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ADVISORY BOARD ON
RADIATION AND WORKER HEALTH

National Institute for Occupational Safety and Health

SC&A's Review of the NIOSH Document Issued March 3, 2016, Titled, *Discussion of Ames Laboratory TBD Findings on External Dose*

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TABLE OF CONTENTS

ABBREVIATIONS AND ACRONYMS

AEC	Atomic Energy Commission
ALRR	Ames Laboratory Research Reactor
CTW	construction trade worker
dpm/m^3	disintegrations per minute per cubic meter
EE	energy employee
Electro Met	Electro Metallurgical Company
ER	evaluation report
mrem	millirem
NIOSH	National Institute for Occupational Safety and Health
pCi	picocurie
SEC	Special Exposure Cohort
TBD	technical basis document

1.0 INTRODUCTION AND BACKGROUND

In response to SC&A's 2013 review of ORAUT-TKBS-0055, *Site Profile for Ames Laboratory*, Revision 03 (ORAUT 2012; hereafter referred to as the "Ames technical basis document" or "TBD"), the National Institute for Occupational Safety and Health (NIOSH) issued *Discussion of Ames Laboratory TBD Findings on External Dose*, Revision 0, dated March 3, 2016 (NIOSH 2016). This report addressed 5 of the 22 findings in SC&A 2013: Findings 3, 4, 5, 21, and 22. A shared feature of these findings is that they pertain to external dose. Eleven findings from SC&A's review of the TBD (SC&A 2013) were previously addressed by NIOSH's report, *NIOSH Response to SC&A Review of the Ames Site Profile Document Regarding Uranium Internal Exposures*, Revision 0, dated July 29, 2015 (NIOSH 2015b). NIOSH has not yet responded to the remaining six SC&A 2013 findings.

2.0 FINDINGS RELATED TO ENVIRONMENTAL EXPOSURES ASSOCIATED WITH THE OPERATION OF THE SYNCHROTRON

2.1 NIOSH RESPONSE

In Section 2.0 of its response (NIOSH 2016), NIOSH responded to the following findings:

> *Finding #3: NIOSH's selection of personnel at the ALRR Facility as the target population is inappropriate and results in dose estimates that are not claimant favorable. At a minimum, survey data/dose rates cited in Exhibit 4-2, which reflect Synchrotron fenceline measurements, should be considered.*
>
> *Finding #4: NIOSH's selection of data from the 1961 survey conducted at the Synchrotron Facility defines fenceline dose rates that are 1 to 2 orders of magnitude lower than other measurements reported in the survey when beam direction was shifted from westerly to easterly direction. For bounding estimates of environmental doses, fenceline data cited in Exhibit 4-3 should be considered.*
>
> *Finding #5: SC&A concludes that the 1961 survey measurements, which were limited to gamma dose rates, were therefore incomplete and may have substantially underestimated total exposure by excluding the contribution of particulate radiation.*

NIOSH stated that the ambient external dose values from the Ames TBD will be eliminated, because the data currently available are limited. When there are insufficient individual monitoring data to complete a dose reconstruction, external coworker doses will be used.

NIOSH expanded on this response in Section 6.0 of the NIOSH 2016 external dose response:

> *For Ames, the ambient external dose should be considered the minimum dose to be assigned to an unmonitored worker from exposure to any source on site. The definition in TBD section 4.0 should be clarified and be consistent with instructions in section 6.3.1.2. That change should resolve some of the issues raised by SC&A. However, SC&A also had comments on the TBD's estimate of dose rates at the Synchrotron facility perimeter fence…*

> *The selected data and method used in the TBD to estimate ambient doses at the Synchrotron boundary are arguable, and there does not appear to be a clear resolution to SC&A's Findings 4 and 5 using the 1961 data….*
>
> *In lieu of sufficient ambient dose data, 50th percentile coworker dose should be assigned to bound ambient dose for unmonitored workers for all years. Thus,* ***all unmonitored workers should be assigned either the 50th percentile dose or the 95th percentile coworker dose****, as specified in TBD section 6.3.1.2. These changes will be included in a TBD revision.* [Emphasis added.]

