WHITE PAPER

TBD 6000 Review by SC&A

Determination of Settling Time

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BACKGROUND

Battelle-TBD-6000 includes a method for estimating surface contamination using measured airborne concentrations of uranium. As part of an earlier review of TBD-6000 by SC&A, the method prescribed by NIOSH was questioned and it was pointed out by SC&A that a good source of information to verify the method was contained in Adley (SRDB 27354). An analysis of Adley was performed by NIOSH and documented in the Issue 5 white paper dated October 9, 2009. The analysis concluded that a 30 day deposition time should be used with the technique. TBD-6000 was revised to include this settling period and the issue raised by SC&A was closed by the TBD 6000 work group.

On May 15, 2013 a supplemental review was issued by SC&A that reanalyzed the technical bases behind TBD 6000. In this review SC&A concluded that the 30 days period may not be sufficient to reach equilibrium between the deposition and removal processes. This white paper explores this new analysis.

SC&A REVIEW

Using Stoke's Law, the new SC&A review derived a settling rate of 0.00052 m/s and concluded that the 0.00075 m/s settling rate used in TBD-6000 was claimant favorable. The settling time to reach equilibrium was then determined, at each of 17 plant locations, using the 0.00052 m/s settling rate and an assumed uniform, plant-wide airborne concentration of 1400 $\mu g/m^3$. The analysis resulted in a variety of settling times at each location, ranging from 13 days to 73 in Table 4 of the report.

NIOSH does not believe the parameters used in this analysis are appropriate for this application. As SC&A points out, the equilibrium surface contamination is the product of the airborne activity, the settling velocity and the settling time. Since TBD-6000 provides both the settling velocity and the settling time, the product of these two values is really the key parameter rather than the individual values themselves. If TBD 6000 used the 0.00052 m/s settling rate, it is agreed that a longer settling time would be required to reach equilibrium. Because TBD 6000 uses a faster settling velocity, the time to reach equilibrium will be fewer days. The product of the two parameters, however, remains the same.

It should also be noted that the airborne level used in the SC&A review comes from a quote in Adley that is apparently attempting to describe the significance of surface contamination. It is not actually a measurement of the airborne activity at the facility. The report estimated 20 grams per day of uranium surface contamination settling throughout the building and pointed out that if all of this were evenly distributed throughout the building volume, the airborne concentration would be 28 times the maximum permissible level (1400 $\mu g/m^3$). The exact quote from the report is:

"The significance of the quantities of uranium oxide dust that settle out is realized when the following two examples are considered:

(1) If the 20 grams of U_3O_8 that settles out daily were dispersed evenly throughout the 500,000 cubic feet of the building, the resulting concentration of dust would be 28 times the maximum permissible level of 5 x 10-5 µg/cc.
(2) When one milligram of U_3O_8 is dispersed in the air, the quantity is sufficient to produce the maximum permissible concentration in 710 cubic feet of air; in one cubic foot of air it will produce 710 times the maximum level."

As such, the statement is an example to demonstrate the potential significance of the quantity of surface dust. With the second example included, it is clear this is not an estimate of airborne activity but rather examples of the possible significance ranging from 1 MPC to 710 MPCs.

The third issue with the SC&A analysis is that the recommendation does not account for a distribution of air samples. When air sample values are available for a site, one of two standard approaches is use. Either the 95th percentile is used as a constant or the full distribution of the air samples is used. The SC&A report recommends using 70 days for the settling time based on the 95th percentile of the settling times calculated in the report.

An example of the problem comes from applying the data from Adley as it would typically be applied by NIOSH at a facility with no measured contamination value. The 95th percentile of the airborne values measured by Adley is 26,757 $\mu g/m^3$ (as determined later in this paper). If a contamination value were to be determined from this using the SC&A recommendations, this value would be multiplied by 70 days and 0.00075 m/s settling rate to obtain a contamination value of 1.21×10^8 $\mu g/m^2$. This is more than 26 times higher than the maximum surface concentration reported by Adley (as shown in Table 2 of the SC&A report).

Since the SC&A recommendation was based on an airborne value that was hypothetical rather than measured, and a settling rate not used by TBD-6000, it does not appear to be a reliable estimate of the appropriate setting time for NIOSH to use. Also, since it does not appear to take into account the distribution of the air samples at a site, it may not be practical to use. Therefore, as recommended in the SC&A report, the settling time is re-examined in the remainder of this paper.

ISSUE 5 WHITE PAPER

The issue 5 white paper explored the appropriate settling rate and settling time based on contamination data from Adley and Simonds Saw and Steel. In that paper, settling time based on both the geometric mean (GM) and the 95th percentile values were calculated and the most favorable of the values was used. However, since the analysis was performed as part of the review of TBD-6000, airborne values contained in TBD-6000 were used in the analysis. This creates the possibility of the technique being used at a site with site specific airborne data but TBD-6000 parameter values (settling time and settling rate). Therefore, the analysis is expanded here to consider site specific airborne values from Adley and Simonds Saw and Steel.

ANALYSIS

After conversion to units of µg/m^3, the air sample values contained in Tables II through VII of the appendix to Adley were used in this analysis. Samples from Table VIII were not included because they contained samples from non-production areas (e.g., office and restroom). In addition, the contamination values from the settling plate data (Table XIII) were used. The settling data, listed in mg/ft^2/day, was multiplied by the applicable number of days the plate was exposed and converted to µg/m^2. Simonds Saw and Steel air sample data was obtained from an October 27, 1948 survey (SRDB 10883 pp. 19-25), while the contamination values were obtained from a summary of three Simonds Saw and Steel surveys (SRDB 23579 Table II). As with the Adley data, the air sample results were converted to µg/m^3 and the contamination values were converted to µg/m^2.

