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NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

ADVISORY BOARD ON RADIATION AND WORKER HEALTH

REVIEW OF NIOSH/ORAUT PROCEDURES AND METHODS USED FOR DOSE RECONSTRUCTION

A PRELIMINARY REVIEW OF NIOSH'S PROGRAM EVALUATION REPORT OCAS-PER-020, "BLOCKSON TBD REVISION"

Contract No. 200-2009-28555
SCA-TR-TASK3-0012, Rev. 0

Prepared by

Hans Behling, PhD
S. Cohen & Associates
1608 Spring Hill Road, Suite 400
Vienna, VA 22182

March 2009

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S. COHEN & ASSOCIATES: ***Technical Support for the Advisory Board on Radiation & Worker Health Review of NIOSH Dose Reconstruction Program***	Document No. SCA-TR-TASK3-0012 Effective Date: Draft — March 23, 2009 Revision No. 0 – (Draft)
Task 3: Review of NIOSH/ORAUT Procedures And Methods Used For Dose Reconstruction **A PRELIMINARY REVIEW OF NIOSH'S PROGRAM EVALUATION REPORT OCAS-PER-020, "BLOCKSON TBD REVISION"**	Page 2 of 25
Document Reviewer: _____ Date: _____ U. Hans Behling, PhD, MPH	Supersedes: N/A
Project Manager: _____ Date: _____ John Mauro, PhD, CHP	

Record of Revisions

Revision Number	Effective Date	Description of Revision
0 (Draft)	03/23/2009	Initial issue
	01/13/2010	Document cleared as written for potential Privacy Act-protected information. Disclaimer updated and "Record of Revisions" table added to page 2.

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EXECUTIVE SUMMARY

Under the existing Task 3 project, SC&A has been tasked by the Advisory Board on Radiation and Worker Health (Advisory Board) to conduct an audit of the Program Evaluation Report (PER) OCAS-PER-020, which was prompted by extensive revisions to OCAS-TKBS-0002, *Technical Basis Document for Atomic Energy Operations at Blockson Chemical Company, Joliet, Illinois*, Revision 0.

Because revisions to the Blockson technical basis document (TBD) impacted dose reconstruction methodology for nearly all exposure pathways, NIOSH elected to reassess all 91 Blockson Chemical Company claims, which had yielded probability of causation (POC) values less than 50% under previous dose reconstructions. SC&A concurs that the selection criteria used by NIOSH do, in fact, encompass the universe of potentially affected dose reconstructions.

As a result of the reassessment that was prompted by OCAS-PER-020, revised dose estimates for 32 claims yielded POC values ∃50% and were, therefore, compensable. For the remaining 59 claims, revised tissue doses increased significantly, but resulted in POC values that were, nevertheless, below 50%. SC&A believes that the PER is being implemented appropriately, given the changes to the TBD. However, given that there might be a need for additional changes to the TBD (in light of issues under active consideration by the Blockson work group),* it is possible that additional revisions to the PER for Blockson might be needed in the future.

As part of our audit, SC&A critically reviewed all revisions to the Blockson TBD for technical merit and/or claimant favorability. Of particular importance to claimant favorability are instances in which dose reconstruction could not be supported by claimant-specific or site-specific data, but required the use of default values, assumptions, or surrogate data.

Our review of OCAS-PER-020 and OCAS-TKBS-0002, Revision 01, identified the following three potential issues that were not adequately addressed in OCAS-PER-020:

(1) For Building 55 workers, exposure to uranium may have involved low solubility or Type S uranium compound(s).

(2) Equally, a lower solubility uranium material, if ingested, would imply the assumption of a lower f_1 value.

(3) Estimates of indoor radon concentrations employed surrogate data that are considered inappropriate and resulted in low exposure values.

As discussed in Section 4 of this report, these three unresolved issues have the potential for significantly affecting organ doses that include the 59 claims that presently remain below a POC value of 50% under OCAS-PER-020.

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* These issues include (1) solubility class Type S for U, (2) f_1 value of 0.002 for U, and (3) higher radon levels in Building 40.

Finally, it should also be mentioned that on November 11, 2007, NIOSH published Revision 02 of OCAS-TKBS-0002, which included (1) changes to footnotes in Table 4a and Table 12a that now require consideration of Type M and Type S thorium in Building 55, (2) correction of errors contained in Table 7 and the resulting graph in Figure 6, and (3) correction to the liver dose in Table 8.

1.0 STATEMENT OF PURPOSE

To support dose reconstruction, the National Institute for Occupational Safety and Health (NIOSH) and the Oak Ridge Associated Universities Team (ORAUT) have assembled a large body of guidance documents, workbooks, computer codes, and tools. In recognition of the fact that all of these supporting elements in dose reconstruction may be subject to revisions, provisions exist for evaluating the effect of such programmatic changes on the outcome of previously completed dose reconstructions. 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 dose reconstructions has been proceduralized in OCAS-PR-008, *Preparation of Program Evaluation Reports and Program Evaluation Plans,* Revision 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 dose reconstructions. A PER includes a qualitative and, in some cases, quantitative assessment of potential impacts. Most important in this assessment is the potential impacts on the probability of causation (POC) of previously completed dose reconstructions with POCs of <50%.

