TO: Advisory Board on Radiation and Worker Health Work Group on TBD-6000
FROM: Robert Anigstein and John Mauro, SC&A
SUBJECT: Review of NIOSH Report: Addendum to Dose Estimates for Betatron Operations
DATE: March 25, 2012

Review of "Addendum to Dose Estimates for Betatron Operations White Paper"

During its meeting on March 15, 2012, the ABRWH Work Group on TBD-6000 assigned several action items to SC&A, including responding to the expected revision of the NIOSH white paper on betatron operations at GSI, originally issued on January 13, 2012. The following is a review of "Battelle-TBD-6000 Appendix BB General Steel Industries: Addendum to Dose Estimates for Betatron Operations" (Allen 2012b), which we received on March 23.

Allen (2012b) reported that he recalculated the dose rates outside the shooting room of the New Betatron Building, removing the lead-shielded door between the betatron building and the adjacent No. 10 Building from his MCNPX model. This change was made because the earliest reference to the lead shielding was in a communication to AEC in January 1968, which was 18 months after the period of covered operations at GSI. Some GSI workers have disputed the presence of the lead shielding during the covered period. Because there is uncertainty about when the lead shield was installed, Allen used the claimant-favorable assumption that the lead was not present during the covered period. We agree with this revision.

However, Allen (2012b) retained in his analysis several features that we previously disputed, as discussed by Anigstein and Olsher (2012). First, we disagree with his arbitrarily selected set of 15 betatron shooting scenarios, 10 of which do not represent realistic practices employed in betatron radiography. During the March 15 work group meeting, Mr. Allen explained that the shots aimed at an angle of 45º to the surface of the casting were meant to encompass other geometries than the radiographic examinations of a hollow cylindrical axle first used by SC&A (2008) as an example of a large casting actually produced and tested at GSI. We do not agree that shooting at a 45º angle to the surface represents a realistic procedure for this or any other casting.

Next, we disagree with Allen's (2012b) methodology of apportioning the shots among these 15 scenarios on the basis of the MCNPX analyses of exposure rates at the location of the film-badge storage rack. Allen revised the location, based on information furnished by [redacted] a former GSI betatron operator. Anigstein and Olsher (2012) presented a diagram showing the location of the rack in the New Betatron Building, but not in the control room. The purpose of that diagram was to illustrate that Allen (2012a) was mistaken in assuming that the badges were stored in the control room and that both the worker badges and the control badge were exposed to stray radiation even when they were not being worn. Having interviewed Mr. [redacted] to obtain that information, we were aware that the badge rack had also been in a second location in the New Betatron Building, but we showed only one location for purposes of illustration.

Allen (2012b) used the location illustrated by Anigstein and Olsher (2012) to adjust the frequency of his various shooting scenarios so that the weekly exposure at the film-badge storage rack would be equal to 10 mR. We disagree with this procedure for several reasons. First, as stated above, the shooting scenarios were arbitrary and, in most cases, unrealistic. Because his report was issued on March 23, two days prior to the present review, we did not have the opportunity to obtain Allen's new MCNPX input files, so we are at a disadvantage in assessing the accuracy of the exposure assessment. However, Anigstein and Olsher (2012) observed that Allen's earlier files utilized a density of 0.92 g/cm^3 for the wall between the control room and the rail tunnel—Allen (2012b) did not indicate that this parameter was changed in his revised analysis. SC&A (2008), in the absence of information about the construction of the wall, had adopted that density in the interest of a claimant-favorable assessment of worker exposures in the control room. Since the drawings accompanying the GSI AEC application indicate that the wall was made of mortar-filled concrete blocks, that assumption is no longer tenable nor, in Allen's analysis, is it claimant favorable: reducing the shielding of the film badges tends to understate the worker exposure in the No. 10 Building.

Furthermore, we question any analyst's ability, based on currently available data, to assess the exposure at the rack location, absent any information on the intervening interior walls, furniture or equipment that could shield the film badges from stray radiation, the presence of a second story that would reduce skyshine, etc. Most exposure assessments use simplifying, claimant-favorable assumptions that tend to maximize the exposures; however, in Allen's approach, maximizing the exposures to the film-badge storage rack minimizes the estimated exposure of the workers.

