Evaluation of Additional Air Sample Data Applicable to GSI
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Background

On July 16, 2012, SC&A submitted a review of NIOSH's use of surrogate data at GSI to the TBD-6000 work group (Anigstein 2012). NOSH responded to that review in a white paper dated August 2012 (Allen 2012). Both papers were discussed during a work group meeting held on August 28, 2012. As a result of this discussion, the work group asked NIOSH to locate and review additional air sampling data associated with the movement of cold uranium metal[1]. This paper presents the data collected in response to that request; and provides an analysis of the applicability of the data to bounding the inhalation of uranium at GSI.

Data Collected

Pursuant to the working group's request, NOISH broadened its search for data related to the handling of cold uranium metal. Difficulties associated with finding this type of data are pointed out in the NIOSH white paper issued in August 2012. In summary, the difficulties include:

a) The operation is not normally a source of high airborne activity so few samples were taken; and,
b) When the metal is moved, it is normally for the purpose of performing some mechanical operation. These mechanical operations often cause high airborne activity in the vicinity, thereby positively skewing the results.

In searching the NIOSH site research database, some air samples were found in which it was difficult to determine if they were representative of the movement of cold uranium metal. An example is the general area air samples found for an ingot storage area at Fernald. The sample descriptions contained no indication of what, if any, work was occurring in the area, therefore, the samples were not used. Other samples that were located also may have been interfered with by nearby airborne activity generating operations. Finally, if the metal was heated, samples associated with additional steps soon after were assumed to be associated with heated metal and were not used. The intent of our data

[1] Cold uranium metal, as used in this white paper, refers to uranium that has not been physically heated.

search was to find samples related to handling cold uranium metal and elevated temperatures can have a great effect on the production of oxides on the surface. An example of this can be seen at the Weldon Springs Site. In an outgassing procedure, 60 slugs were loaded into wire baskets and 8 baskets were loaded into a "boat" which was placed into a furnace. When the slugs were placed in the basket, the airborne level was 25 dpm/m^3. When the slugs came out of the furnace, they had to be handled to read the numbers stamped in the slug. The measured airborne level from this handling operation was 1530 dpm/m^3.

As a result of the expanded data search, a few additional samples were, however, located that have little or no influence from nearby operations. The samples include data collected at several facilities and cover the years 1956 through 1968. The data also cover operations involving four forms of uranium metal: slugs, derbies, billets and dingots.

Forms of Uranium

Slugs were typically 8 inches long and approximately 1 inch diameter weighing approximately 4 pounds. They were intended to be used as fuel in plutonium production reactors. Operations associated with the selected samples primarily involved moving slugs into or out of a container.

Derbies are approximately 12 inches in diameter and 4 inches high weighing approximately 300 pounds. They are created by a thermite process used to reduce uranium tetrafluoride to uranium metal. Once produced, the derby has to be "broken out" of a reduction pot and the excess magnesium fluoride cleaned off by mechanical means. The operations found associated with derbies include breaking the derby out of the pot, cleaning the magnesium fluoride from the derby and removing the derby from the table. The airborne contamination results in these steps may be interfered with by the mechanical removal of the derby from the pot and the mechanical removal of the magnesium fluoride from the derby. However, most of the dust created in those operations is from magnesium fluoride and though it is contaminated with uranium, the concentration is low and so the interference should be small.

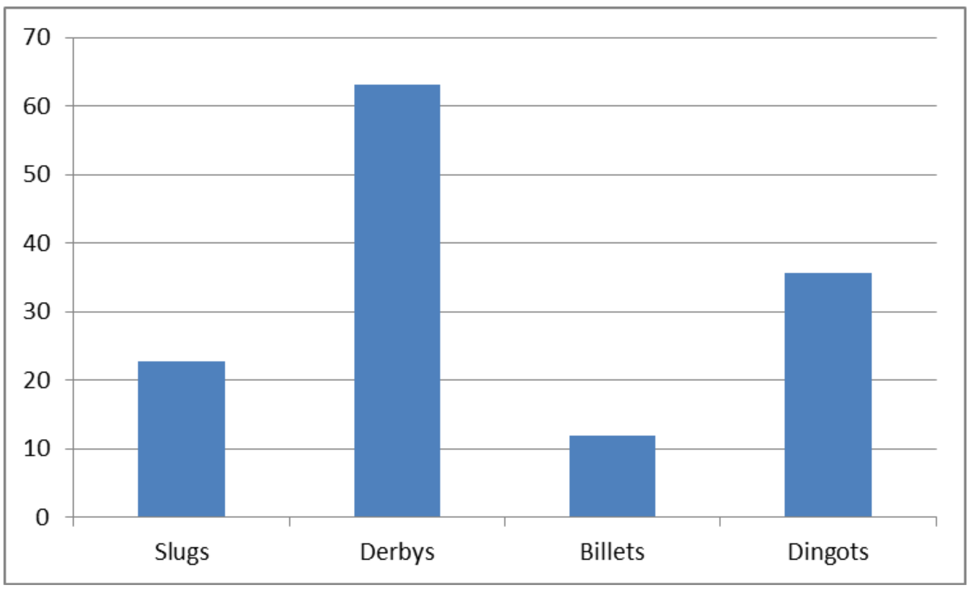
A billet is a generic metallurgical term used to describe a semi-finished piece of metal. In uranium fuel fabrication, it is a piece of uranium metal that was originally cast into an ingot and rolled into a smaller dimension using a blooming mill. The billet would later be further rolled to a finished product using a rolling mill. The billets associated with the data found for this report were approximately 7 inches in diameter and 20 inches long. This would result in a billet weighing approximately 525 pounds.