As needed, a PEP may be issued that serves as a formal notification of an impending PER. The PEP provides a preliminary description of the issue(s) that will be addressed in the PER, and summarizes the likely scope of the effort required to complete the PER.

Under the existing project, SC&A has been tasked by the Advisory Board to conduct an audit of OCAS-PER-020, *Blockson TBD Revision*. In conducting the PER review, SC&A is committed to perform five subtasks, each of which is discussed in this report.

2.0 SUBTASK 1: IDENTIFY THE CIRCUMSTANCES THAT NECESSITATED THE NEED FOR OCAS-PER-020

On September 11, 2006, NIOSH issued a technical basis document (TBD) entitled, *Technical Basis Document for Atomic Energy Operations at Blockson Chemical Company, Joliet, Illinois*, OCAS-TKBS-0002, Revision No. 0.

Following initial reviews of this TBD, NIOSH informed the Advisory Board on January 8, 2007, that NIOSH OCAS was withdrawing OCAS-TKBS-0002 for further evaluation and revision. A series of draft revisions identified as Revision 01-A, Revision 01-B, and Revision 01-C were issued on March 30, 2007; April 11, 2007; and June 14, 2007; respectively. These draft revisions addressed internal as well as external review comments, and resulted in expanded site descriptions, new radiological data, and the addition of several radionuclides.

On June 20, 2007, NIOSH issued Revision 01 of OCAS-TKBS-0002, which formalized the acknowledged draft revisions and concluded that said changes ". . . revised internal and external dose modeling . . . [that] result in an increase of dose, and a PER is required."

On July 31, 2007, NIOSH issued OCAS-PER-020. Because PER-020 consists of three very brief sections (contained on a single page), it is introduced in this report as Exhibit 1.

EXHIBIT #1 – OCAS-PER-020

Office of Compensation Analysis and Support **Program Evaluation Report**	Document Number: OCAS-PER-020 Effective Date: 7/31/2007 Revision No. 0
Blockson TBD Revision	Page 1 of 1

Author: Signature on file Date: 7/31/2007 Supersedes: None
Dave Allen, HP Team Leader

Approval: Signature on file Date: 7/31/2007
J.W. Neton, Associate Director for Science

RECORD OF ISSUE/REVISIONS

ISSUE AUTHORIZATION DATE	EFFECTIVE DATE	REV. NO.	DESCRIPTION
7/31/2007	7/31/2007	0	New document to determine which previously completed claims require evaluation for the effect of revising the Blockson TBD.

1.0 Description

The Blockson Chemical Company Technical Basis Document (OCAS-TKBS-0002) was revised on 6/20/2007. A previous revision was issued on 7/31/2006. Prior to that, two Oak Ridge Associated University versions of this TBD were used (ORAU-TKBS-0002).

2.0 Issue Evaluation

The revisions to the Blockson TBD revised the Dose Reconstruction methodology for several exposure pathways. Some of the changes to methodology will increase radiation dose estimates. Due to the nature of some of the changes, the magnitude of the effect on individual dose estimates will vary from claim to claim. It is therefore, not possible to determine the effect on the Probability of Causation without a new dose estimate.

3.0 Plan for Resolution or Corrective Action

It is not possible to determine the magnitude of the change to dose without a new dose estimate. Since (as of issuance of this PER) no Blockson Chemical Company claims have yet been completed with the newest revision to the TBD, NIOSH is requesting that all Blockson Chemical Company claims with a Probability of Causation less than 50% be returned for a new estimate. A list of the entire population of the ninety-one potentially affected claims is attached. A new dose reconstruction will be completed for each of the claims using the latest revision to the Blockson TBD.

3.0 SUBTASK 2: ASSESS NIOSH'S EVALUATION/CHARACTERIZATION OF THE ISSUES AND THEIR POTENTIAL IMPACTS ON DOSE RECONSTRUCTION

Under Subtask 2, SC&A is to ensure that PER issue(s) is/are fully addressed and characterized in the PER.

Section 2.0 of PER-020 (see Exhibit #1) briefly states that revisions incorporated in Revision 01 of OCAS-TKBS-0002 will impact several exposure pathways and are likely to increase radiation dose estimates, and that the magnitude of revised dose estimates will vary among the types of cancers that represent individual claimants. Correspondingly, NIOSH concluded that ". . . It is, therefore, not possible to determine the effect on the Probability of Causation (POC) without a new dose reconstruction."

Due to the fact that OCAS-PER-020 does **not** identify or characterize specific revisions to OCAS-TKBS-0002 that are likely to affect dose estimates and POC values, a brief summary of revisions **salient** to OCAS-PER-020 is presented below.

3.1 SITE DESCRIPTION AND OPERATIONAL HISTORY

Critically new information added to Blockson's site description and operational history includes non-uranium work activities inclusive of those in Building 40. This facility received calcined phosphate feed, which was oxidized with chlorine and digested with sulfuric acid. This produced phosphogypsum in Building 40 and phosphoric acid, which was transferred as feed material to Building 55, where uranium was extracted under contract to the Atomic Energy Commission (AEC).

