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ADVISORY BOARD ON RADIATION AND WORKER HEALTH

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

A REVIEW OF NIOSH'S PROGRAM EVALUATION REPORT DCAS-PER-053, "ALLIED CHEMICAL CORPORATION"

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Record of Revisions

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0 (Draft)	07/7/2015	Initial issue

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ABBREVIATIONS AND ACRONYMS

Advisory Board or Board	Advisory Board on Radiation and Worker Health
ACCP	Allied Chemical Corporation Plant
AEC	U.S. Atomic Energy Commission
DCAS	Division of Compensation Analysis and Support
DR	dose reconstruction
EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
NIOSH	National Institute for Occupational Safety and Health
NRC	Nuclear Regulatory Commission
OCAS	Office of Compensation Analysis and Support
ORAUT	Oak Ridge Associated Universities Team
PEP	Program Evaluation Plan
PER	Program Evaluation Report
POC	Probability of Causation
SC&A	S. Cohen and Associates (SC&A, Inc.)
SEC	Special Exposure Cohort
TIB	technical information bulletin
TLD	thermoluminescent dosimeter
UF_4	uranium tetrafluoride
UF_6	uranium hexafluoride
U_3O_8	triuranium octoxide

1.0 STATEMENT OF PURPOSE

To support dose reconstruction (DR), the National Institute for Occupational Safety and Health (NIOSH) and the Oak Ridge Associated Universities Team (ORAUT) assembled a large body of guidance documents, workbooks, computer codes, and tools. In recognition of the fact that all of these supporting elements in DR may be subject to revisions, provisions exist for evaluating the effect of such programmatic revisions on the outcome of previously completed DRs. Such revisions may be prompted by document revisions due to new information, misinterpretation of guidance, changes in policy, and/or programmatic improvements.

The process for evaluating potential impacts of programmatic changes on previously completed DRs has been proceduralized in OCAS-PR-008, *Preparation of Program Evaluation Reports and Program Evaluation Plans* (OCAS 2006), Rev. 2, dated December 6, 2006. This procedure describes the format and methodology to be employed in preparing a Program Evaluation Report (PER) and a Program Evaluation Plan (PEP).

A PER provides a critical evaluation of the effect(s) that a given issue/programmatic change may have on previously completed DRs. This includes a qualitative and quantitative assessment of potential impacts. Most important in this assessment is the potential impact(s) on the Probability of Causation (POC) of previously completed DRs with POCs of <50%.

During a teleconference by the Advisory Board's Procedures Review Subcommittee meeting on April 28, 2015, SC&A was tasked by the Board to conduct reviews of two PERs. Included among the PERs is DCAS-PER-053, *Allied Chemical Corporation* (DCAS 2015). In conducting a PER review, SC&A is committed to perform the following five subtasks, each of which is discussed in this report:

Subtask 1: Assess NIOSH's evaluation/characterization of the "issue" and its potential impacts on DR. Our assessment intends to ensure that the "issue" was fully understood and characterized in the PER.

Subtask 2: Assess NIOSH's specific methods for corrective action. In instances where the PER involves a technical issue that is supported by document(s) [e.g., white papers, technical information bulletins (TIBs), procedures] that have not yet been subjected to a formal SC&A review, Subtask 2 will include a review of the scientific basis and/or sources of information to ensure the credibility of the corrective action and its consistency with current/consensus science. Conversely, if such technical documentation has been formalized and previously subjected to a review by SC&A, Subtask 2 will simply provide a brief summary/conclusion of this review process.

Subtask 3: Evaluate the PER's stated **approach** for identifying the universe of potentially affected DRs, and assess the **criteria** by which a subset of potentially affected DRs was selected for re-evaluation. The second step may have important implications in instances where the universe of previously denied DRs is very large and, for reasons of practicality, NIOSH's re-evaluation is confined to a subset of DRs that, based on their scientific

judgment, have the potential to be significantly affected by the PER. In behalf of Subtask 3, SC&A will also evaluate the timeliness for the completion of the PER.

Subtask 4: Conduct audits of DRs affected by the PER under review. The number of DRs selected for audit for a given PER will vary. (It is assumed that the selection of the DRs and the total number of DR audits per PER will be made by the Advisory Board.)

Subtask 5: Prepare a written report that contains the results of DR audits under Subtask 4, along with our review conclusions.

