~~	Allen 2012b	Cleaning derby
Fernald	derby	~~74~~	Allen 2012b	
Fernald	derby	~~47~~	Allen 2012b	
Fernald	derby	~~88~~	Allen 2012b	Removing derby from breakout table
Fernald	derby	~~11~~	Allen 2012b	
Fernald	derby	~~60~~	Allen 2012b	
Weldon Spring	dingots	24	Allen 2012b	Removing and installing dingot
Weldon Spring	dingots	21	Allen 2012b	
Weldon Spring	dingots	~~56.24~~	Allen 2012b	Spurious data based on average

NOTICE: This report has been reviewed for Privacy Act information and has been cleared for distribution. However, this report is pre-decisional and has not been reviewed by the Advisory Board on Radiation and Worker Health for factual accuracy or applicability within the requirements of 42 CFR 82.

Table 1 (continued)

Site	Form	α activity (dpm/m³)	Reference	Description
Weldon Spring	dingots	66.6	Allen 2012b	Installation and removal of dingot in lathe
Weldon Spring	dingots	46.62	Allen 2012b	
Weldon Spring	slugs	~~25~~	Allen 2012b	General air samples, not breathing zone
Weldon Spring	slugs	~~25~~	Allen 2012b	
Weldon Spring	slugs	~~25~~	Allen 2012b	
Weldon Spring	slugs	23	"Core Outgassing" 1960	Positioning & bolting to flange (BZ)
Weldon Spring[c]	dingots	11.8	Allen 2012b	Setting up dingot
Weldon Spring[c]	dingots	nd	Allen 2012b	
Weldon Spring[c]	dingots	23.7	Allen 2012b	

Source: Allen (2012b, Attachment 1)

[a] Red text and underlined values indicate data added in the present review; blue text and struck-out values indicate data excluded by present review

[b] nd = not detected

[c] As listed by Allen (2012b)—operations took place at the Mallinckrodt Chemical Works in St. Louis

4.1 Criterion 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 are no monitoring data relating to uranium intakes at GSI. The only data relating to uranium contamination are from FUSRAP surveys of the Old Betatron Building performed in 1989 and 1993. The TBD-6000 work group concluded that these data cannot be used to calculate airborne uranium concentrations during the operational and residual periods because of the long time that elapsed before the surveys were performed and because of reports that the building was cleaned following the operational period. Thus, we conclude that the use of surrogate data conforms to the hierarchy of data.

We next need to determine if appropriate adjustments have been made to the surrogate data as it was applied to GSI. As discussed in preceding sections of this review, the surrogate airborne activity concentrations were derived by calculating the 95th percentiles of the assumed lognormal distributions, which produces a claimant-favorable result. This constitutes "appropriate adjustments" to the surrogate data. We find that Criterion 1 is satisfied both by Allen's (2012b) data, and by the revised data set in the present review.

4.2 Criterion 2: Exclusivity Constraints

> [In situations where] there are no or very little monitoring data available . . . 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.[3]

As stated previously, there are no monitoring data on uranium intakes at GSI. NIOSH searched the site research data base (SRDB) and found seven sites or operations that appeared to include data on airborne uranium concentrations that resulted from the handling of cold uranium metal. As discussed earlier, we found that two of these data sets, as well as some individual values from the remaining five operations, do not constitute suitable surrogate data. However, we found that 21 measurements did conform to the requirements for surrogate data;[4] in addition, we found seven more measurements at these same work sites that are suitable additions to the surrogate data set. We believe that the use of these data is, in fact, adequately justified, and that Criterion 2 is satisfied.

4.3 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. Factors that could be considered include, but are not limited to, similarity of the production processes, presence or absence of conditions that might affect exposure, and monitoring methods employed at the site(s). The potential availability of other sources of surrogate data needs to be considered and the selection of the surrogate data used for dose reconstruction justified. Some of the questions to be considered where appropriate are:
>
> - Are there other sources of surrogate data that were not used?
> - Do these other potential sources contradict or undermine the application of the data from the selected site?
> - Are there adequate data characterizing the site being used that would help support its application to other sites?
> - Do the surrogate data reflect the type of operations and work practices in use at the facilities in question?

