Use of Surrogate Data at GSI
Response to SC&A Review Dated July 16, 2012
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Background

On July 16, 2012, SC&A released a review of the use of surrogate data at GSI which evaluated the use of surrogate data at GSI against the Advisory Board's Surrogate Data Criteria. This paper provides NIOSH's response to that review.

Overview

Unlike most Atomic Weapons Employer (AWE), the AEC contracted work at GSI did not involve active manipulation of uranium metal through processes such as rolling, machining, cutting, or straightening. The work at GSI consisted solely of taking x-rays of uranium metal that were used to evaluate the integrity of the casted billets manufactured at Mallinckrodt Chemical Works. Thus, the only potential for generation of airborne uranium at GSI would be from the movement of the metal into position for the examination.

Most active manipulation of uranium metal requires the metal to be heated. Typically uranium in these processes is heated to well over 1000 degrees Fahrenheit. At these high temperatures, the uranium metal oxidizes readily forming a loose oxide layer that can easily create airborne contamination. An exception to heating uranium metal during operations is machining. When uranium metal is machined or cut, it is not normally preheated. Rather, the area being cut is cooled with machine oil, water or some other coolant. This not only reduces the release of airborne activity, but also cools the metal to prevent fuming.

In all cases, however, the metal is moved by various means to the furnace or equipment prior to working. The movement of cold uranium metal presents such a low potential for airborne uranium that

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very few air samples were ever taken. Those that were, are often taken while other operations are also occurring causing the air in the vicinity to be contaminated by the nearby operations. Therefore, samples intended to be representative of the operation at GSI must consider not only the type of operation but the potential interferences in the vicinity.

Responses to SC&A's Review Comments

Criterion 1: Hierarchy of Data

SC&A points out that FUSRAP contamination data from 1993 exists at GSI and could be used to estimate intakes, thereby eliminating the need for surrogate data. However, the hierarchy of data criterion adopted by the Board does not exclude the use of surrogate data when actual site data is available. The criterion states:

> *"Surrogate data should only be used to replace data if the surrogate data have some distinct advantage over the available data and then only after the appropriate adjustments have been made to reflect the uncertainty inherent in this substitution"*

NIOSH agrees the use of the FUSRAP data would eliminate the need for the use of surrogate data, however, the uncertainty associated with back extrapolating the data 40 years would likely far exceed the uncertainty associated with the use of more contemporaneous sources of surrogate data. Thus, NIOSH believes that the use of surrogate data at GSI is justified under criterion 1, given the complete lack of available contemporaneous monitoring data and the large degree of uncertainly inherent in backwards extrapolation of data collected in 1993.

In TBD-6000, the daily average slug production airborne activity was estimated as 198 dpm/m3 by assuming an operator was exposed to the maximum airborne causing concentration 75% of the time. SC&A pointed out a mathematical error in TBD-6000 that caused the calculated geometric mean to be too high. SC&A also points out that while the geometric mean of the airborne contamination may be appropriate for lognormal distribution, Appendix BB uses it as a constant.

Appendix BB used the geometric mean as a constant instead of a lognormal distribution because the airborne concentration TBD-6000 is associated with slug production rather than simply moving cold uranium metal. The use of the geometric mean is an attempt to prevent the value from being unrealistically high (i.e., it represents a plausible upper bound) as SC&A appears to indicate in their review of criterion 5.

Criterion 2: Exclusivity Constraints

This criterion requires the use of surrogate data to be stringently justified. SC&A points out that the basis for selecting the surrogate data used by NIOSH was that uranium handling alone results in less disturbance of the metal than the other scenarios listed in Battelle-TBD-6000. That is, the data used are higher than the exposure conditions that existed at GSI. SC&A does not believe this qualifies as stringently justified.

NIOSH agrees the use of surrogate data at GSI has not been stringently justified in Appendix BB. However, Appendix BB was written approximately three years prior to the Board formally adopting its surrogate data criteria. In response to SC&A's comment, NIOSH has reviewed the airborne exposure data available from a number of sites to determine if a more comprehensive dataset are available to satisfy the intent of this criterion. At the end of this paper NIOSH provides a more robust analysis of the use of surrogate data at GSI (see section titled *Evaluation of Other Sources of Surrogate Data)* with the intent to incorporate relevant parts in the next revision to Appendix BB.