While certain radionuclides originally contained in calcined phosphate rock are predominantly retained in the phosphoric acid along with uranium, select other radionuclides do not report to the acid feed, but are retained in the phosphogypsum produced in Building 40. Key among the radionuclides with potential radiological impacts to workers in Building 40 are polonium, radium, and radon (and associated progeny).

3.2 INCLUSION OF NON-URANIUM ACTIVITIES IN DOSE RECONSTRUCTION

For non-uranium activities (that include workers assigned to Building 40), NIOSH selected the calciner on the assumption that this facility/operation was likely to have subjected non-uranium workers to bounding intakes of radioactivity. The calciner was a large **outdoor** furnace used to heat phosphate rock in order to degrade organics in preparation of acid digestion in Building 40.

Inhalation intakes for non-uranium workers are based on surrogate-facility air sampling data, which identified a peak dust loading of 50.4 mg/m^3 in the vicinity of a phosphate rock calciner. Applying a 0.014% uranium content in phosphate rock, NIOSH derived daily inhalation and ingestion activity values for 12 radionuclides, as given in Table 1 below, along with their recommended solubility classes.

Table 1. Inhalation and Ingestion Intakes for Calcining

Radionuclides	**Inhalation** (pCi/day)	**Ingestion** (pCi/day)
U-238[1]; Th-230[1]; U-234[1,] Ra-226[2]; Pb-210[3]	16	0.47
Po-210[4]	160	4.7
Th-231[1]; Pa-231[1]; Ac-227[1]	0.73	0.021
Th-232[1]; Ra-228[2]; Th-228[1]	0.52	0.016

[1] Solubility Class 1 = Type M or S (based on claimant favorability)
[2] Solubility Class 2 = Type M
[3] Solubility Class 2 = Type F
[4] Solubility Class 2 = Type F or M (based on claimant favorability)

3.3 REVISED INTAKES FOR URANIUM EXTRACTION IN BUILDING 55

Internal exposure to workers in Building 55 from either inhalation or ingestion in OCAS-TKBS-0002, Revision 0, Revision 01, and Revision 02, are all based on the results of 122 urinalyses representing "20" workers. The analyses for uranium was performed by fluorometry and defined in units of μg/liter.

In order to derive daily **inhalation** quantities from urine data, NIOSH assumed the solubility class Type M for uranium, which at the 95th percentile level yielded (1) an inhalation intake of 82 pCi/day total uranium (or 41 pCi/day for U-238 and 41 pCi/day for U-234) for production workers; and (2) 26 pCi/day total uranium (or 13 pCi/day U-238 and 13 pCi/day U-234) for administrative personnel.

Alternatively, NIOSH converted urine data to a daily **ingestion** exposure by means of a f_1 value of 0.02, which yielded ingestion intakes of 278 pCi/day total uranium for production workers and 82 pCi/day for administrative workers.

Changes incorporated in Revision 01 and Revision 02 to OCAS-TKBS-0002 that are relevant to PER-020 include the addition of the following radionuclides; Th-230, Pb-210, Po-210, Th-231, Pa-231, Ac-227, Ra-226, and Ra-228.

For ease of comparison, original intakes derived for inhalation and ingestion as cited in Revision 0 are reproduced below in Table 2 and Table 3. These should be compared to the revised values shown in Table 4 and Table 5.

OCAS-TKBS-0002 Rev. 0 Intakes

Table 2. Inhalation Rate for Operations Cited in OCAS-TKBS-0002 Revision 0

Worker Category	Intake Rate for Type M Material	Distribution
Administrative	25 pCi/day total U	Constant value
Administrative	0.35 pCi/day Th-2282	Constant value
Administrative	0.35 pCi/day Th-2322	Constant value
Production workers	82 pCi/day M total U	Constant value
Production workers	1.1 pCi/day Th-2282	Constant value
Production workers	1.1 pCi/day M Th-2322	Constant value

1. Intake rates are normalized to units of calendar days. The intake period for operations is March 1, 1951, through March 31, 1962.
2. Thorium intake rates are derived from ratios in ORAUT-OTIB-0043. Solubility types for thorium are based on recommendation in ICRP Report 68.

Table 3. Ingestion Rate for Operations Cited in OCAS-TKBS-0002 Revision 0

Worker Category	Intake Rate Type M Material	Distribution
Administrative	83 pCi/day total U	Constant value
Administrative	1.2 pCi/day Th-2282	Constant value
Administrative	1.2 pCi/day Th-2322	Constant value
Production workers	270 pCi/day total U	Constant value
Production workers	3.6 pCi/day Th-2282	Constant value
Production workers	3.6 pCi/day Th-2322	Constant value

1. Intake rates are normalized to units of calendar days. The intake period for operations in March 1, 1951, through March 31, 1962.
2. Thorium intake rates are derived from ratios in ORAUT-OTIB-0043.
3. Ingestion intakes provide bounding dose to the stomach intestine, upper large intestine, lower large intestine, and colon. The f_1 values are 0.02 for uranium ingestions and 0.0005 for thorium ingestions.