[3] Only the relevant text from Criterion 2 is quoted here.

[4] These include five values that we adjusted to reflect activity concentrations that may have been generated by the handling of depleted uranium.

> Surrogate data should not be used if the equivalence of working conditions, source terms, and processes of the surrogate facility to the one for which dose reconstructions are being done cannot be established with reasonable scientific or technical certainty as outlined here.

Six of the measurements in our revised data set were made while the operator was handling uranium billets, while six more (that we added) were made while the operator was operating the controls in the vicinity of a boring machine. Since the boring did not generate any airborne activity, he can be presumed to be exposed to residual dust from the handling operation. Seven other airborne concentrations were from the handling of dingots. Since both billets and dingots can be assumed to have been radiographed at GSI, these data are directly relevant to GSI operations. Nine other measurements were during the handling of uranium slugs. While the slugs do not exactly conform to uranium objects known to have been radiographed at GSI, they do fall into the general category of handling cold uranium metal, and are thus suitably included in the data.

In response to the first bullet item under Criterion 3, we are satisfied that NIOSH explored the available data and included all reasonable sources of surrogate data; bullet item 2 is thus moot. Items 3 and 4 are likewise satisfied by the descriptions of site operations that accompany the adopted data.

We observe that the data cover cold uranium handling operations involving slugs, billets, and dingots. The range of the shapes and sizes adequately encompasses the uranium shapes handled at GSI. The materials handling processes for moving large metal shapes are not unique to GSI or to the surrogate data sites. They are representative of general heavy industry practices. We thus conclude that the surrogate data basically conform to Criterion 3.

4.4 Criterion 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.

The surrogate data span the years 1956–1968, which overlap most of the 1953–1966 period of operations at GSI. There is no reason to believe that work practices at GSI in 1953–1955 differed from those in later years, since we are not aware of any efforts to mitigate the generation of uranium dust nor the workers’ exposure to such dust during the later years.

4.5 Criterion 5: Plausibility

> The manner in which the surrogate data are to be used must be “plausible” with regard to the reasonableness of the assumptions made. 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?

The measurements at the various sites were done in the course of safety inspections by AEC contractor personnel and are presumed to have conformed to applicable health and safety standards. We assume that they represent the same level of scientific validity as any other health physics monitoring of that era. We believe that these data satisfy the criterion of scientific plausibility.

Dust generation from the movement of heavy metal shapes and materials is not expected to be strongly site specific. Lifting equipment is generally selected on the basis of the loads to be handled. Thus, use of data from lifting and handling at surrogate sites is a fair representation of operations that occurred at GSI. This is especially true when the same shapes (e.g., dingots) were handled at both GSI and surrogate sites. We believe that use of the proposed surrogate data is consistent with the plausibility criterion.

5 Conclusion

We have reviewed the data on airborne uranium activity concentrations resulting from the handling and transport of cold uranium metal presented by Allen (2012b). We find that, with appropriate adjustments and revisions, such data yield a suitable surrogate for the airborne uranium activity concentrations resulting from the handling and transport of uranium at GSI. The revised and adjusted data satisfy the five Board criteria for the use of surrogate data and are statistically robust, the ROS method and the nonparametric empirical method yielding almost identical values.

NOTICE: This report has been reviewed for Privacy Act information and has been cleared for distribution. However, this report is pre-decisional and has not been reviewed by the Advisory Board on Radiation and Worker Health for factual accuracy or applicability within the requirements of 42 CFR 82.

References

ABRWH Work Group on Use of Surrogate Data. 2010. "Criteria for the Use of Surrogate Data," Final Draft (May 14, 2010). http://www.cdc.gov/niosh/ocas/pdfs/abrwh/proc/abrwh-proc-sd-r0.pdf.