Allen (2012b) performed an "example calculation," in which he assumed that the betatron operator received an exposure of 5 mR per week from residual radiation from the betatron after shutdown. Because the weekly exposure at the film badge rack is thus reduced to 5 mR, Allen recalculated the frequency of the various shot scenarios. This had the effect of increasing the betatron operator's annual exposure to photon radiation while reducing his neutron dose. Both the exposure and the neutron dose to the layout man were reduced on the basis of this calculation. This calculation was performed to explore the possible effect of the residual betatron operation. Since, as shall be shown, the results do not change the maximum doses from the bounding scenario, we did not examine these calculations any further.

Table 1 lists the annual doses to the betatron operators calculated by Anigstein and Olsher (2012), as well as the maximum exposures and doses presented by Allen (2012b). We list the photon doses based on the assumed 5-mR/week exposure to residual betatron radiation; since this assumption reduces the neutron doses, as calculated by Allen, we list the neutron doses calculated in the absence of this assumption. We list the beta doses to the skin presented by Allen (2012a) for ease of reference—these doses have not been revised.

Table 2 lists the corresponding doses to layout men. Since the assumed residual betatron radiation reduces both Allen's photon and neutron exposure estimates, we list the doses calculated in the absence of such an assumption. We disagree with Allen's assignment of these doses for 1953–1966 (with a 50% reduction in 1966 to account for the end of covered operations on June 30). This scenario places the layout man near the entrance to the New Betatron Building. Since this building was constructed in 1963, assigning these doses for prior years does not constitute a plausible scenario. We believe that the bounding exposure scenario for earlier years should be represented by a radiographer employing ^{226}Ra using the fishpole technique, as discussed by Anigstein (2011). As in Table 1, we list the beta doses to the skin presented by Allen (2012a)—these doses have not been revised.

Table 1. Annual Doses to Betatron Operators

Year	Exposure (R)		Neutron dose (rem)		Beta dose to skin (rads)			
					Hands and forearms		Other skin	
	SC&A[a]	DCAS	SC&A	DCAS	SC&A	DCAS[c]	SC&A	DCAS[c]
1953-1957	1.35	0.734	0.48	0.050	33.4	25.9	6.27	2.27
1958	1.35	0.734	0.48	0.050	32.1	25.9	6.22	2.27
1959-1960	1.35	0.734	0.48	0.050	30.9	25.9	6.18	2.27
1961	1.35	0.763	0.48	0.056	34.2	29.5	6.30	2.47
1962	1.35	0.702	0.48	0.043	27.2	21.8	6.04	2.04
1963	1.35	0.586	0.47	0.019	13.9	7.0	5.56	1.23
1964	1.35	0.558	0.46	0.013	10.7	3.5	5.45	1.03
1965	1.35	0.554	0.46	0.012	10.2	3.0	5.43	1.00
1966[b]	0.68	0.275	0.23	0.006	4.8	2.4[d]	2.71	0.97[d]

Note: SC&A values from Anigstein and Olsher (2012)

[a] Maximum exposure, assuming hypothetical 30-keV residual radiation from betatron behind operator's back

[b] During contract period: January 1–June 30

[c] Not revised from Allen (2012a)—included for reference

[d] As listed by Allen (2012a)—should be prorated for 6-months of exposure in 1966

Table 2. Annual Doses to Layout Men

Exposure (R)		Neutron dose (rem)		Beta dose to skin (rads)			
				Hands and forearms		Other skin	
SC&A	DCAS	SC&A	DCAS	SC&A	DCAS	SC&A	DCAS
9.20	4.483	0.46	0.148	4.20	1.02	2.45	0.54

Note: SC&A values from Anigstein and Olsher (2012). See text for applicable periods.

As shown in Tables 1 and 2, the layout man constitutes the limiting scenario for photon exposures in both the SC&A and DCAS analyses. However, the exposure calculated by DCAS is less than one-half of that estimated by SC&A (Anigstein and Olsher 2012). Although the SC&A scenario is based on a single bounding exposure geometry, it is a realistic scenario, based on a photograph and information from a former betatron operator. Furthermore, whereas Allen (2012b) located the layout man at the center of the railroad track, an implausible location, we placed him at equal distances on either side of the track and found that one position had almost twice the exposure rate of the other, indicating that the center would not necessarily lead to the maximum exposure. The DCAS neutron calculations yield far lower doses than do the SC&A estimates—10-fold lower in the case of the betatron operator, and less than one-third for the layout man.

In summary, we conclude that the analyses presented by Allen (2012a and 2012b) represent a major advance over the betatron studies described by Allen and Glover (2007). However, we believe that further revisions are required in order for the results to be scientifically correct and claimant favorable.

References

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