Revised Intakes Cited in Rev. 02 of OCAS-TKBS-0002

Table 4. Inhalation Rate for Building 55[1,2,3]

Radionuclides	Intake (pCi/d) Production Workers	Intake (pCi/d) Administrative Workers
U-238, Th-230, U-234, Pb-210, Po-210	41	13
Th-231, Pa-231, Ac-227[4]	1.9	0.59
Ra-226	1.9	0.59
Th-232, Ra-228, Th-228	1.4	0.41

1. Intake rates have been normalized to calendar days.
2. Intakes are based on Type M lung solubility for materials likely to have been present in Building 55 operations except for thorium, lead, and polonium. Pb-210 is Type F, and Po-210 is Types F or M per ICRP 1994. Thorium could have been Type M or Type S. Thorium and polonium solubility types must be selected based on the types that provide the largest dose to the organ or tissue of concern.
3. See Table 3b of OCAS-TKBS-0002, Rev. 02, for dose to tissues of the gastrointestinal tract.
4. U-235 is allowed for in the U-238 and U-234 values. Values given are for radionuclides in the U-235 chain.

Table 5. Ingestion Rate for Building 55[1,2]

Radionuclide	f1 Values[4]	Intake (pCi/d) Production Workers	Intake (pCi/d) Administrative Workers
U-238, U-234, Th-230 Pb-210 Po-210	0.02 0.0005 0.2 0.1	139	41
Th-231, Pa-231, Ac-227[3]	0.0005	6.4	1.9
Ra-226	0.2	6.4	1.9
Th-232, Th-228 Ra-228	0.0004 0.2	4.5	1.4

1. Intake rates are normalized to units of calendar days.
2. Ingestion intakes provide bounding dose to the stomach, small intestine, upper large intestine, lower large intestine, and colon. See Table 3a [of OCAS-TKBS-0002, Rev. 02] for estimating dose to all other tissues.
3. U-235 is allowed for in the U-238 and U-234 values. Values given are for radionuclides in the U-235 chain.
4. f_1 values are from ICRP 68.

3.4 REVISION TO RADON EXPOSURE ESTIMATES

In the absence of Blockson-specific radon measurements, NIOSH employed surrogate values described in ORAUT-OTIB-0043, Revision 00, *Characterization of Occupational Exposure to Radium and Radon Progeny During Recovery of Uranium from Phosphate Material.*

Initial radon dose estimates defined in Revision 0 of OCAS-TKBS-0002 were based on a **geometric mean** radon air concentration value of 0.751 pCi/l having a geometric standard deviation (GSD) of 2.0 and an assumed equilibrium fraction of 0.4. These values translated into annual exposures as reproduced in Table 6.

Table 6. Radon Exposures Cited in OCAS-TKBS-0002 Revision 00

Dose Component	Annual Dose/Exposure[1]	Distribution
Radon progeny	0.036 WLM (lungs only)	Lognormal, GSD=2.0
Radon progeny	75 rem alpha (ET1 only)[2]	Lognormal, GSD=2.0
Radon progeny	0.30 rem alpha (ET2 only)[2]	Lognormal, GSD=2.0
Radon gas	0.002 rem alpha (non-respiratory tract tissues only)	Constant value

1. Exposure and dose values from ORAUT-OTIB-0043.
2. ET1 and ET2 dose conversion factors from OCAS-TIB-0011.

In Revision 01 of OCAS-TKBS-0002 radon dose estimates were based on the identical dataset described in ORAUT-OTIB-0043. However, the geometric mean of 0.751 pCi/l and GSD of 2.0 were replaced with the constant 95th percentile radon air concentration of 2.33 pCi/l and corresponding annual doses reproduced in Table 7.

Table 7. Radon Exposures Cited in OCAS-TKBS-0002 Revision 01

Dose Component	Annual Dose/Exposure[1]	Distribution
Radon progeny	0.112 WLM (lungs only)	Constant value
Radon progeny	ET1 and ET2 tissues[2]	Constant value
Radon gas	0.002 rem alpha (non-respiratory tract tissues only)	Constant value

1. Exposure and dose values from ORAUT-OTIB-0043. Values are normalized for a 365 day year.
2. ET1 and ET2 doses are to be applied as alpha dose and calculated from WLW values using conversion factors in OCAS-TIB-0011.

3.5 CHANGES ASSOCIATED WITH EXTERNAL EXPOSURE

Penetrating Radiation. Revisions to **external** penetrating exposures reflect the addition of numerous radionuclides contained in yellowcake inclusive of Th-232 and its progeny. As a result of the expanded list of contributing radionuclides, dose rates at 30 cm from a drum of yellowcake **increased** by a factor of about 6.6.

To determine annual doses, the median external dose was based on an exposure period of 400 hours per year at a 1-foot distance from a drum with a GSD of 2.7; for a 95th percentile value, the exposure duration was assumed at 2,000 hours per year.

Beta Dose. The expanded list of radionuclides that were assumed to exist in yellowcake also increased estimates of beta doses to the skin. The original median beta dose to skin of 0.8 rem per year with a GSD of 2.7 increased to 1.2 rem per year with a GSD of 2.7. Furthermore, Revision 01 of OCAS-TKBS-0002 also added a beta skin dose of 1.5 rem per year from **contaminated clothing**, and an annual dose of 30 rem to hands and forearms from contact with yellowcake.

