Discussion of Remaining Issues to Sanford Cohen & Associates Review of Battelle -TBD-6000 Appendix BB

(General Steel Industries, Rev. 1)

Response Paper

National Institute for Occupational Safety and Health

Division of Compensation Analysis and Support

July 10, 2015

By David Allen

Reviewed by James W. Neton, Ph.D., CHP

Background

The Advisory Board work group on TBD-6000 held numerous meetings to discuss issues associated with the site profile for General Steel Industries (GSI). During these discussions, most issues associated with estimating doses at GSI were resolved. On 6/6/2014, NIOSH issued revision 1 of Appendix BB to TBD-6000 which is the site profile for GSI. SC&A reviewed this document and issued a memo on 12/10/2014 that contained 9 findings. On 1/8/2015, NIOSH issued two white papers providing responses to the 9 findings. On 1/26/2015, SC&A issued a new memo responding to the NIOSH white paper. This new memo added one additional finding.

The work group held a meeting on 2/5/2015 to discuss these findings. Six of the ten findings were closed (Findings 1, 3, 4, 7, 8, and 9). Findings 2, 5, 6 and 10 were discussed but no resolution to these findings was reached. This white paper contains a discussion of the 4 remaining issues. Because some of the findings are interrelated, it is clearer to discuss the findings out of numerical order.

Finding 2 – Betatron Operator Beta Doses

In 2013, NIOSH and SC&A exchanged files to reconcile differences in the betatron operator beta dose calculations. In drafting revision 1 to Appendix BB, NIOSH realized an inconsistency existed in the calculations. The uranium dose calculation assumed work for 7.5 hours per 8 hour shift, which apparently accounted for a lunch break. The irradiated steel dose numbers, however, assumed 8 hours of work. NIOSH changed the uranium dose calculation to 8 hours to be consistent.

In the 12/10/2014 report, SC&A pointed out that both SC&A and NIOSH had previously failed to include the 1 meter beta dose. NIOSH agreed that this dose should be included and, in a 1/8/2015 white paper, indicated that this dose would be added in the next revision. NIOSH further indicated their intention to adjust the beta dose to account for intermittent irradiation of castings. SC&A stated during the 2/5/2015 meeting that there were other differences and presented a table showing SC&A values versus NIOSH values. The SC&A values included the 1 meter dose while the NIOSH values did not. NIOSH responded during the meeting that the other difference was the 8 hours NIOSH used for the uranium doses. The information below shows the timeline and values using 1953 as an example. It should be noted that revision 1 of Appendix BB did not list the steel and uranium values separately, only the total was provided.

Uranium Hand and Forearm Beta Dose

- SC&A 12/5/2013 report = 31.96 rem
- Appendix BB rev.1 = 33.98 (31.86 rem if 7.5 hours per shift is used)
- SC&A 12/10/2014 memo = 31.96 rem

Steel Hand and Forearm Beta Dose

- SC&A 12/5/2013 report = 2.76 rem
- Appendix BB rev.1 = 2.76
- SC&A 12/10/2014 memo = 3.33 rem

The beta dose from irradiated steel in SC&A's 12/10/2014 memo includes 1 meter doses that were left out of the 12/5/2013 SC&A memo and revision 1 of the Appendix. NIOSH recalculation of that dose now is 3.38 rem based on assumptions used in revision 1 (compared to 3.33 from SC&A). Adjusting this value to account for intermittent irradiation rather than 30 continuous hours produces a new value of 1.54 rem.

Uranium Whole Body Beta Dose

- SC&A 12/5/2013 = 2.03 rem
- NIOSH rev 1 = 2.16 rem (2.03 rem if 7.5 hours per shift is used)
- SC&A 12/10/2014 = 2.03 rem

Steel Whole Body Beta Dose

- SC&A 12/5/2013 report = 1.7 rem
- NIOSH rev 1 = 1.71 rem
- SC&A 12/10/2014 memo = 2.29 rem

The beta dose from irradiated steel in SC&A's 12/10/2014 memo includes 1 meter doses that were left out of the 12/5/2013 SC&A memo and revision 1 of the Appendix. NIOSH recalculation of that dose now is 2.33 rem based on assumptions used in revision 1 (compared to 2.29 from SC&A). Adjusting this value to account for intermittent irradiation rather than 30 continuous hours produces a new value of 1.05 rem.