2.0 RELEVANT BACKGROUND INFORMATION PERTAINING TO FACILITY OPERATIONS, POTENTIAL SOURCE TERMS AND WORKER MONITORING PROTOCOLS

2.1 FACILITY OPERATIONS

The Allied Chemical Corporation Plant (ACCP) in Metropolis, Illinois, was under contract to the U.S. Atomic Energy Commission (AEC) to convert uranium ore concentrations (U_3O_8) to uranium hexafluoride (UF_6) from January 1, 1959, to December 31, 1976.[1] ACCP processed about 5,000 tons per year of ore to supply UF_6 feed for the Paducah Gaseous Diffusion Plant.

After 1976, ACCP, under ownership of Honeywell and under license to the Nuclear Regulatory Commission (NRC), resumed ore processing to provide UF_6 to gaseous diffusion plants for the production of UF_6 used by commercial fuel fabrication facilities that are not covered by EEOICPA.

Due to the fact that residual contamination that resulted from ore processing associated with weapons-related activities under contract to the AEC is indistinguishable from later contamination (produced under NRC license for the commercial sector), the **residual contamination period** for ACCP has been defined for the time period from January 1, 1977, through March 1, 2011.

2.2 SOURCE TERMS

For the production of UF_6, feed materials of uranium ores (or yellowcake) generally contain 70% to 75% **uranium** by mass representing U-238, U-235, and U-234. In addition, these concentrates included potentially significant trace quantities of radioactive impurities representing Th-232, Th-230, and Ra-226, depending on the mines and mills that produced the yellowcake.

Based on the uranium conversion process employed at ACCP, exposure to **non-**uranium radionuclides varied during the conversion process that begins with the receipt of ores contained in drums. For example, **radon** concentrations and exposures to workers would likely have been elevated from the buildup and release of radon during the **initial** opening of the drums and from the continuous production and release of radon in the feed area/work areas where the radium containing-ore and waste streams existed.

2.3 WORKER MONITORING AT ACCP

Internal Monitoring. During the years of UF_6 production at ACCP, workers were monitored for **uranium** by means of urinalysis. Bioassays were typically performed at time of hire to establish a baseline, and periodically thereafter. In vitro urinalysis data by uranium fluorimetry were reported in micrograms uranium per liter urine, which for natural uranium is readily converted to corresponding activity contributions by U-238, U-235, and U-234.

[1] Records indicate that the ACCP was closed on June 30, 1964, and resumed operation in February 1968.

Based on the likely presence of **non-uranium** radionuclides at ACCP and the absence of corresponding monitoring data, NIOSH concluded that internal dose to non-uranium radionuclides cannot be reconstructed with sufficient accuracy for the full ACCP operational period 1959 through 1976. As a result, the U.S Department of Health and Human Services designated a class of ACCP employees for inclusion in the Special Exposure Cohort (SEC).

External Monitoring. With some gaps in monitoring data during operational years, ACCP workers were generally monitored for **gamma** and **beta** exposures with film dosimeters for years 1959 through March 1976, and by means of thermoluminescent dosimeter (TLDs) thereafter, which included the residual period.

When alpha particles from the decay of uranium isotopes interact with select materials, such as fluorine atoms, neutrons are generated. A limited amount of neutron monitoring data exist for the years 1959–1969, but may not be complete or reliable for DR due to monitoring practices at the site.

3.0 SUBTASK 1: IDENTIFY THE CIRCUMSTANCES THAT NECESSITATED THE NEED FOR DCAS-PER-053

3.1 CHRONOLOGY OF EVENTS

ORAUT-TKBS-0044, Rev. 00. On February 1, 2006, NIOSH issued a Site Profile for the ACCP, ORAUT-TKBS-0044, Rev. 00 (ORAUT 2006), which included an exposure matrix aimed at providing data and guidance for DR of ACCP workers.

ORAUT-TKBS-0044, Rev. 01. In recognition of residual and variable amounts of non-uranium radioisotopes (i.e., Th-230 and Ra-226) that remained in the feedstock of U_3O_8 processed at ACCP, and the realization that internal doses from non-uranium radionuclides cannot be reconstructed with sufficient accuracy, a class of ACCP workers was added to the SEC in 2007 (Leavitt 2007). The inability to reconstruct internal doses from non-uranium isotopes and the designation of the SEC class mandated Rev. 01 of ORAUT-TKBS-0044, which was issued on October 1, 2007 (ORAUT 2007).

SC&A's Draft Review of ORAUT-TKBS-0044, Rev. 01. SC&A was tasked to conduct a technical review of Rev. 01 of ORAUT-TKBS-0044 (ORAUT 2007). In its review (SC&A 2011), SC&A cited findings that impacted the reconstruction of worker doses. One finding that impacted the reconstruction of ACCP worker dose during the **operational years** was NIOSH's model for estimating neutron exposure from the alpha/neutron reaction of UF_4 and UF_6. Other recommendations by SC&A pertained to **non-uranium** contaminants to which workers were exposed during the residual period.