2.2 ANALYSIS OF PROPOSED SOLUTION

SC&A acknowledges that replacing the ambient dose with coworker dose is more claimant favorable than the model presented in the Ames TBD. SC&A's review of the Ames TBD (SC&A 2013) had no findings related to the unmonitored dose. SC&A accepts NIOSH's proposed approach as favorable for energy employees (EEs) who worked at the main campus, but SC&A can find no justification for why it might be technically appropriate to apply unmonitored dose from the chemistry facilities to workers at the Synchrotron. It appears that some Synchrotron badge readings were incorporated into the coworker dose; however, most weekly Synchrotron dosimetry was omitted from the modelling. These facilities were located roughly 1.5 miles apart and performed very different research functions, such that the unmonitored dose at the facilities should not be representative of dose at the Synchrotron. It is unclear if Synchrotron workers spent all their time at that facility, or if they also worked at the main campus.

As was indicated in *SC&A's Review of the NIOSH Document Issued July 29, 2015, Titled, NIOSH Response to SC&A Review of Ames Site Profile Document Regarding Uranium Internal Exposure* (SC&A 2015), the reported "background" 0.5–1 millirem per hour at the Synchrotron facility (Ames 1961) was significantly larger than the national average (311 millirem per year). This would translate to a dose of 1–2 rem per year, assuming a 2,000-hour work year. In the Ames TBD NIOSH states, "*apparently the background reading was taken near the synchrotron when the radiation level was slightly elevated above the normal background level*." Film dosimetry records from Synchrotron workers in 1952–1954 report weekly doses in the range of 0–36 milliroentgen (Ames 1954a and 1954b). All of these doses are reported at levels that are below the detection limits of the film dosimeters used at the time. Although all Synchrotron workers should have been monitored for external exposure, accounting for missed dose, the minimum dose an EE should be assigned is 1 rem.

Additionally, replacing the ambient dose with unmonitored dose does not address the time period 1949–1952. These years do not have monitoring records available to develop a coworker model, and no Synchrotron workers were monitored for external exposures before 1952.

3.0 FINDING 21 ISSUES RESOLUTION

3.1 NIOSH RESPONSE

Finding 21 from SC&A's 2013 review of ORAUT-TKBS-0055 (SC&A 2013) states:

> *Finding #21: SC&A's concerns about the use of the same surrogate data sources and questionable assumptions for deriving external dose for Ames' workers exposed to uranium closely parallel those related to uranium intakes as cited in Findings #10 and #13.*

NIOSH responded to Finding 21 in Section 2.0 of NIOSH 2016:

> *NIOSH recommends changes to the surrogate dose data in the TBD, as discussed in section 5.3. As noted in related Finding #13, SC&A also questions the sufficiency of providing multiple building and multiple job category levels of exposure for external dose during the uranium production years. Based on review of available information on work locations for claimants, job categories, and the nature of work evolutions at the Ames facilities during the uranium production years of 1942 through 1945, NIOSH is proposing a simpler approach that should be favorable to claimants and that can be implemented consistently.*

For the years 1946–1952, NIOSH proposed the following change in Section 5.3:

> *External dose from uranium contamination is derived from the median Type S uranium intake of 6,932 pCi/day (*[NIOSH 2015b]*). This production era calendar day intake rate was derived from Ames bioassay data during uranium operations. An air concentration correlating to that intake rate was estimated by assuming an annual inhalation volume of 2,400 m^3. This results in an air concentration of 2,340 dpm/m^3. An estimate of surface contamination was made using the methods specified in Battelle-TBD-6000 section 3.4.2. These assumptions provide a contamination level of 4.55 x 10^6 dpm/m^2. The dose rate factors from Battelle-TBD-6000, Table 3.10, were then used to estimate a photon dose of 0.004 rem per year and a beta dose of 0.042 rem per year based on a 48 hour work-week.*

3.2 ANALYSIS OF PROPOSED SOLUTION

3.2.1 Uranium Production Period Annual Doses, 1942–1945

NIOSH proposed replacing the surrogate data in the TBD with the coworker external doses from the Electro Metallurgical Company (Electro Met). The Electro Met data are more representative of potential exposures to uranium production workers at Ames than what is currently provided in the Ames TBD. The surrogate data come from Electro Met dosimeters worn June 1948 through September 1949. During these years, Electro Met's uranium production facility used the "Ames process" to reduce uranium tetrafluoride (UF_4) to uranium metal ingots (NIOSH 2015a). The Electro Met plant was built to mirror the Ames production process, and Electro Met engineers made trips to Ames in 1942 and 1943 to build their facility to mimic the process at Ames.