Recalculated values including the 1 meter dose and accounting for intermittent irradiation are included in the Table 1.

Table 1 - Betatron Operator Annual Beta Doses (rem)

	Hands and forearms			Whole body Skin		
Year	Uranium	Steel	Total	Uranium	Steel	Total
1952	8.50	0.38	8.88	0.54	0.26	0.80
1953-1957	33.98	1.54	35.52	2.16	1.05	3.21
1958	28.48	1.58	30.06	1.81	1.08	2.89
1959	26.22	1.59	27.81	1.67	1.09	2.76
1960	26.22	1.59	27.81	1.67	1.09	2.76
1961	30.10	1.57	31.66	1.91	1.07	2.98
1962	21.85	1.62	23.47	1.39	1.11	2.50
1963	5.95	1.74	7.68	0.38	1.19	1.56
1964	2.18	1.76	3.95	0.14	1.20	1.34
1965	1.59	1.77	3.36	0.10	1.21	1.31
1966	0.50	0.89	1.38	0.03	0.60	0.64

Finding 10 – Betatron Operator Gamma Dose

SC&A documented a new finding in their 1/26/2015 response memo. This finding indicated that the 26 mrem per week used in revision 1 of the Appendix was actually an effective dose and thus not compatible with OCAS-IG-001. SC&A suggested using the air kerma dose that was calculated as one step in finding the 26 mrem per week value. The air kerma dose rate would be 204.5 mrad per week. This would be for 30 keV photons in the PA geometry.

During the work group meeting on 2/5/2015, NIOSH pointed out that the value is only used for hands and forearms skin dose. The OCAS-IG-001dose conversion factors for skin determine a skin entrance dose, areas of the skin not exposed to the entrance dose have to be adjusted. Dose to skin on the opposite side of the body would be considerably less for low energy photons. Since the exposure is in a PA geometry, the entrance dose would only be applicable to the hands and forearms if the operator stood with this hands behind his back or to his sides. If he were working with his hands in front of him, the value would be much lower and the actual film badge reading would be an appropriate representation of the dose.

Since most accounts of work in the betatron building indicate they were always rushed to get the next shot started, it is unlikely anyone stood for a length of time with their hands behind their back or even to their sides. Therefore, assuming this occurred only half the time appears to be a favorable assumption.

The applicable tables in Appendix BB will be changed from 1.3 rem photon dose to 10.225 rad. A footnote will specify the appropriate OCAS-IG-001 dose conversion factor (DCF) as the air kerma factor for photons <30kev in the PA geometry. A footnote will also specify that the DCF is to be used for the skin of the back and sides. Skin locations on front of the body will be assigned 0.5 rem. Also, hands and forearm dose will be assigned 50% of the skin entrance dose plus 0.25 rem (50% of the 0.5 rem dose in front).

Finding 5 – Adding Betatron Operator Dose to Radium Radiography Dose

SC&A commented that the radium radiography only occurred during 30% of a shift and it is therefore possible the radiographer could be exposed in the betatron building the remaining 70% of the time. NIOSH pointed out that 30% represented the shot time (the fraction of time the source was exposing the film) but other associated tasks were necessary before and after that in order to perform radiography. During the work group meeting on 2/5/2015, the work group indicated they felt some betatron dose should be added to the radium radiography dose. Also during the meeting, SC&A conceded that something less than 70% might be appropriate.