Allen, D. 2012a. "Use of Surrogate Data at GSI: Response to SC&A Review Dated July 16, 2012." http://www.cdc.gov/niosh/ocas/pdfs/dps/dc-gsisd-0812.pdf

Allen, D. 2012b. "Evaluation of Additional Air Sample Data Applicable to GSI." http://www.cdc.gov/niosh/ocas/pdfs/dps/dc-gsiasd-1112.pdf

Allen, D., and S. Glover. 2007. "Site Profiles for Atomic Weapons Employers That Worked Uranium and Thorium Metals - Appendix BB: General Steel Industries," Battelle-TBD-6000, Appendix BB, Rev. 0. http://www.cdc.gov/niosh/ocas/pdfs/tbd/b-6000-apbb-r0.pdf.

Anigstein, R. 2012. "Review of the Use of Surrogate Data for Estimating Intakes of Uranium at General Steel Industries." http://www.cdc.gov/niosh/ocas/pdfs/abrwh/scarpts/sca-gsisd-r0.pdf

"Core Outgassing." 1960. SRDB Ref. ID: 14956.

Department of Energy (U.S.), Office of Environmental Management, Depleted Uranium Hexafluoride Management Program (DOE). 2001. "Characteristics of Uranium and Its Compounds." http://web.ead.anl.gov/uranium/pdf/UraniumCharacteristicsFS.PDF

Energy Employees Claimant Assistance Project (EECAP). 2012. "Tocco Induction Heating Division, Cleveland Ohio." http://www.eecap.org/Covered_Facilities/Ohio/Tocco.htm

Mallinckrodt Chemical Works, Uranium Division. 1957. "Dust and Radiation Study of the Machining of Dingot and Ingot Metal at Plant 7W." SRDB Ref. ID: 17254.

National Lead Company of Ohio (NLO). 1957. "Analytical Data Sheet." SRDB Ref. ID: 43252.

National Lead Company of Ohio (NLO). 1968. "Analytical Data Sheet." SRDB Ref. ID: 98533.

Reyland, W. L. 1960. "Dust Study of Dingot Lathe in Building 301," memo to W. L. Utnage, Mallinckrodt Chemical Works, Uranium Division, Weldon Spring (December 14, 1960) SRDB Ref. ID: 12363, pp. 75–78.

Ross, K. L., R. L. Rube, and R. C. Wissman. 1963. "Air Dust Evaluation of Metal Reduction – Pilot Plant." SRDB Ref. ID: 34390.

Rube, R. L. "Trip Report to Chambersburg Engineering Co., Chambersburg, Pennsylvania, on March 20 & 21, 1957." National Lead Company of Ohio Memorandum to J. A. Quigley, M.D. SRDB Ref. ID: 10048.

NOTICE: This report has been reviewed for Privacy Act information and has been cleared for distribution. However, this report is pre-decisional and has not been reviewed by the Advisory Board on Radiation and Worker Health for factual accuracy or applicability within the requirements of 42 CFR 82.

"Uranium Dust Study for Dingot Machining Station – 301." 1961. SRDB Ref. ID: 12363, pp. 19–23.

Westbrook, J. L., and C. W. Bloom. 2007. "Basis for Development of an Exposure Matrix for the Mallinckrodt Chemical Company St. Louis Downtown Site and the St. Louis Airport Site, St. Louis, Missouri," ORAUT-TKBS-0005, Rev. 02. http://www.cdc.gov/niosh/ocas/pdfs/tbd/mallink-r2.pdf

Workum, A. D. 1961. "Trip Report to LeBlond Machine Tool Company, Cincinnati, Ohio, on January 16 to 20, 1961." National Lead Company of Ohio Memorandum to J. A. Quigley, M.D. SRDB Ref. ID: 10634.

NOTICE: This report has been reviewed for Privacy Act information and has been cleared for distribution. However, this report is pre-decisional and has not been reviewed by the Advisory Board on Radiation and Worker Health for factual accuracy or applicability within the requirements of 42 CFR 82.