Revision to ORAUT-OTIB-0070. In **Rev. 01** of the ACCP Site Profile (ORAUT 2007) issued on October 1, 2007, the depletion of the source term during the residual period was defined in Section 5.0 as follows:

> *Current project guidance (ORAUT-OTIB-0004) establishes a **source term depletion factor of 1% of the surface activity per day**. Use of this 1% depletion factor is favorable to claimants, based on the depletion behavior reported above, however, to account for the observed steady-state resuspension condition, this factor is held constant after 1979. The factors to account for depletion of the pre-1977 source term during the residual period are presented in Table 5-2.* [Emphasis added.]

Table 5-2, Adjustment factors to account for depletion of pre 1977 source term during the residual contamination period.

Year	*Factor*
1977	*1*
1978	*0.03*
1979-Present	*0.0007*

This source term depletion factor of 1% per day originally cited in ORAUT-OTIB-0004 was subsequently adopted in ORAUT-OTIB-0070, Rev. 00, *Dose Reconstruction During Residual*

Radioactivity Periods at Atomic Weapons Employer Facilities (ORAUT 2008), issued on **March 10, 2008**.

On March 5, 2012, Rev. 01 of ORAUT-OTIB-0070 was issued (ORAUT 2012), which revised the source term depletion factor from 0.01 day^{-1} to 0.0067 day^{-1}.

ORAUT-TKBS-0044, Rev. 02. On May 5, 2014, NIOSH issued **Rev. 02** (ORAUT 2014) of the ACCP Site Profile. Changes that were incorporated in Rev. 02 of ORAUT-TKBS-0044, and with potential impacts on previously derived dose estimates, included the following:

- New guidance in Section 4.1 of the Site Profile for the assignment of external dose for periods when monitoring records are incomplete or missing. The recommended approach for gaps in dosimetry records is to use dose data of "adjacent" time periods with available dose data.

- Additions to and revised isotopic ratios for non-uranium radionuclide intakes during the residual period as shown in Section 5.3 and Tables 5-1 and 5-3 of the Site Profile.

3.2 SC&A'S COMMENTS

SC&A reviewed each of the documents leading up to changes incorporated in Rev. 02 of the *Site Profile for Allied Chemical Corporation Plant* (ORAUT 2014). SC&A agrees with NIOSH regarding these changes and their impacts on ACCP worker doses that mandate the need for DCAS-PER-053 (DCAS 2015).

There are no findings pertaining to Subtask 1.

4.0 SUBTASK 2: ASSESS NIOSH'S SPECIFIC METHODS FOR CORRECTIVE ACTION

In the Publication Record of Rev. 02 of the ACCP Site Profile (ORAUT 2014), NIOSH acknowledged the following:

> *Revision initiated to add text in Section 5.0 and to incorporate changes to Table 5-2 based on* ***ORAUT-OTIB-0070, Revision 01*** [ORAUT 2012]. *Revised Sections 2.3, 2.4, 2.5, 2.7, 3.0, 3.2, 4.0, and 5.0, including Tables 5-1 and 5-3, as indicated pursuant to recommendations in* ***Report-SCA-TR-SP2011-0012-PA*** [SC&A 2011]. . . . [Emphasis added.]

In brief, critical changes that were incorporated in Rev. 02 of the ACCP Site Profile (ORAUT 2014) and the need for DCAS-PER-053 (DCAS 2015) principally reflect **changes** incorporated in Rev. 01 of ORAUT-OTIB-0070 (ORAUT 2012), and recommendations cited in SC&A's draft review of Rev. 01 of the ACCP Site Profile (SC&A 2011).

In instances where the PER involves technical issues that are supported by a document(s) that was previously subjected to a review by SC&A, Subtask 2 will simply provide a brief summary/conclusion of this review process.

4.1 AN OVERVIEW OF SC&A'S PREVIOUS REVIEW OF ORAUT-OTIB-0070

SC&A reviewed Rev. 00 of ORAUT-OTIB-0070 in August 2008 (SC&A 2008). It was SC&A's opinion that surrogate models/data and specific default values recommended in Rev. 00 of ORAUT-OTIB-0070 (ORAUT 2008) for the derivation of air concentrations were likely to underestimate inhalation doses. Surrogate models of concern included those identified in NUREG-1400 (Hickey et al. 1993) and in Attachment B of ORAUT-OTIB-0070 and **assumed default values** pertaining to the **source term depletion rate of 1% per day**, and to the **resuspension of residual contamination of 1×10^{-6} m^{-1}**.