In the fast paced work in the betatron building, operators indicated 15 minutes between shots was a reasonable value. Therefore, we will consider that a reasonable value for the radium radiography as well. The radium radiography exposure estimate is based on 10 shots per 8 hour shift with the shots themselves taking 30% of the shift. That is 144 minutes per shift for the shots plus 150 minutes between totaling 294 minutes. If the employee is assumed to be exposed as a betatron operator the remaining 186 minutes per shift it would equal 38.75% of the shift.

In light of this, NIOSH proposes adding 38.75% of the values in Table 1 to the radium radiography dose. This differs from the SC&A recommendation in three ways. First, SC&A recommended 70% rather than 38.75%. Second, SC&A recommended adding only beta and neutron dose but not gamma dose. NIOSH can find no basis for adding these without the gamma dose so NIOSH is recommending adding gamma dose also. Third, SC&A recommended adding 100% of the uranium dose plus enough steel dose to account for the remainder of the time. NIOSH sees no basis for biasing the doses towards the uranium work. In the past, there has never been any relationship alleged between radium work and uranium work so this biasing doesn't appear to be appropriate.

Finding 6 – Layout Man Beta Dose

The layout man beta dose was discussed in SC&A's review of revision 1 of Appendix BB as well as in the NIOSH response and SC&A's response to that. During the work group meeting on 2/5/2015, the work group wanted some additional written discussion from NIOSH. What follows is an attempt to clarify the issue.

The model for the beta dose requires a number of parameters some of which there is agreement between SC&A and NIOSH and others in which there is no agreement. In comparing SC&A's model with the NIOSH model proposed in the 1/8/2015 white paper, it can be seen that parameters in which there is agreement include:

- Both models use some fraction of short and long shots in the calculation (the value of that fraction differs)
- Both assume the layout man is exposed to freshly irradiated castings (SC&A assumes this occurs 100% of the time while NIOSH assigns a fraction to this scenario)
- Both assume short shots are performed at a distance of 6 feet between the betatron target and the casting while long shots are performed at a distance of 9 feet.
- Both assume the layout man exposure to freshly irradiated castings start 15 minutes after irradiation
- Both assume the layout man exposure to the irradiated castings are from 1 meter 10% of the time and close (contact for extremity and 1 foot for whole body) the remaining 90% of the time.
- With the exception of accounting for intermittent irradiation, both use the same calculations as the betatron operator beta dose changing only the parameters that go into those calculations.

Differences in the parameters used include:

- SC&A accounts for repeated shots on a casting by assuming a 30 hour continuous irradiation while NIOSH accounts for them by assuming 2 castings are alternately cycled into and out of the betatron building.
- While both agree 10% of the shots were long shots, NIOSH assumes that defects are as likely in thin metal as in thick metal. SC&A assumes thick castings are more likely to show defects and assigns a 36% factor to them.
- NIOSH assumes 90% of the time the layout man is working on a single large casting - the same as the gamma dose scenario. The remaining 10% of the time, is accounted for by interrupting castings. SC&A assumes 100% of the time the layout man is working on interrupting castings.
- NIOSH assumes the layout man works on a short shot for 15 minutes while SC&A assumes 75 minutes (both assumed 75 minutes for long shots).

The parameters that differ between models are explored further below.

1. Alternating castings versus 30 continuous hours of irradiation

During the 2/5/2015 meeting of the work group, SC&A appeared to agree that the 30 continuous hour exposure scenario was not possible, but the last report by SC&A indicated the NIOSH bounding approach of 2 castings alternating back and forth was unrealistic. If SC&A indeed agrees that the 30 hour scenario is not possible, it is not clear if they continue to take issues with the alternating castings scenario.

2. 10% long shots versus 36%.

Based on statements by workers, it has been assumed that 10% of the shots in the betatron were long shots. NIOSH assumes defects are as likely in thick as thin metal. SC&A assumes thick castings are more likely to show defects and assigns a 36% factor to them. SC&A indicated during the 2/5/2015 meeting that this was intuitive. A former worker was asked to comment on this and indicated that he felt it was may have depended more on the type of casting. He indicated thick submarine missile tubes had few defects while turbine castings, which had both thick and thin places, had many defects.