Criterion 3: Site or Process Similarities

SC&A points out that slug production by powder metallurgy is not similar to x-raying uranium metal. As discussed previously, each task in TBD-6000 inherently includes the movement of cold uranium metal at some step in the particular process. In the slug production process described in Harris and Kingsley[1], the process starts with a uranium metal ingot loaded into a hydriding furnace. In the process, a uranium

[1] Harris, W.B., and I. Kingsley, 1959. "The Industrial Hygiene of Uranium Fabrication," *A.M.A. Archives of Industrial Health, 19*, 540–565.

hydride is formed and later dehydrided to form a metal powder that is shaped into slugs. As with each process described in TBD-6000, the airborne contamination from this movement of cold uranium metal is not quantified so Appendix BB used one of the lowest airborne creating tasks as a bounding estimate of the movement of cold uranium metal. While the task as a whole is not representative of the movement of cold uranium metal, the movement of cold uranium metal is included in the task.

Criterion 4: Temporal Considerations

SC&A notes that the data used was likely collected prior to 1958 which is therefore not contemporaneous with the end of the operational in 1966. However, the Board's criterion indicates the data should be from the same general period *unless* it can be demonstrated that the "working conditions, procedures, monitoring methods, and (perhaps) legal requirements were comparable to the period in question".

In addressing this, we note that there has never been any indication of any intentional controls over airborne contamination at GSI. The source of airborne uranium was simply movement of cold uranium metal in order to position it for x-ray examination. The source of airborne is then a physical characteristic of uranium metal which doesn't change over time.

Criterion 5: Plausibility

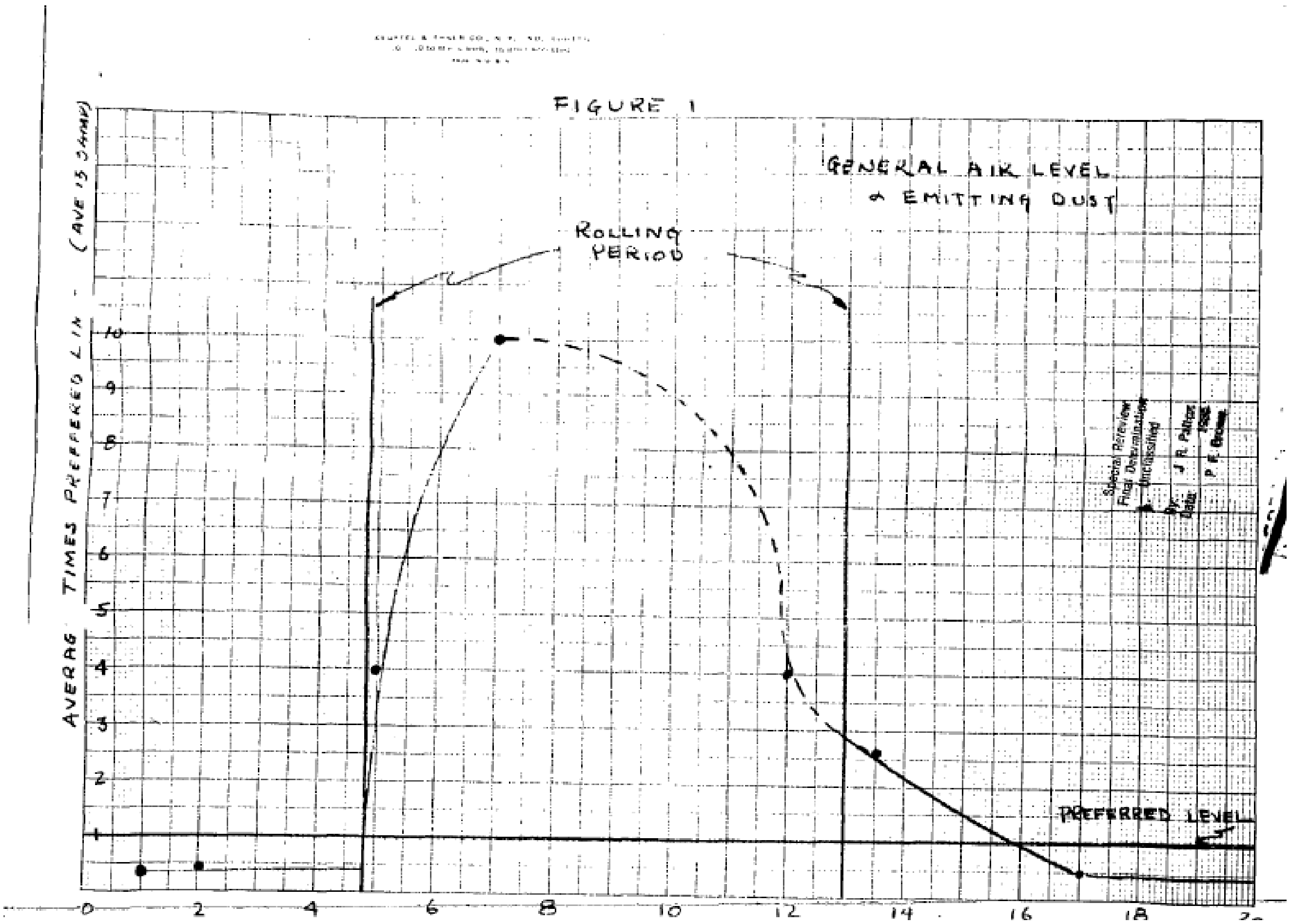
SC&A appears to be indicating the airborne contamination calculation in Appendix BB is not plausible because uranium work at GSI was intermittent and thus "large flakes" of uranium oxides would not be quickly ground into dust under foot or forklift traffic. This results in the equilibrium value in Harris and Kingsley for a continuous operation being higher than that expected at GSI.