Although some minor process differences can be noted during early development work at Ames, overall surrogate dosimetry data from Electro Met make it an ideal candidate site to develop a surrogate model for Ames Laboratory during its uranium production period.

Table 1. Proposed Uranium Production Period Annual Doses, 1942–1945

Operators	Whole body, photons	4.403 rem
	Non-penetrating, skin of whole body	44.03 rad
	Non-penetrating, hands and forearms	276 rad
Administrative Workers	Whole body, photons	1.356 rem
	Non-penetrating, skin of whole body	13.56 rem

Source: Table 2 of Ames 2016.

NIOSH's response specifically defines "operator" as "*anyone involved with research, production, labor, maintenance, or any non-administrative type of work.*" Administrative workers "*should be applied to secretaries, security personnel, managers, or other office personnel*." Administrative workers are workers that level of dose will allow for intermittent exposure in the production areas under the presumption that they could have intermittent exposure for a significant amount of time.

SC&A recommends these definitions be expanded to include reference to construction trade workers (CTWs). Under the current definitions, CTW occupations could reasonably be interpreted to fall into both categories. Based on Attachment B of the NIOSH response, 5 of the 15 workers referenced in Table B1 would fall into this category (NIOSH 2016). Provided the terms "operator" and "administrative worker" are adequately defined in the proposed revision such that there is no ambiguity for dose reconstructors, SC&A finds this approach appropriate for the years 1942–1945. Ames' uranium production operations ceased by the end of 1945; other operations continued in Annex I and Annex II. After production ceased, surrogate data from Electro Met are no longer appropriate.

3.2.2 Post-Uranium Production Period Annual Doses, 1946–1952

The NIOSH response essentially proposes two intake models based on the EEs' employment. The first, "Uranium Facility Workers," is identical to the "Administrative category" workers from the 1942–1955 model. The "Uranium Facility Workers" dose model is to be applied to any worker in the Chemistry Building, Annex I, or Annex II, or to workers whose work locations cannot be determined. The second model, "Other Workers," uses the median uranium intake distribution from NIOSH 2015b to estimate likely dose from surface contamination. The "Other Workers" category is for "*all other workers, or for workers who had only occasional entries in those three facilities.*"

Table 2. Proposed Post-Uranium Production Period Annual Doses, 1946–1952

Uranium Facility Workers	Whole body, photons	1.356 rem
	Non-penetrating, skin whole body	13.56 rem
Other Workers	Whole body, photons	0.004 rem
	Non-penetrating, skin whole body	0.042 rem

Source: Table 3 of Ames 2016.

SC&A agrees the model provided is appropriate for low- and medium-category workers; however, it does not appear to be claimant favorable for high-category workers. These categories are defined in NIOSH 2015b as:

> *High (Assign 95th percentile intakes) – Individuals who operated the process equipment and/or routinely handled radiological materials. This category would include operators, maintenance workers, laboratory workers, health physics monitors, etc. Doses will be applied as a constant.*
>
> *Medium (Assign 50th percentile intakes) – Individuals who routinely worked in the production areas and may have been periodically in the vicinity of where processing was occurring. This includes supervisory staff, engineers, individuals who were not normally in contact with the radiological materials but who worked routinely in the production areas, etc. Doses will be applied as a lognormal distribution.*
>
> *Low – This category is for individuals exposed to ambient air in the environment outside of the uranium production areas who may have been incidentally exposed. This includes office workers or non-uranium workers who are documented to have been in a different location from the uranium work. These intakes allow for incidental exposures and will be applied as a constant.*

SC&A previously reviewed the uranium intake values presented in NIOSH 2015b. The values from Table 2 are based on the production model and the 50th percentile inhalation model; however, workers who operated the process equipment and/or routinely handled radiological materials were exposed to high levels of contamination. It is unclear that "Administrative" dose from production years bounds external dose to workers exposed to uranium during 1946 through 1952. Although most production ceased in 1945, it appears there was still the potential for some workers to receive higher levels of exposure. Also, it is not known if, or when, these facilities were decontaminated.