A dingot (direct ingot) is a term used at Mallinckrodt to describe an ingot made directly from the metal reduction process. The alternative procedure was to remelt several derbies and cast them into ingots. The dingot is approximately 18 inches in diameter and 18 inches long weighing approximately 3300 pounds.

Analysis of Samples

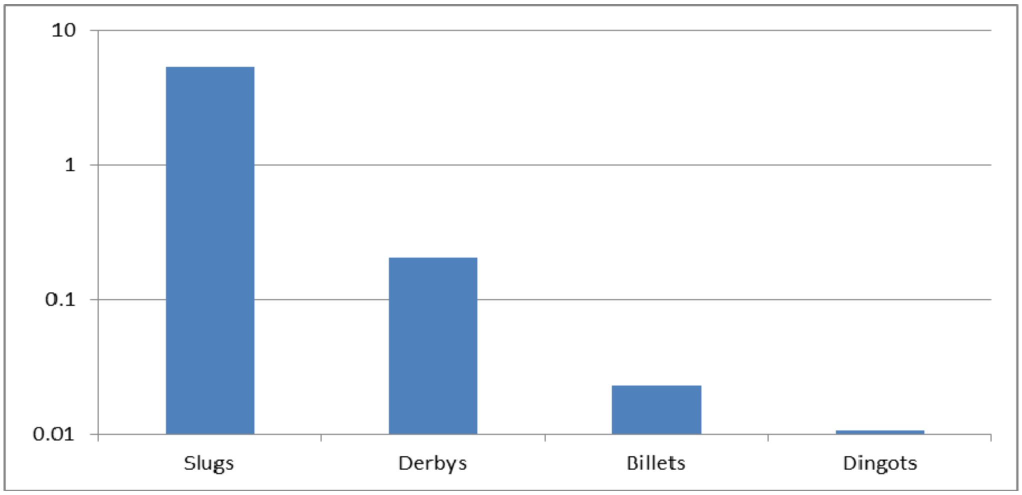
Air samples were found related to handling cold uranium metal in each of the four forms described above. The sample results, along with the form associated with the sample, are provided in Attachment 1. Figure 1 graphically depicts the average airborne value associated with handling each form of uranium.

Figure 1 – Average Airborne Activity while Handling Cold Metal (dpm/m^3)



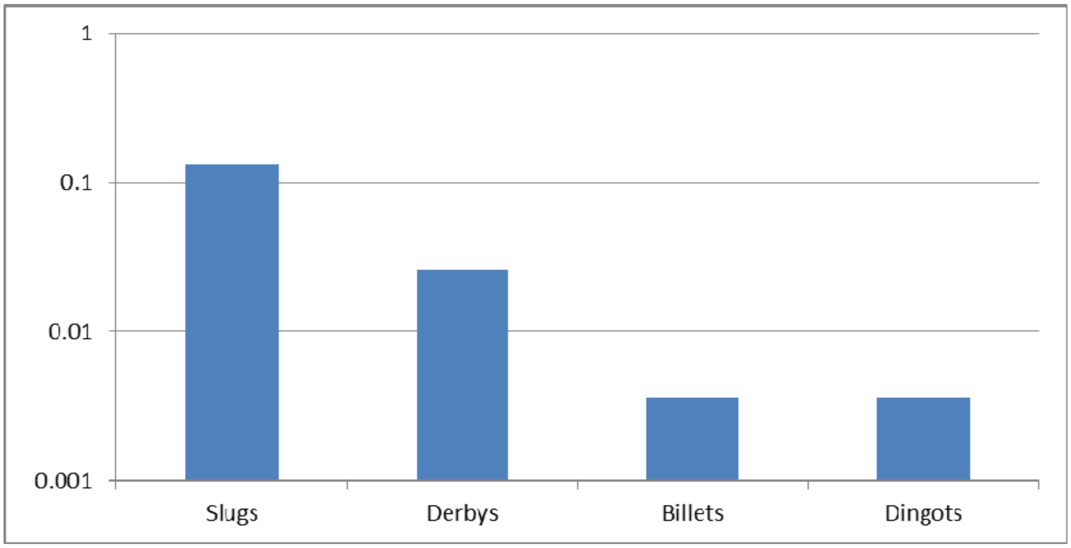
The figure is arranged from left to right by the weight associated with each form of metal. No specific pattern can be seen that would indicate one form of metal creates higher airborne activity than another. Although it would seem intuitive that a large metal object would create more airborne activity than a small one, as shown in Figure 2, the data indicate the opposite. In Figure 2, the average airborne activity from handling each form of metal is normalized to the weight of the object.