NIOSH agrees that work with uranium at GSI was intermittent and thus it is less likely that an equilibrium concentration would be reached. This implies the value in Appendix BB is too high. However, the argument used by SC&A appears to be based on the idea that the resuspension of surface contamination is the major source of airborne contamination during operational periods.

In reality, airborne contamination while working with uranium metal would initially be caused entirely by disturbing uranium oxides on the surface of the uranium metal. This contamination would be relatively consistent from one piece of uranium to the next. As additional pieces of uranium metal are brought in, a fresh source of contamination is available. Since this source of airborne does not depend on the slow buildup of contamination, it occurs immediately and builds up quickly to a maximum.

The other source of airborne, resuspension from surface contamination, will build up to a maximum more slowly as the surface contamination builds up from continued operations. This source of airborne is much lower than the operational source. This effect can be seen in Figure 1 which depicts the relative levels of airborne contamination during operational and post-operational period at Simonds Saw and Steel. The time scale in this figure is days. Once the rolling operations end, the airborne contamination decreases quickly to a steady level caused by resuspension. It should be noted that, at Simonds Saw and Steel, the uranium metal was heated and rolled resulting in a much larger fraction of the metal being oxidized. This would result in higher levels of airborne and surface contamination than would be seen with the movement of cold uranium.

Figure 1 – Airborne Uranium at Simonds Saw and Steel During and After Rolling Operations



Evaluation of Other Sources of Surrogate Data

As described earlier, monitoring data associated with the movement of cold uranium metal is limited. A review of the data from AWE facilities indicate that most data are associated with actual airborne causing activities, rather than simply moving the metal. Also, some sample results that are associated with moving the metal are positively biased by nearby work with uranium metal. In searching the available data from a number of AWEs, however, a few examples were found.

Heald Machine Company (SRDB 40986 page 10, Figure 2 in this paper)

At the Heald Machine Company, air samples were taken while machining uranium metal slugs. Values ranged from 1 to 11 dpm/m^3. It is likely coolant was used to cool and lubricate the uranium while it was being machined so air samples while machining were not necessarily representative of uranium metal handling. However, coolant is normally supplied by a fixed nozzle on the machine. Thus, dry uranium metal would be moved to the machine prior to machining. If significant airborne contamination was caused by this movement, it would still be present while machining the slugs. Although this activity may not be directly applicable to the movement of cold uranium metal, they do provide an indication that actual values are relatively low.