Restricting external exposure to the low- and medium-category workers is also not consistent with the dose reconstruction assumptions applied to internal exposure from these same years (NIOSH 2015b). Guidance on internal dose recommends the following (NIOSH 2015b, page 14):

> *To allow for potential intakes of uranium after the end of 1945, the production era intake rates are to be applied through 1953 for the Chemistry Building, Annex 1 and Annex 2.*

This guidance allows the higher category worker to be assigned 95th percentile intakes. SC&A recommends that NIOSH consider a higher external dose category for workers who may have been involved in ongoing production activities.

4.0 FINDING 22 ISSUES RESOLUTION

4.1 NIOSH RESPONSE

Finding 22 from SC&A's 2013 review of ORAUT-TKBS-0055 (SC&A 2013) states:

> *Finding #22: Given the availability of highly credible and site-specific data for deriving external doses from thorium exposure, NIOSH's decision to exclude said exposure/doses is not justified.*

NIOSH responded to Finding 22 as follows:

> *In the designation for the SEC class added via petition SEC-00185, the Secretary of Health and Human Services determined certain external doses cannot be reconstructed with sufficient accuracy from 1942 through 1954 (Sebelius, 2011). SC&A suggested radiation surveys taken in March 1952 are sufficient for estimating doses from 1942 – 1952. NIOSH does not consider those results sufficient to characterize external radiation exposures from thorium production, as indicated in the Evaluation Report for SEC-00038 (NIOSH, 2006).*
>
> *Additional review by NIOSH for this finding indicates some limited gamma dose results are available from film badges in late 1952, but these were reportedly for some Synchrotron workers. Regular dosimetry for beta-gamma exposures began at Ames Laboratory in 1953. Thorium production ended in April 1953.*
>
> *NIOSH has compiled dosimeter results and considers the available beta-gamma dosimetry data sufficient to use for unmonitored doses starting in 1953. Some neutron dosimeter data are available starting in 1954, and NIOSH intends to use that data to assign unmonitored dose for workers potentially exposed to neutrons starting in 1954.*

4.2 ANALYSIS OF PROPOSED SOLUTION

The Special Exposure Cohort (SEC)-00185 petition evaluation report (ER) (NIOSH 2011) did not evaluate the ability to reconstruct external exposures from thorium for 1942–1952; instead, it deferred to a recommendation made in the SEC petition ER for SEC-00038 (NIOSH 2006). That ER did not attempt to evaluate external beta and gamma exposure from thorium and its progeny, because it previously determined source term information was not adequate to reconstruct internal doses. SC&A reviewed this SEC ER in 2006 but did not evaluate the possibility of using the 1952 Atomic Energy Commission (AEC) study (Klevin 1952) to estimate external dose.

SC&A does acknowledge that the SEC-00185 ER (NIOSH 2011) found that limited information was available on claimant-specific work locations, such that NIOSH was unable to eliminate a specific worker from potential exposure scenarios based on his or her assigned work location. This was the basis for the SEC class being granted that extended the Ames SEC classes already in effect to include all work locations. However, if it can be reasonably determined that an EE worked in a thorium area, a minimum exposure can easily be determined.

SC&A argues that external thorium exposures can be reasonably estimated by using the 1952 study results for non-presumptive cancers (Klevin 1952). The current approach denies EEs who worked in thorium areas with non-presumptive cancers (most notably skin cancers) an accounting of their external exposures despite the availability of task-specific thorium dose rate measurements. The lack of precise knowledge of the source term age is not necessary to reasonably estimate potential external exposures.

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