Appendix A

Regression Analyses of Surrogate Data

A.1 Regression Analysis of Allen's (2012b) Data

The regression of order statistics (ROS) method was used to fit a lognormal distribution to Allen's (2012b) data, including the six nondetect values. A plot of the logarithms of the data versus the normal score for each observation is shown in Figure A.1. (The figure omits six nondetect data points included in the distribution.) The plot also contains a regression line which best fits the plotted data points. The slope and intercept of the regression line are also shown on the figure. Although the data approximately follow the regression line, the data points are below the regression line at both ends of the plot, while they are above the regression line in the middle of the plot. The value of R^2 = .8781 indicates a reasonable fit to a lognormal distribution.

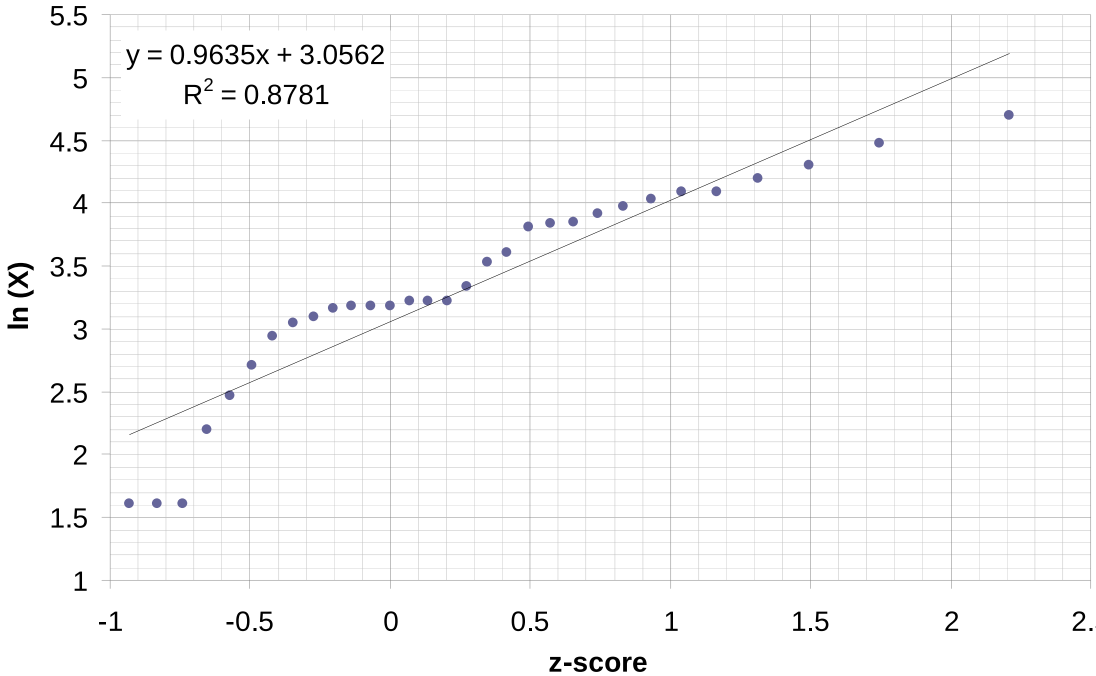

Figure A.1. Lognormal Distribution of NIOSH Data, Using Regression on Order Statistics

The slope and intercept of the regression line are used as estimates of the parameters of a lognormal distribution. The characteristics of this lognormal distribution are shown in Table A.1. The estimate of the 95th percentile confirms the result of 104 dpm/m^3 obtained by Allen (2012b). At the right of the plot in Figure A.1, the highest five data points fall below the regression line, indicating that the data distribution has a smaller right-hand tail than would be expected from a lognormal distribution. Hence the estimate of the 95th percentile obtained using the ROS method exceeds the empirical 95th percentile of 83.1 dpm/m^3, which lies between two sample values located at 74 and 88 dpm/m^3. The ROS estimate of 104 dpm/m^3 for the 95th percentile appears to be claimant favorable, as it exceeds the empirical 95th percentile of the distribution by approximately 20%.