Figure 2 – Average Airborne Activity Created per Pound (dpm/m^3/pound)



The figure shows clearly that more airborne activity per unit mass is created from smaller objects than from larger ones. Given that only the loose surface activity contributes to the airborne levels, it would be more relevant to normalize the airborne activity on a surface area basis rather than a mass basis. Figure 3 provides the results of normalizing the data in this manner. This figure is the same as Figure 2 except that the average airborne activity is divided by the surface area in square centimeters rather than the weight.

Figure 3 – Average Airborne Activity per Square Centimeter of Surface Area (dpm/m³/cm²)



While Figure 3 shows that the airborne activity is indeed more closely related to surface area than weight, there is still a clear trend indicating that smaller objects produce higher levels of airborne activity per unit of surface area.

This trend can be explained by considering that airborne activity is not solely related to the amount of oxide contamination on the surface of the metal. It is also necessary to have some force to dislodge the contamination and suspend it into the air. When handling cold uranium metal, that force will be associated with the mechanism used to move the metal. Movement of a four pound slug is most often accomplished by hand. A hand can easily wrap around a one inch diameter rod and can easily cover about half of the eight inch length. Thus, approximately half of the surface area of the slug could be disturbed by moving the slug. A dingot on the other hand weighs 3300 pounds and will not be moved by hand. The use of a chain hoist or fork truck or other means would have to be employed. If a one inch thick chain is wrapped around an eighteen inch diameter dingot, it would cover less than 4% of the surface area of the dingot. While a single chain may not be employed, it is very likely that whatever means is used, a small fraction of the surface area would be disturbed. So, it is possible that a larger fraction of the surface area of small objects is disturbed when compared to larger objects.

While this may explain why more airborne contamination per unit surface area is created from small objects, it is also true that large objects contain more surface area overall. Given these two competing concepts, it is not obvious which form of metal will create more airborne contamination. Based on Figure 1, it appears as though the size of object being handled is not related to the amount of airborne contamination created. From Figures 2 and 3, it also appears that the airborne contamination created from the movement of cold uranium metal is independent of weight and surface area. Based on the data reviewed, however, the levels of airborne activity are relatively low and are can be represented by a fairly consistent quantity regardless of the form of the metal. Therefore, to establish the range of exposures associated with the movement of cold uranium metal, all the data in Table 1 were combined into a single distribution of airborne activity.

Attachment 1 contains the results for the samples utilized in this report. The attachment includes the Site Research Database document number and page number where the sample was located. It also includes the site from which the samples were collected as well as the type of metal and the date the sample was collected. A few of the values are listed as "nd" which represents a "none detectable" sample.

The samples were analyzed assuming they can be represented as a lognormal distribution. The resulting distribution has a geometric mean of 21.2 dpm/m^3 with a geometric standard deviation of 2.6. This distribution results in a 95th percentile value of 104 dpm/m^3. This is the value NIOSH intends to use for the assessment of inhalation exposure to uranium at GSI.

<u>Surrogate Data Analysis</u>

Below is a comparison of the proposed approach to the Board's surrogate data criteria.

Hierarchy of Data

As discussed in the NIOSH white paper from August 2012, the only data available at GSI is FUSRAP data from 1993 and the use of the surrogate data presented in this paper would represent less uncertainty than back extrapolating the FUSRAP data over a 40 year period.