Rev. 01 of ORAUT-OTIB-0070 (issued on March 5, 2012) deleted the NUREG-1400 source term approach and Attachment B, and revised the source term depletion rate from 0.01 d^{-1} to **0.0067 d^{-1}**. With the exception of the footnote in Table 5-1, the resuspension factor of 1×10^{-6} m^{-1}, however, remained unchanged.

In summary, a critical change in Rev. 02 of the ACCP Site Profile (ORAUT 2014) that prompted the need for DCAS-PER-053 (DCAS 2015) was the revision of the source term depletion rate from 0.01 d^{-1} to 0.0067 d^{-1}. For ACCP worker DR, the revised source term depletion rate has the potential to significantly increase internal and external doses during the residual period.

4.2 RECOMMENDATIONS CITED IN SC&A'S DRAFT REVIEW OF THE ACCP SITE PROFILE, REV. 01

In Section 4.0 of SC&A's draft review issued in September 2011 (SC&A 2011), a critical finding that impacted the reconstruction of worker external dose during the **operational period**

pertained to NIOSH's model for estimating neutron exposures from the alpha, neutron reaction of UF_4 and UF_6. SC&A questioned (1) NIOSH's assumed source term of a "500 pound drum," (2) NIOSH's use of ORAUT-OTIB-0024, Rev. 00 [*Estimation of Neutron Dose Rates from Alpha-Neutron Reactions in Uranium and Thorium Compounds* (ORAUT 2005)], and (3) NIOSH's inappropriate use of the **inverse square law** involving a 500-pound source term for deriving neutron dose rate at a 3-foot distance.

Section 5.1 of the SC&A draft review questioned NIOSH's failure to include Ra-228 and other non-uranium radionuclide contaminants in the reconstruction of internal dose during the residual period.

4.3 SC&A'S COMMENTS

In Rev. 02 of the ACCP Site Profile (ORAUT 2014), NIOSH acknowledged the revised source term depletion rate defined in ORAUT-OTIB-0070, Rev. 01 (ORAUT 2012) and SC&A's recommendations for modeling neutron dose during operational years and internal inhalation dose from non-uranium contaminants during the residual period.

There are no findings associated with Subtask 2.

5.0 SUBTASK 3: EVALUATE THE PER'S STATED APPROACH FOR IDENTIFYING THE NUMBER OF DRS REQUIRING RE-EVALUATION OF DOSE

5.1 NIOSH'S SELECTION CRITERIA

Section 3.0 of DCAS-PER-053 identified the following criteria employed by NIOSH to identify previously completed claims requiring re-evaluation using guidance cited in Rev. 02 of ORAUT-TKBS-0044 (ORAUT 2014) and mandated by DCAS-PER-053 (DCAS 2015):

- The database for completed DRs was queried for containing the word "allied" as in the document title of the Site Profile for **Allied** Chemical Corporation Plant. This search identified a total of **205** claims.
  - 58 claims were removed from this list because the claims yielded POC values ≥ 50%
  - 42 claims were removed from this list because the word "allied" was **not** associated with the ACCP facility.
  - 4 additional claims met the criteria for ACCP SEC status and were removed from further consideration
  - During this PER review process, 3 DRs had been completed using Rev. 02 of the ACCP Site Profile (ORAUT 2014)
  - Lastly, 2 claims were removed from further consideration, because one qualified for SEC status at another facility, and the other involved the claimant's long-term employment at another facility that is being evaluated under a different PER

5.2 SC&A'S COMMENTS

Selection criteria used by NIOSH for previously completed DRs that require re-evaluation under DCAS-PER-053 are valid. There are no findings associated with Subtask 3.

6.0 SUBTASK 4: CONDUCT AUDITS OF A SAMPLE SET OF RE-EVALUATED DRs MANDATED BY DCAS-PER-053

Previous sections of this report cited changes introduced in Rev. 02 of the ACCP Site Profile (ORAUT 2014), which impact/increase the assignment of dose during the operational period (e.g., NIOSH's neutron dose model), as well as the residual period (e.g., revision of the source term depletion factor; addition of non-uranium radioactive contaminants).

In order for SC&A to satisfy its commitment under Subtask 4, a single DR may be selected for review, provided the employment period at ACCP covers both the **operational** and **residual periods**. Alternatively, two DRs may be selected that represent the operational period and the residual period separately.

7.0 REFERENCES

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