NOTICE: This report has been reviewed for Privacy Act information and has been cleared for distribution. However, this report is pre-decisional and has not been reviewed by the Advisory Board on Radiation and Worker Health for factual accuracy or applicability within the requirements of 42 CFR 82.

Table A.1. Lognormal Distribution Parameters Estimated using ROS Method

Parameter	Surrogate Data Set		
	NIOSH[a]	Revised[b]	Adjusted[c]
Intercept (μ)	3.0562	2.34	2.5387
Slope (σ)	0.9635	1.2155	1.0076
R^2	0.8781	0.7811	0.946
Geometric mean (dpm/m^3)	21.25	10.38	12.66
GSD	2.62	3.37	2.74
95th %ile (dpm/m^3)	103.66	76.67	66.43

[a] Allen 2012b

[b] Present analysis—all data points

[c] Present analysis—curve fit omits lowest data point

A.2 Regression Analysis of Revised Data

Figure A.2 shows a plot of our revised data set. The value of R^2 = .7811 indicates a poorer fit to the regression line for the lognormal distribution. (The figure omits eight nondetect data points included in the distribution.) The characteristics of this distribution are shown in Table A.1. At the right of the plot in Figure A.2, the highest two data points fall below the regression line, indicating that the distribution has a smaller right-hand tail than would be expected from a lognormal distribution. Hence the estimate of the 95th percentile obtained using the ROS method, ~77 dpm/m^3, exceeds the empirical 95th percentile of 66.92 dpm/m^3, which lies between two sample values located at 66.6 and 69.83 dpm/m^3, by approximately 13%.

A.3 Regression Analysis of Adjusted Revised Data

The poor fit of the data in Figure A.2 is due to a single datum of 1 dpm/m^3, which appears to be an outlier. If we retain it in the data set but exclude it from the curve fit, we obtain the plot shown in Figure A.3. The characteristics of this distribution are shown in Table A.1. This plot has an R^2 = .946, which indicates a very good fit to a lognormal distribution. Hence the estimate of the 95th percentile obtained using the ROS method, 66.43 dpm/m^3, is within 1% of the empirical 95th percentile of 66.92 dpm/m^3.

NOTICE: This report has been reviewed for Privacy Act information and has been cleared for distribution. However, this report is pre-decisional and has not been reviewed by the Advisory Board on Radiation and Worker Health for factual accuracy or applicability within the requirements of 42 CFR 82.