SC&A also pointed out in its review that appropriate adjustments to the TBD-6000 data were not made. NIOSH believes the intent of that statement in the surrogate data criteria is intended to apply to adjustments necessary to make the data applicable to the site. This is not to be confused with other parameters used to estimate intakes from the data such as exposure time. Those parameters would be used even on measurements take at the site. They are therefore, not related to surrogate data. While it is agreed those parameters are subject to review, NIOSH disagrees that the surrogate data criteria would be relevant in that review.

Exclusivity

This criterion requires that the use of surrogate data be stringently justified. SC&A pointed out in its review that the use was not justified in Appendix BB. NIOSH agreed in the white paper dated August 2012 and intends to include justification made here in the next revision to Appendix BB.

Site or Process Similarities

The airborne creating operations at GSI consisted only of the movement of cold uranium metal. The air sample results presented in this white paper consists of the movement of cold uranium metal in various forms with no or little interference from nearby operations. The various forms require different means of moving the metal. As discussed in this paper, all forms and means of movement appear to result in similar results and the data can therefore be considered to be from a similar process regardless of the size and shape of metal moved at GSI.

Temporal Considerations

No special controls or means of handling the uranium metal have ever been reported at GSI. Therefore the airborne activity at GSI is associated with the physical characteristics of uranium metal which doesn't change over time and no temporal considerations are relevant. However, the data was collected between 1956 and 1968 which is relatively contemporaneous to the GSI uranium work.

Plausibility

The data used was collected while moving cold uranium metal. The analysis in this paper indicates the results are relatively consistent regardless of size and shape of the metal or the means of movement. The data then represent real measurements associated with conducting comparable tasks on comparable material. Thus, the value is considered plausible.

Conclusion

NIOSH was able to find 37 air samples applicable to the movement of cold uranium metal. The results were consistent across various sizes and shapes of uranium as well as several sites and years. The 95^{th} percentile of the data resulted in an airborne contamination value of 104 dpm/m^3 which is what NIOSH intends to use at GSI.

References

Allen, D. 2012. “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.

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.

Attachment 1 – Airborne Activity Samples

SRDB#	Pg#	Activity (dpm/m^3)	Site	type	Date
10634	11	9	Leblond	billets	8/22/1961
10634	11	nd	Leblond	billets	8/22/1961
10634	11	nd	Leblond	billets	8/22/1961
10634	11	15	Leblond	billets	8/22/1961
10634	11	nd	Leblond	billets	8/22/1961
10634	11	nd	Leblond	billets	8/22/1961
43252	2	24	Chambersburg	slugs	3/21/1957
43252	2	5	Chambersburg	slugs	3/21/1957
43252	2	28	Chambersburg	slugs	3/21/1957
98533	129	53	Tocco	slugs	2/16/1968
98533	129	22	Tocco	slugs	2/16/1968
98533	124	5	Tocco	slugs	6/6/1968
98533	124	37	Tocco	slugs	6/6/1968
98533	124	5	Tocco	slugs	6/6/1968
98533	124	24	Tocco	slugs	6/6/1968
98533	124	nd	Tocco	slugs	6/6/1968
98533	124	19	Tocco	slugs	6/6/1968
34390	2	45 $_{(1)}$	Fernald	derby	8/19/1963

34390	2	50 (1)	Fernald	derby	8/19/1963
34390	2	34 (1)	Fernald	derby	8/19/1963
34390	3	60 (1)	Fernald	derby	8/19/1963
34390	3	74 (1)	Fernald	derby	8/19/1963
34390	3	47 (1)	Fernald	derby	8/19/1963
34390	3	88 (1)	Fernald	derby	8/19/1963
34390	3	110 (1)	Fernald	derby	8/19/1963
34390	3	60 (1)	Fernald	derby	8/19/1963
12363	78	24	Weldon Springs	dingots	11/14/1960
12363	78	21	Weldon Springs	dingots	11/14/1960
12363	22	56.24 (1)(2)	Weldon Springs	dingots	7/26/1961
12363	22	66.6 (1)(2)	Weldon Springs	dingots	7/26/1961
12363	22	46.62 (1)(2)	Weldon Springs	dingots	7/26/1961
14956	4	25	Weldon Springs	slugs	3/30/1960
14956	4	25	Weldon Springs	slugs	3/30/1960
14956	4	25	Weldon Springs	slugs	3/30/1960
17254	6	11.8	Weldon Springs	dingots	12/10/1956
17254	6	nd	Weldon Springs	dingots	12/10/1956
17254	6	23.7	Weldon Springs	dingots	12/10/1956

(1) Values listed as maximum, minimum and average were used as three different samples
(2) Values back calculated using conversion factors at the bottom of summary report