3.6 REVISIONS TO DOSES FROM RESIDUAL CONTAMINATION

A modest change to external exposures from residual facility contamination resulted from shift in fractional contribution of photon energy. In Revision 00 of OCAS-TKBS-0002, the photon dose was divided equally between 30–250 keV and the >250 keV energy ranges; in Revision 01, the photon dose is split 10% for 30–250 keV and 90% for >250 keV.

Internal Dose. The revised increase in the number of radionuclides assumed present in yellowcake during the years of uranium extraction (see Section 3.5 above) also raised estimates of inhalation and ingestion intake rates post-1962 from residual contamination.

The assigned solubility classes of inhaled or ingested radionuclides from **residual contamination** were identical to those assigned during the uranium extraction period. Except for Th, Pb, and Po, all other intakes are assumed Type M.

Radon Exposures. Revision 0 of OCAS-TKBS-0002 did not address potential exposure to radon in Building 55 after the cessation of uranium extraction in 1962. In Revision 01, radon exposure from declining residual contamination is assumed to have occurred. Starting with the pre-1962 operational annual exposure of 0.112 WLM, NIOSH assumed a decline in radon that paralleled the decline in residual surface contamination.

4.0 SUBTASK 3: ASSESS NIOSH'S SPECIFIC METHODS FOR CORRECTIVE ACTION

In instances where the PER involves a technical issue, SC&A will review the scientific basis and/or sources of information to ensure the credibility of the corrective action and its consistency with current/consensus science.

4.1 GENERAL COMMENTS

SC&A examined all relevant changes introduced in OCAS-TKBS-0002, Revision 01 (and Revision 02) that gave rise to OCAS-PER-020 and concludes the following:

(1) All changes introduced in revisions to OCAS-TKBS-0002 had the effect of either adding radiation exposure that had not been previously considered in Rev. 0 of OCAS-TKBS-0002 or, by varying degree, increased previous internal and external dose estimates.

(2) With potentially three exceptions, all revisions were either based on credible science or employed reasonable, plausible assumptions that were claimant favorable.

Of potential concern regarding the adequacy of OCAS-PER-020, therefore, are three issues with significant potential impacts on worker dose reconstruction. Important to note here is the fact that these issues have already been raised by SC&A at previous Blockson Work Group meetings/discussions. A brief overview of the issues is presented below, with the intent to stimulate further discussion and resolution.

4.2 ISSUE #1: NIOSH'S ASSIGNED SOLUBILITY CLASS TYPE M FOR URANIUM AND ITS USE FOR CONVERTING URINE EXCRETION DATA TO INHALATION QUANTITIES FOR BUILDING 55 MAY BE INAPPROPRIATE

In Section 3.2.2 of OCAS-TKBS-0002, Revision 01, NIOSH states the following:

> *. . . Various studies have shown that U_3O_8 closely corresponds to the clearance rate associated with material **Type M**. Some studies have also shown that high fired material can produce uranium compounds that clear more slowly from the lungs, i.e., indicative of material Type S (Rucker, et al. 2001). Type M uranium is the most appropriate lung solubility material type based on the process used for uranium extraction at Blockson. The U_3O_8 product was produced from wet phosphoric acid by filtering the precipitated uranium and then using a dryer to dewater the solids (Blockson 1953a). . . . Based on these processes and the results of various studies that have been summarized by Rucker, et al., Type M material is used to derive intakes from bioassay results.*
>
> *. . . Individual worker intakes were determined using IMBA-Expert™ by assuming a chronic inhalation intake of Type M uranium with parameters recommended by the **ICRP** **[ICRP 1994]**.* [Emphasis added.]

OCAS-TKBS-0002 provides the following information regarding the Blockson urine bioassay data and their interpretation:

(1) One hundred twenty-two (122) urine sample results are available, for which total uranium levels were defined fluorometrically.

(2) Urine sample data represent a total of 20 Blockson workers.

(3) Results ranged from 0 to **17 µg** uranium per liter urine.

(4) Bioassay data reported for uranium in µg/l were converted to daily excretion defined in pCi/day by multiplying values by 1.4 liter/day and 0.677 pCi/µg of uranium.

(5) Individual worker intakes were determined using IMBA Expert^{TM} by assuming a chronic inhalation intake of Type M uranium.

(6) For daily intake rate calculation purposes, intakes were assumed to have occurred beginning in the year sampled and ending with the last sample date.

Regarding NIOSH's basis for assigning solubility class Type M for uranium, SC&A reviewed the cited reference (Rucker et al. 2001) and came to a different conclusion. Rucker et al. (2001) did, in fact, cite a 2000 DOE Standard (*Guide of Good Practices for Occupational Radiological Protection in Uranium Facilities*), which had classified U_3O_8 as Class W. However, the 2000 DOE Standard was replaced by a 2004 DOE Standard with the same title (DOE 2004). In Table 2-11 of DOE 2004, U_3O_8 is classified of "Y." Under the new ICRP classification system, solubility class "Y" is now designated as absorption Type S. It must further be noted that ICRP Publication 68 (ICRP 1994) recommends solubility class Type S for UO_2 and U_3O_8, as shown in Exhibit #2.