Chambersburg Engineering Co (SRDB 10048 page 39, Figure 3 in this paper)

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. A summary of the air samples are provided in Figure 3. 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.

R. W. Leblond Machine Tool Co. (SRDB 10634 page 11, Figure 4 in this paper)

A test was conducted at Leblond 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 first thee samples on the data sheet (Figure 4) were taken as breathing zone air samples while "hooking hoist to billet and placing billet into position on 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 Lablond samples the most directly relevant samples to the work at GSI. One of the samples measured 9 dpm/m3 while the other two samples had results that were labeled as "nd" which stands for none detected.

Conclusions

While it is difficult to find air sample data representative of moving cold uranium metal, it must be realized that this movement is inherent with every operation involving uranium metal. If the movement were to cause high levels of airborne uranium, it would in most cases continue to be present during the tasks for which samples were taken. The most relevant samples to GSI discussed in this paper are those taken at Leblond, which involved moving an ingot to a boring machine. Because this data set contains only three samples collected over a one day period, it is not a very robust sample set. Samples taken at Chambersburg Engineering while loading cold uranium slugs into a furnace were as high as 174 dpm/m^3. While it is very possible some of this airborne activity was caused by nearby operations, it is not definitely known. Therefore, it is possible that handling cold uranium metal could cause airborne activity this high. This is relatively close to the 198 dpm/m^3 used in Appendix BB.

The value used in Appendix BB, therefore, appears to be bounding without increasing it by a factor of 2.9 as suggested by SC&A in criterion 1. It also appears to be a plausible upper bound when the degree of uncertainty is taken into consideration, rather than implausibly high as implied in SC&A criterion 5. The process of moving cold uranium metal without special controls or ventilation is a function of the physical characteristics of uranium metal and not a function of the time frame in which the samples were taken (criterion 4). While the processes described in TBD-6000 are based on sources of airborne contamination with greater potential to generate airborne activity than merely the movement of uranium metal, they do include the movement of metal and therefore represent work at GSI in part (criteria 3). Lastly, it is NIOHS's position that, while it is difficult to find air samples that perfectly match the exposure condition at GSI, the value used in Appendix BB is both plausible and bounding. It is believed that this paper provides justification for its use and applicable portions of this justification will be incorporated in the next revision to Appendix BB (criterion 2).

Figure 2 – Airborne Uranium Data Sheet from Heald Machine Company

NATIONAL LEAD COMPANY OF OHIO
HEALTH AND SAFETY DIVISION – ANALYTICAL DEPT.
ANALYTICAL DATA SHEET

INDUSTRIAL HYGIENE AND RADIATION DEPT.

I.H. NO.: 234 | SAMPLE NOS.: 12 | DATE COLLECTED: 5/18/60 | BY: ER | ROUTE TO: ER

LOCATION: HEALD MACHINING COMPANY | TYPE OF SAMPLE: air dust

ANALYZED FOR: F; U; NO_3; Oil; Be; X Alpha; Beta; Ra; pH; Th

REMARKS:

ANALYTICAL CHEMISTRY SECTION

DATE RECEIVED: 5-23-60 BY:

DATE REPORTED: 5-25-60 BY:

METHOD OF ANALYSIS: ASC # 3

1:00 8-23-60 BY:

COUNTING DATA: BKGD .17 c/m GEO 48%

SAMPLE NO.	HOUR	SAMPLE DESCRIPTION	R	T	Q	Count	Time	c/m	d/m/m3
3499	1335	GA Top center of machine – cutting 4 slugs.	.03	5	.15	24	48.00	.54	11
3498	1335	GA Top left of machine – cutting 4 slugs start to finish including loading and unloading trays flush chips.	.03	5	.15	13	35.00	.20	4
3497	1335	GA Left of machine over open coolant tank during cutting.	.03	5	.15	7	36.00	.05	1
3496	1345	GA Same as 3499 – while examining cutter.	.03	14	.42	15	30.00	.26	2
3495	1345	GA Same as 3498	.03	14	.42	11	34.00	.15	1
3494	1345	GA Same as 3497 – while examining machine flushing chips and loading, starting, finishing, and unloading slugs.	.03	14	.42	15	40.00	.16	1
3491		GA Same as 3499	.03	6.5	.195	24	39.00	.45	7
3492		GA Same as 3498	.03	6.5	.195	13	39.00	.05	1
3493		GA Same as 3497	.03	6.5	.195	14	34.00	.24	4
3490		GA Same as 3499 New drill broke on.	.03	5	.15	20	45.00	.27	6
3489		GA Same as 3498 Entering cut.	.03	5	.15	12	32.00	.21	4
3488		GA Same as 3497	.03	5	.15	11	30.00	.20	4

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2	Industrial Hygiene & Radiation Dept.

Figure 3 – Airborne Uranium Summary from Chambersburg Engineering

Operation or Location	Concentration–α d/m/M³ High	Low	Average	X MAC
GA (4) Background samples prior to start-up.	2	0	1	.01
GA (8) Impactor area during start-up, while slugs were being stamped at approx. 15-minute intervals.	20	0	5	.07
GA (5) Impactor area during faster stamping rate; one slug every 2 minutes.	13	9	11	.16
BZ (4) Operator putting cold slugs into furnace; one slug every 15 minutes.	174	11	69	1.0
BZ (2) Operator putting cold slugs into furnace; one slug every 2 minutes.	106	49	77	1.1
BZ (5) Operator removing slugs from furnace and transferring to impactor approx. 7 ft. away.	310	39	238	3.4
BZ (3) Impactor operator controlling impactor at a 10 ft. distance; one slug every 2 minutes. Air movement was in direction of this operator on north side of impactor.	1268	314	895	12.8
BZ (3) Operator working safety control from 5 ft. directly west of impactor; one slug every 2 minutes.	28	5	19	.27
BZ (2) Operator removing washers from impactor die by means of a screw driver and hammer.	870	200	535	7.6

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Figure 4 – Airborne Uranium Data Sheet from Leblond

NATIONAL LEAD COMPANY OF OHIO
HEALTH AND SAFETY DIVISION – ANALYTICAL DEPT.
ANALYTICAL DATA SHEET

*8/23/61

INDUSTRIAL HYGIENE AND RADIATION DEPT.					ANALYTICAL CHEMISTRY SECTION	
I.H. NO.: 774	SAMPLE NOS.: 6	DATE COLLECTED: 8/22/61	BY: BL	ROUTE TO: BL	DATE RECEIVED: 8/25/61	BY:
LOCATION: LeBlond		TYPE OF SAMPLE: Air dust	ANALYZED FOR: F, U, NO_3, Oil, Be, Cl, **x** Alpha, Beta, Ra, pH, Th, TSS		DATE REPORTED: 9/1/61	BY:
REMARKS: :LeBlond Carlstedt Rapid Borring Machine Borring Billets - No ventilation on machine - very little air movement in areas.					METHOD OF ANALYSIS: MAC#1 1:30 9/1	BY:
					COUNTING DATA: BKGD .29 c/m	GEO 39%

SAMPLE NO.	HOUR	SAMPLE DESCRIPTION	R	T	Q	count	time	c/m	d/m/M^3
4305	10:30	BZ Operator hooking hoist to billet and placing billet into position on machine.	.03	3	.09	14	28	.21	9
4306	1:15	BZ same as 4305	.03	2	.06	6	19	nd	nd
4308	2:05	BZ same as 4305	.03	2.2	.066	4	17.5	nd	nd
4307	1:30	BZ Operator removing billet from machine after billet had been bored and placigg billet on scale.	.03	2	.06	16	30	.24	15
4309	2:20	BZ same as 4307	.03	2	.06	4	15	nd	nd
4312	9:00	BZ same as 4305	.03	2	.06	0	10	nd	nd

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