DCAS does not know if defects are more likely in thick castings than in thin, but we do not agree that it is intuitive. Intuitively, thicker castings would remain molten longer and allow more time for impurities to separate (similar to slag floating to the surface of a weld). Thinner castings would thus more likely trap impurities as they would solidify faster.

In any case, the 36% is based on the fraction of time it takes to x-ray long shots if they make up 10% of the shots. The difference being the amount of time it would take to produce an image on the film. Since the time necessary to locate and correct a defect is not dependent on the time necessary to produce the x-ray, this does not appear to be a relevant basis.

NIOSH proposes using the 10% fraction for long shots.

3. Single Large Casting

It is not clear what SC&A's argument is against this scenario. SC&A appeared to be indicating there are too many possibilities to assign one scenario. They supplied e-mails as attachments to demonstrate this. However, the e-mails indicate:

- At the beginning of the month maybe 8 castings were chosen as priorities because they were close to shipping.
- Defects in these castings could be fixed and reshot right away. They may make 10 trips into the betatron building.

These e-mails would then indicate about 80 priority shots per month. Assuming the facility operated 24 hours a day 7 days a week there would be an average of 91.25 shifts per month (365 days x 3 shifts per day/12 months). That equals an average of 0.88 priority shots per shift. If the casting was worked on for 75 minutes, that would equate to 13.7% of the shift. If the casting is worked on for 15 minutes, it would equate to less than 3% of the shift.

This does not appear to dispute the original assumption that 10% of the shift was taken up with interrupting castings.

4. 15 minute exposure to short shots versus 75 minutes

NIOSH assumed the layout man worked on the short shot castings for 15 minutes and the long shot castings for 75 minutes. The values are the result of using the alternating castings scenario to bound the dose. That is, since it requires 15 minutes to produce a freshly irradiated casting and move it to the layout man position, the maximum dose would be to assume he received a fresh one every 15 minutes. SC&A's time may be more realistic but that is not clear there is a good estimate of the amount of time necessary to repair a defect. Therefore, NIOSH used the bounding estimate.

5. Two Betatrons on site

SC&A mentioned in their report and during the 2/5/2015 meeting that NIOSH failed to account for 2 betatrons in its alternating casting scenario. This can be easily accomplished by assuming three alternating castings cycling between 2 betatrons and the layout man. SC&A considered the two casting scenario unrealistic. NIOSH agrees but intends to use it as a bounding scenario. Since SC&A considers the two casting scenario as unrealistic, it does not appear to be necessary to expand it further to a three casting scenario.

Path Forward for Layout Man Beta Dose (finding 6)

SC&A has indicated that the NIOSH calculations associated with the intermittent irradiation model is correct. The rest of the calculation technique was agreed to when the betatron beta dose was explored. The only remaining items to resolve involve the exposure scenario for the layout man. The parameters are outlined below and discussed previously.

The path forward is to reach agreement on the following parameters:

1. Fraction of short and long shots.
2. Whether a single large casting dose is to be included.
3. Fraction of time worked on "hot shots" – related to #2 above. If it is assumed that a single large casting represents some of the time, that fraction is necessary.
4. Whether the alternating castings is a reasonable bounding scenario.
5. Two betatrons – whether the scenario should include 3 castings alternating between 2 betatrons and the layout man.
6. Work time after short shots (15 minutes or 75 minutes).

Path Forward for Findings 2, 5 and 10

In order to resolve the remaining findings, it is necessary to reach agreement on the following parameters.

1. Using 8 hours per shift of exposure for uranium work in the betatron building (Finding 2)
2. Using intermittent irradiation equation for beta dose calculation for betatron operator (Finding 2)
3. Fraction of time a betatron operator stands with his hands behind his back or to his sides (NIOSH recommends 0.5) (Finding 10)
4. Fraction of betatron operator dose to be added to radium dose (Finding 5)
5. Biasing of betatron dose fraction toward uranium work (Finding 5)