On the basis of these recommendations and the absence of empirical site-specific solubility studies, there is no technical justification for NIOSH to unequivocally assign a solubility class M for Blockson. It is SC&A's opinion that for dose reconstruction, either Type M or Type S should be assumed, depending on which type results in a more claimant-favorable dose assessment. Lastly, support for Type S solubility class is provided in a 1984 study that was acknowledged by NIOSH but dismissed, as explained below.

EXHIBIT #2: ICRP's Default f1 Value: U – Zr

Table A.38-7. ICRP-recommended "default" values of f_1 (**U - Zr**).

Element	Route of Intake - Type of Material	Default Value of f_1	ICRP Publ. #[(a)]	Comments
U - Uranium	Inhalation - F	0.02	71	-
	- M	0.02	71	Recommended default in the absence of specific information.
	- S	0.002	71	-
	- F	0.02	68	Most hexavalent compounds [UF_6, UO_2F_2 and $UO_2(NO_3)_2$].
	- M	0.02	68	Less soluble compounds (UO_3, UF_4, UCl_4) and most other hexavalent compounds.
	- S	0.002	68	Highly insoluble compounds (UO_2 and U_3O_8).
	Ingestion	0.02	68	Unspecified compounds.
	Ingestion	0.002	68	Most tetravalent compounds (UO_2, U_3O_8, UF_4).
Y – Yttrium	Inhalation - M	0.0001	30(2), 68	Unspecified compounds.
	- S	0.0001	30(2), 68	Oxides and hydroxides.
	Ingestion	0.0001	68	All compounds.
Zn – Zinc	Inhalation - F	0.5	71	-
	- M	0.1	71	Recommended default in the absence of specific information.
	- S	0.01	71	-
	- S	0.5	68	All compounds.
	Ingestion	0.5	68	All compounds.
Zr - Zirconium	Inhalation - F	0.002	71	-
	- M	0.002	71	Recommended default in the absence of specific information.
	- S	0.002	71	-
	- F	0.002	68	Unspecified compounds.
	- M	0.002	68	Oxides, hydroxides, halides and nitrates.
	- S	0.002	68	Zirconium carbide.
	Ingestion	0.002	68	All compounds.

[(a)] **Key to ICRP Publications:**
Publ. #30(2) - ICRP Publication 30: Part 2. (ICRP 1980).
Publ. #68 – ICRP Publication 68 (ICRP 1994).
Publ. #71 – ICRP Publication 71 (ICRP 1995).

Summary of the 1984 Eidson and Damon Study. As part of a potential alternative method for estimating inhalation intakes at Building 55, NIOSH had reviewed air sampling data reported in a 1984 study by Eidson and Damon. This study cited uranium air concentrations in behalf of yellowcake **packaging operations** at **four** uranium processing mills, which employed the following six steps common to those at Blockson:

(1) No Activity* – This includes time when no other activity is occurring or has occurred for at least two hours prior. Generally, the mill was shut down for maintenance or all available dried yellowcake was packaged during a previous shift. Workers are generally not present in the packaging area during this time.

(2) Barrel loading – This occurs when a barrel is placed under a hopper containing the dried yellowcake. The yellowcake is allowed to fall into the barrel. The amount of time workers spend in this area depends on the volume of the yellowcake in the hopper.

(3) Barrel uncovering – This step occurs when a filled barrel is removed from beneath the hopper. In some cases, the barrel may be vibrated to compact the yellow cake before removing the barrel from beneath the hopper. (It is not known if the barrels at Blockson were vibrated.)

(4) Powder sampling – This occurs when a worker takes a sample of yellowcake for laboratory analysis. At Blockson, this was done prior to the pans of yellowcake being dumped into the barrels.

(5) Lid sealing – This occurs when a worker places a lid on the barrel and seals it.

(6) Other activities – This step includes maintenance and cleaning of the area with water hoses.

Airborne concentrations reported by Eidson and Damon (1984) in behalf of the six packaging steps are summarized in Table 8 as median, maximum, and minimum values. On the basis of these empirical measurements, the authors concluded that the **median** aerosol concentrations in the packaging areas ranged from 27 pCi/m^3 to 230 pCi/m^3 uranium.

Table 8. Airborne Uranium Concentrations During Packaging Operations of Yellowcake
(Source: Data from Table 1 of Eidson and Damon 1984)

Packaging Step	Uranium Concentration (pCi/m^3)		
	Medium	Maximum	Minimum
No Activity	27	34	18
Drum Loading	115	948	14
Powder Sampling	55	68	12
Lid Sealing	230	433	74
Small Spill	1,963	2,031	1,286

* Note: The definition of "No activity" given above was taken verbatim from Eidson and Damon (1984).

Using the lowest median air concentrations of 27 pCi/m^3 defined for the "No activity" measurement, a daily inhalation intake of 259 pCi/day U is estimated (i.e., 27 pCi/m^3 × 1.2 m^3/hr × 8 hr/d = 259 pCi/d). This minimum value is more than three times the 95th percentile value of 82 pCi/d derived by NIOSH from urine data that **assumes** the solubility class Type M.

