MEMO

TO: Advisory Board on Radiation and Worker Health Work Group on TBD-6000

FROM: John Mauro, Robert Anigstein, and Steve Marschke, SC&A

SUBJECT: SC&A Commentary on "White Paper – Square Function Approximation to Estimating Inhalation Intakes," Prepared by David Allen, DCAS, June 2013

DATE: June 11, 2013

Members of the Advisory Board, NIOSH, and SC&A have held numerous discussions regarding methods that can be used to assign a plausible upper bound to the airborne uranium dust loadings that workers might have experienced at General Steel Industries (GSI) during the years when GSI was handling uranium. Our discussions unfolded in two phases. The first phase was primarily concerned with selecting the appropriate surrogate uranium dust loading for GSI. The main concern was that no dust loading data were available for GSI, and it was necessary to make use of surrogate data taken from other facilities where uranium was handled in a similar manner. This was challenging because most of the dust loading surrogate data were available from facilities that were machining, rolling, grinding, extruding, etc., uranium, and where the dust loadings were implausibly high as applied to GSI. After some additional research, NIOSH identified a number of sites where uranium was handled much in the same manner as it was at GSI, and all participants agreed that these uranium dust loading data could be used as surrogate data for GSI.

The second phase of discussion, which is the topic covered in this white paper, has to do with reconstructing the exposures to airborne uranium dust at GSI, recognizing that the exposures were intermittent, and not continuous, as they were at the facilities that were used as the source of the surrogate data. At GSI, after handling the uranium for the purpose of radiography, the uranium dust settles over some time period that depends on the settling rate of the uranium. However, while the dust is settling on surfaces and also during the time after the dust has all settled, there is residual uranium dust on surfaces that can be resuspended. Typically, the amount of airborne uranium dust associated with resuspension processes is small compared to the amount of airborne uranium dust associated with the actual handling of uranium. Hence, one would expect cycles of relatively high followed by relatively low concentrations of airborne uranium dust throughout the facility where uranium is periodically handled. This cyclic process is referred to as the "square wave function" in NIOSH's white paper.

All parties have been struggling with how best to address this cyclic phenomenon in a scientifically sound, plausible, and claimant-favorable manner, and we believe that, in its current white paper, NIOSH has developed a simple, but elegant approach to addressing this complex problem.

In their white paper, NIOSH begins from first principles, explaining that the airborne activity (A in Bq) can be described by a simple first order differential equation, where A at any point in time, t in seconds, is a function of the production rate P in Bq/sec and the removal rate of the uranium, λ, in units of sec^{-1}. Under such first order process, at times that are long compared to the rate of removal, the airborne inventory of uranium reaches equilibrium, and the equation reduces to A = P/λ. In NIOSH's white paper, they point out that equilibrium may not be achieved during any given radiography campaign and the airborne activity at any given point in time during the handling of uranium is simply expressed as:

$$A = \frac{P}{\lambda} * \{1 - \exp(-\lambda t)\}$$

At some time t1 (the term used in NIOSH's white paper), the airborne activity will build up to a given level and then, when uranium handling ceases, uranium production ceases, and the airborne activity will begin to decline according to A = A(t1) * exp(-λ(t-t1)). Hence, the graph depicting the amount of airborne activity of uranium in the work area at any time following the beginning of the first uranium handling campaign will take the form shown in Figure 1 of the NIOSH white paper, reproduced below.

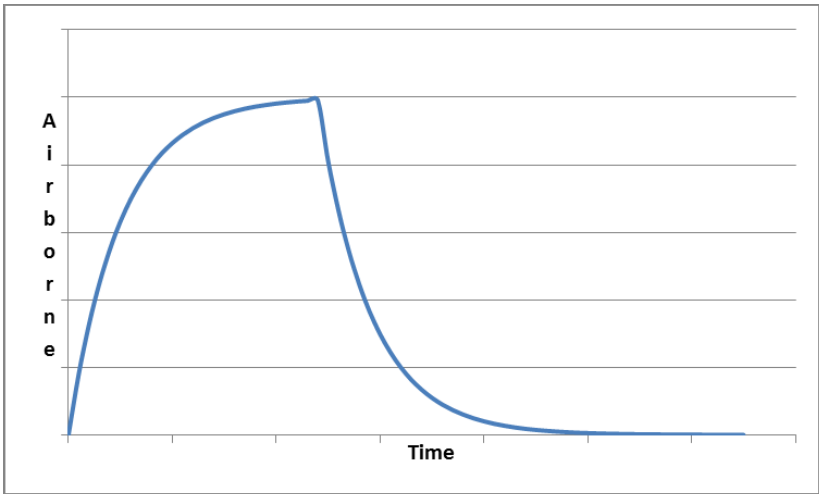

Figure 1 – Buildup and Decline of Airborne Activity from a Single Episode

Integrating under the curve will yield the total amount of airborne uranium (Bq-sec) over all time due to the handling of uranium over the time duration t = t1. Here is where the elegant nature of the NIOSH paper comes in. Attachment A of the NIOSH white paper demonstrates that the total amount of airborne uranium over infinity, expressed in units of Bq-sec, due to a single campaign that lasts for a time of t1 seconds (such as 15 minutes; i.e., 900 seconds) is simply P/λ*t1. Then, the total inventory of airborne uranium over all campaigns is simply P/λ*t1 times the number of such campaigns.

The above discussion does not present specific concentrations, but we assume that NIOSH plans to use the upper 95^{th} percentile concentration of uranium; i.e., A/V, where V is the volume of the space (m^3) and 68.7 dpm/m^3 is the equilibrium dust loading (Allen 2013). Since the volume of the space is a constant, both sides of the above equations can be divided by the volume, and the equation solved for the airborne concentration, i.e., C = P/(V*λ)*t1.

Given this understanding, SC&A agrees with NIOSH's basic strategy. The only question that we need to discuss is the duration that uranium is handled during each radiography campaign. It is our understanding that NIOSH plans to assume 15 minutes. We also need to know the total number of campaigns during the time that uranium was undergoing radiography at the site. We believe that, at present, NIOSH is assuming that during each campaign, uranium is handled for about 15 minutes, and for the rest of the time that uranium is on site, it is not actually being handled in a manner that would generate uranium dust. This is a topic that will need to be discussed at the next work group meeting, along with the number of assumed campaigns. One of the challenges will be how to deal with the production of uranium dust when uranium is handled at times when it is not in the set-up and take-down mode for radiography; for example, when it is being brought onto the site, placed in storage prior to radiography, and being removed from the site. Does the 15 minutes of handling account for these other handling operations?

References

Allen, D., 2013. White Paper – "Square Function Approximation to Estimating Inhalation Intakes," Prepared by David Allen, DCAS. June 2013.