Each of these four data sets was analyzed as a lognormal distribution and the geometric mean (GM) and the geometric standard deviation (GSD) were determined. The settling time was then determined using the following equation.

Settling time = Surface contamination ÷ airborne value ÷ 0.00075 m/s

In determining the settling time, the values used for the surface contamination and airborne levels were from the same site (Adley or Simonds Saw and Steel) and same point in the distribution. For example, the GM of the Adley airborne and the GM for the Adley contamination data were used in the equation. Settling time was determined for the GM as well as the 95th percentile of the distributions for each site. Also, as discussed later, settling time was determined for the average values from the data sets. Table 1 provides the calculated settling times from the Simonds saw and Steel and the Adley data.

Table 1 – Settling Days

Data Source	Distribution parameter	Surface Contamination (μg/m^2)	Airborne Concentration (μg/m^3)	Settling Days
Simonds Saw and Steel	GM	1005276	841	18.45
	Average	1552083	5204	4.60
	95th	5324129	27675	2.97
Adley	GM	1839873	534	53.13
	Average	2350865	8436	4.30
	95th	5645961	26757	3.26

As can be seen in Table 1, the settling time for the Adley data is 53 days when the GM of the distributions are used and 3.26 days when the 95th percentile of the distributions are used. The disparity in the values is due to the large difference in the GSDs of the two distributions, which directly affects the calculated 95th percentile values. It is likely that air samples tend to have a wider distribution due to localized sources of airborne. Once released however, that airborne would tend to mix and migrate, causing the settled contamination to be more evenly distributed.

The GM of the surface contamination would not normally be used alone for exposure estimates. Instead, either a full distribution or a constant at the 95th percentile value would be used. Therefore, the GM is not necessarily a good parameter to use in determining the appropriate settling time.

It is clear from the table that neither the GM nor the 95th percentile will describe the appropriate settling time for a full distribution of airborne and contamination values. In an attempt to relate the full distribution to single value, the use of the average of the distribution was evaluated. The average of each distribution was calculated from the GM and GSD of each distribution using the equation from Table 2.2 in Battelle-TIB-5000 and reproduced in the current SC&A review. Based on the average of the air samples and the average of the contamination values, the number of settling days using the Adley data would be 4.3 days.

Another set of data examined in the Issue 5 white paper was the Simonds Saw and Steel data. The values calculated for this data are also provided in Table 1. The number of settling days determined from this data is less than 30 days for each of the three parameters in the table.

Attachment A to this white paper provides an evaluation of a hypothetical case to determine what constant value would be equivalent (i.e., result in the same PC value) to a lognormal distribution when entered into IREP. The examination determined that the constant value would fall somewhere between the average and the 95th percentile of that distribution. This implies that the appropriate settling time based on Adley and Simonds Saw and Steel data falls somewhere between 2.97 days and 4.6 days.

The issue 5 white paper used the GM and the 95th percentile values and resulted in a 27 day estimate (rounded to 30 days) based on the GM. However, as appendix A demonstrates, the average would be a more appropriate value and would result in a settling time of 7.4 days rather than 27 days.

CONCLUSION

If the 95th percentile were to be used, both the Adley and the Simonds Saw and Steel data indicate a 30 day settling time is favorable. If the full distribution is to be used, the Simonds Saw and Steel data indicates a 30 day settling time is favorable while the Adley data is unclear. It is unclear because the GM indicates it is not favorable while the 95th percentile indicates it is favorable.

The data therefore appears to give mixed results. This is true, however, only if the GM is to be used as a constant which is not normally the case. Based on Appendix A, the constant value that is equivalent to a lognormal distribution (for the purposes of IREP) would fall somewhere between the average of the lognormal distribution and the 95th percentile of that distribution. Using these parameters, the 30 day settling time is favorable for both the Adley data and the Simonds Saw and Steel data.

Based on this limited reanalysis of the data, it is recommend that the 30 days settling time be retained in TBD-6000. It is recommended that the value not be lowered at this time until further analysis of possible additional datasets can be completed at some date in the future.

ATTACHMENT A

The following analysis was undertaken to determine if a single constant value could be found that approximates the same result at the 99th percentile as the input of a lognormal distribution into IREP. The analysis utilized a hypothetical case entered into IREP. The details of the hypothetical case are:

Born - 1930
Exposure – 10 years from 1961 to 1970
Date of cancer diagnosis – 2000
Type of cancer – lung
Other details – non-smoker, alpha radiation, chronic exposure

Dose was entered into IREP as a lognormal distribution with a GM of 1 rem and a GSD that varies as shown in the table below. The Probability of Causation (POC) was determined for each of several distribution that varied only by GSD. The annual dose was identical for each of the 10 years for each IREP run. The GM was 1 rem for each year for each IREP run but the average and 95th percentile doses were different for each run due to a different GSD being used. These are included in the table below.

For each distribution, the POC was determined and recorded in the table. Next, the distribution type was changed from lognormal to constant and a value was determined for each distribution that would produce the same POC as the lognormal distribution. Each of these doses was entered into IREP and the POC recorded in the table to verify the POC did indeed result in in the same POC as the lognormal distribution.

It can be seen from the data in the table that for a wide range of GSDs, the constant dose necessary to produce the same POC always falls between the average and the 95th percentile of the distribution.

Lognormal Distribution						Constant Value	
Rem/year	GSD	POC (%)	Average	95th		Rem/year	POC (%)
1	2	41.91	1.272	3.127		1.403	41.91
1	4	63.17	2.614	9.781		3.335	63.17
1	6	78.63	4.979	19.057		7.155	78.63
1	8	87.03	8.689	30.590		13.049	87.03
1	10	92.19	14.167	44.157		22.955	92.19