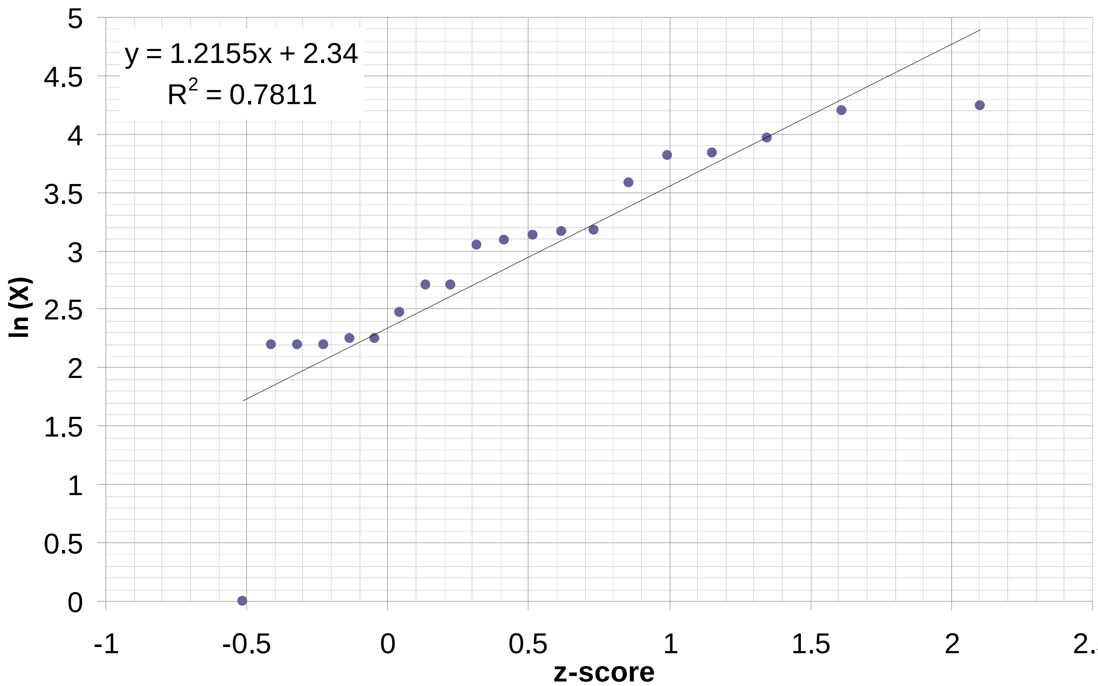

Figure A.2. Lognormal Distribution of Revised Data, Using Regression on Order Statistics

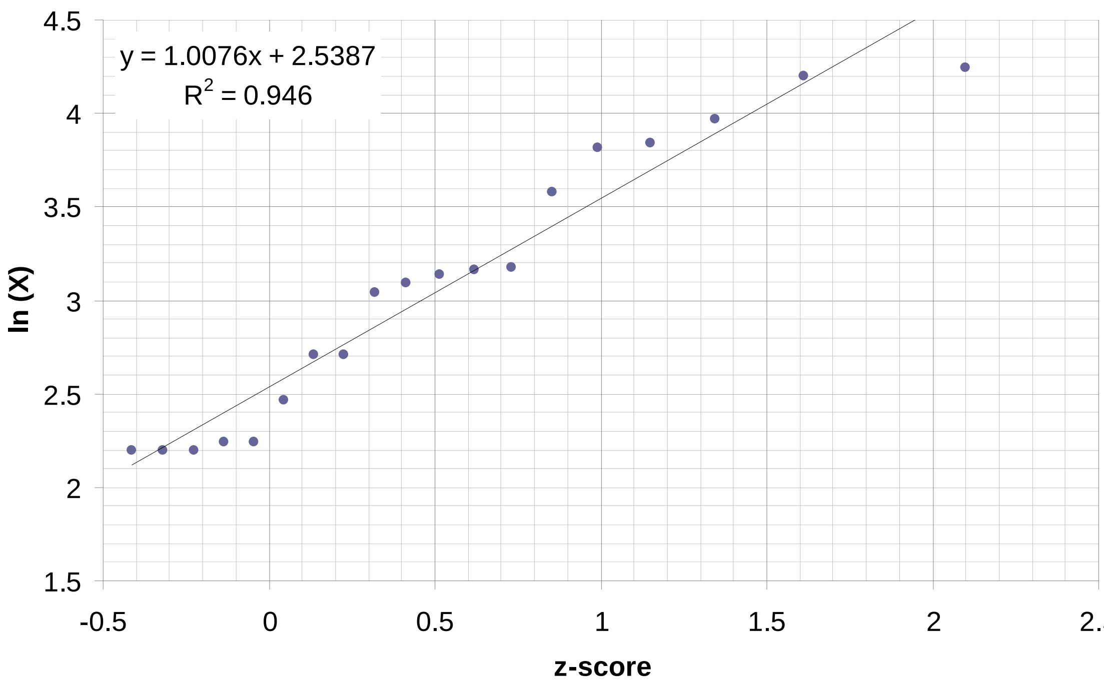

Figure A.3. Lognormal Distribution of Adjusted Data Using Regression on Order Statistics

NOTICE: This report has been reviewed for Privacy Act information and has been cleared for distribution. However, this report is pre-decisional and has not been reviewed by the Advisory Board on Radiation and Worker Health for factual accuracy or applicability within the requirements of 42 CFR 82.