NIOSH dismissed this discrepancy with the following explanation (see Section 3.2.2 of OCAS-TKBS-0002, Rev. 01):

> *Comparison of the above uranium mill results* [i.e., study data reported by Eidson and Damon 1984] *to Blockson operations cannot readily be made due to differences in operations and in quantities produced. . . . The mills processed uranium bearing ores that contained larger relative uranium concentrations, and in typically larger quantities.*

SC&A questions the merit of this explanation for the following reasons: (1) the specific activity level of yellowcake must be assumed as constant regardless of the starting levels of uranium in the ore from which it was derived; (2) minimum and median values reported by Eidson and Damon (1984) must reasonably be assumed to have involved packaging activities involving a single drum at-a-time; and (3) whenever site-specific data are unavailable, NIOSH routinely makes use of surrogate data such as these.

In order to illustrate the potential impact on converting urine data to inhalation intake by erroneously assuming a solubility class Type M for uranium (if, in fact, the true solubility had been Type S), the following IMBA calculations were performed for a 24-hour termination urine sample containing 10 μg of total uranium after a 1-year and a 5-year chronic exposure period.

	Derived Inhalation (pCi/day)		
Exposure Duration	Type S	Type M	Ratio Type S/Type M
1 year	664	109	6.1
5 year	546	84	6.5

Our sample calculation suggests that, if the solubility class Type S had been applied by NIOSH to convert Blockson urine data, a daily inhalation quantity of about 600 pCi would have been estimated. Such a value would be entirely consistent with the empirical air monitoring data reported by Eidson and Damon (1984), as summarized in Table 8.

4.3 ISSUE #2: NIOSH'S ASSIGNED f_1 VALUE OF 0.02 FOR URANIUM AND ITS USE FOR CONVERTING URINE EXCRETION DATA TO INHALATION/INGESTION QUANTITIES MAY BE INAPPROPRIATE

Section 3.2.2 of OCAS-TKBS-0002, Revision 01, allows for an alternative use/interpretation of Blockson urine bioassay data, as given in the following statements:

> *Workers also had the potential to ingest uranium from contact with contaminated surfaces or from eating or drinking in the area* [i.e., Building 55]. *When deriving intakes from the bioassay results, a chronic ingestion of uranium results in a*

> *higher dose to certain tissues of the gastrointestinal tract when compared to the dose from the inhalation intakes described above. Therefore, intakes are presented in Table 4b based on the presumption that* ***all the uranium in the workers urine was due to ingestion****. . . . Since bioassay results are from intakes by all pathways a worker should be assigned Building 55 intakes from inhalation or ingestion, not both.* [Emphasis added.]

Inspection of Table 4b in OCAS-TKBS-0002, Revisoin 01, identifies the assumed f_1 value of 0.02 for uranium. As noted in Exhibit #2 above, ICRP Publication 68 recommends a 10-fold lower default f_1 value of 0.002 for most tetravalent uranium compounds that include UO_2, U_3O_8, and UF_4.

Use of the lower ICRP f_1 value for converting bioassay data to ingestion quantities would have the obvious effect of raising ingestion quantities, which in turn would differentially raise doses to select tissues during transit through the GI tract.

4.4 ISSUE #3: THE ASSIGNED RADON EXPOSURE VALUE OF 0.112 WLM/YEAR AS A BOUNDING VALUE FOR BLOCKSON MAY BE INAPPROPRIATE

Currently, NIOSH's bounding radon estimate of 0.112 WLM per year for Blockson workers was based on 1998 data reported by the Florida Institute of Phosphate Research (FIPR 1998), as summarized in ORAUT-OTIB-0043. Data extracted from this study and deemed applicable to Blockson by NIOSH yielded a radon air concentration of 2.33 pCi/l at the 95th percentile. Applying the fractional progeny equilibrium value of 0.4, the annual bounding exposure of 0.112 WLM was derived by means of the following equation:

$$Radon\ Exposure = \left(2.33\ pCi/l\right)\left(\frac{0.01WL}{pCi/l}\right)(0.4)\left(12\ work-mo/yr\right)$$
$$= 0.112\ \text{WLM/yr}$$

SC&A has previously questioned the value of 0.112 WLM per year as a bounding value, as well as the applicability of FIPR (1998) data as the basis for this value. Using first principles, SC&A developed a model for Blockson radon exposures that was described in the report, "Evaluation of Radon Levels in Building 40 at Blockson Chemical" that was submitted for evaluation to NIOSH and the Blockson Work Group on July 29, 2008, and posted on the OCAS website on August 12, 2008.

SC&A's model yielded exposures that were substantially higher (i.e., 62 pCi/l) than NIOSH's bounding value of 2.33 pCi/l of radon air concentration and the corresponding 0.112 WLM/yr exposure. During the October 15, 2008, Blockson Work Group meeting, SC&A was asked to address issues raised by NIOSH and its consultant, Dr. Naomi Harley, and to reassess select parameters used in our model. Key model parameters of concern included the range of radon evolution fractions and building ventilation rates.

In response to the Work Group's directive, SC&A issued a supplemental report on December 8, 2008, entitled "Revised Calculation of Rn^{222} Concentrations in Building 40." SC&A's revised

calculation yielded radon air concentrations in Building 40 of 5.97 pCi/l and 36.30 pCi/l at the 50th and 95th percentile levels, respectively.

However, NIOSH opined that a more realistic range of radon evolution fractions from the digestion of ore in hot sulfuric acid and a lower building air exchange rate would yield radon levels of 3.65 pCi/l and 12.92 pCi/l at the 50th and 95th percentile values. Figure 1 depicts the two datasets and their differences, which at the time of this review, however, have not been formally resolved.

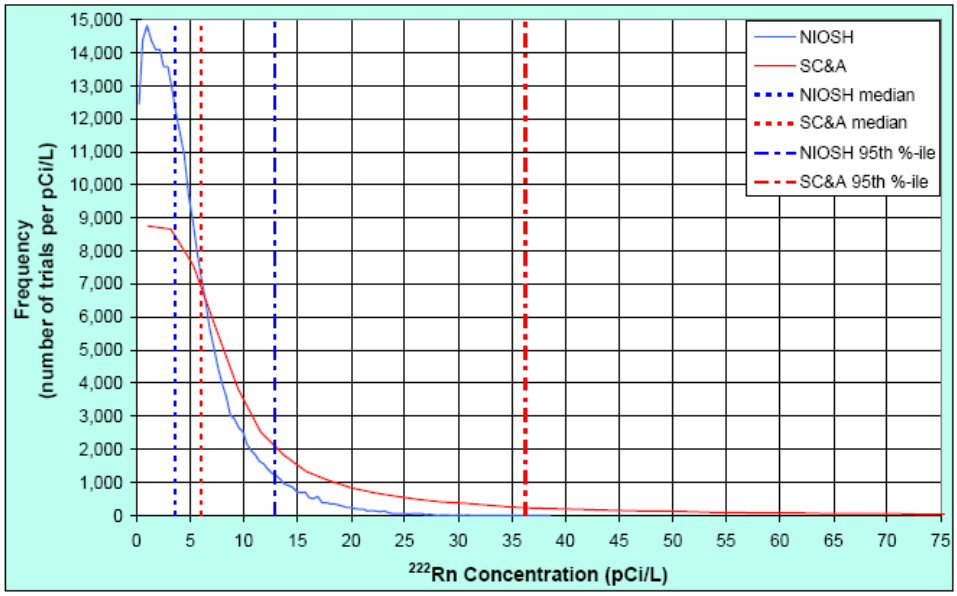

Figure 1. Comparison of ^{222}Rn Concentrations Using SC&A and NIOSH Parameters

5.0 SUBTASK 4: EVALUATE THE PER'S STATED APPROACH FOR IDENTIFYING THE UNIVERSE OF POTENTIALLY AFFECTED DOSE RECONSTRUCTIONS; AND ASSESS THE CRITERIA BY WHICH A SUBSET OF POTENTIALLY AFFECTED DOSE RECONSTRUCTIONS WAS SELECTED FOR RE-EVALUATION

In Section 3.0 of OCAS-PER-020 entitled, "Plan for Resolution or Corrective Action," NIOSH provides the following explanation and plan for corrective action:

> *It is not possible to determine the magnitude of the change to dose without a new dose estimate. Since (as of issuance of this PER) no Blockson Chemical Company claims have yet been completed with the newest revision to the TBD, NIOSH is requesting that* ***all Blockson Chemical Company claims with a Probability of Casusation less than 50% be returned for a new estimate****. . . . A new dose reconstruction will be completed for each of the claims using the latest revision to the Blockson TBD.* [Emphasis added.]

NIOSH identified a total of 91 claims for which a dose reconstruction was performed prior to the revision of OCAS-TKBS-0002 and for which the calculated POC was less than 50%. SC&A concurs that the selection criteria used by NIOSH do, in fact, encompass the universe of potentially affected dose reconstructions and, therefore, obviate the need for further analysis.

6.0 SUBTASK 5: CONDUCT AUDITS OF DOSE RECONSTRUCTIONS AFFECTED BY OCAS-PER-020

The selection and number of dose reconstructions to be audited by SC&A will be made by the Advisory Board. At this time, NIOSH has informed SC&A that all 91 claims that were identified as potentially affected by OCAS-PER-020 have been reassessed. Of the 91 claims reassessed, dose reconstructions that were based on new guidance contained in Revision 01 of OCAS-TKBS-0002 resulted in 32 claims for which the new POCs were ∃50% and were, therefore, compensable. For the remaining 59 claims, revised tissue doses increased significantly, but resulted in POC values that were, nevertheless, below 50%.

Thus, the universe of dose reconstructions from which the Advisory Board may select a subset for audit under Subtask 5 is currently defined by these 59 Blockson claims. However, given the three unresolved issues raised under Subtask 3 in this review [i.e., (1) solubility class Type S for U, (2) f_1 value of 0.002 for U, and (3) higher radon levels in Building 40], the Board may wish to delay a dose reconstruction audit under OCAS-PER-020 until these issues are resolved.

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