Draft

ADVISORY BOARD ON

RADIATION AND WORKER HEALTH

National Institute for Occupational Safety and Health

Assessment of the Disposition of SC&A's Linde Site Profile Review Issues in Response to SEC Petitioner Concerns

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ABBREVIATIONS AND ACRONYMS

ABRWH	Advisory Board on Radiation and Worker Health
AEC	Atomic Energy Commission
AWE	Atomic Weapons Employer
BNI	Bechtel National, Inc.
CDC	Centers for Disease Control and Prevention
CFR	Code of Federal Regulations
Ci	Curie: unit of activity
DOE	Department of Energy
DOL	Department of Labor
dpm	Disintegrations per Minute
EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
GM	Geometric Mean
GSD	Geometric Standard Deviation
HASL	Health and Safety Laboratories
HHS	U.S. Department of Health and Human Services
ICRP	International Commission on Radiological Protection
IMBA	Integrated Modules for Bioassay Analysis
INEL	Idaho National Engineering Laboratory
INL	Idaho National Laboratory (formerly, INEL, etc.)
IREP	Interactive RadioEpidemiological Program
L	Liter
LAPC	Linde Air Products Company
LOD	Limit of Detection
MAC	Maximum Allowable Concentration
MED	Manhattan Engineering District
mg	Milligram
mR	milli-Roentgen
µR	micro-Roentgen
m^3	cubic meters

NIOSH	National Institute for Occupational Safety and Health
NYOO	(AEC) New York Operations Office
OGC	(CDC) Office of the General Counsel
OCAS	(NIOSH) Office of Compensation Analysis and Support
ORAU	Oak Ridge Associated Universities
ORAUT	Oak Ridge Associated Universities Team
PAS	Personal Air Sampling
pCi	pico-curies
R	Roentgen
rem	Roentgen Equivalent Man
SRS	Savannah River Site
SC&A	Sanford Cohen & Associates
SEC	Special Exposure Cohort
TIB	Technical Information Bulletin
TBD	Technical Basis Document
WG	(ABRWH) Work Group

1.0 INTRODUCTION

This report is intended to provide information to help inform the deliberations of the Advisory Board on Radiation and Worker Health (the Board or ABRWH) Linde Work Group (WG) related to (1) the disposition of issues raised by SC&A about NIOSH's Linde Site Profile, and (2) certain concerns expressed by a petitioners' representative for Special Exposure Cohort (SEC) status. NIOSH issued its initial, Rev. 0, Linde Site Profile (NIOSH 2005a) in May 2005, and SC&A reviewed it in July 2006 (SC&A 2006a). The SC&A review identified 22 issues (some labeled "findings" and some "observations") that were subsequently discussed and addressed in meetings and technical papers until all issues were declared closed by the WG in June 2008, nearly 2 years later; but, has NIOSH incorporated all its issue resolution commitments into its latest Linde Site Profile (NIOSH 2008a)?

In the course of this study, SC&A examined the latest Linde Site Profile, Rev. 1 (NIOSH 2008a), to see if NIOSH met its issue resolution commitments, but did not perform an in-depth review ("audit") of the document, nor look for any "new" issues beyond those already identified. These actions were deemed beyond SC&A's authorized scope at this time. In addition, while SC&A (SC&A 2009a) had looked at aspects of SEC Petition 00107 (SEC-00106/00107 2008) and NIOSH's related Petition Evaluation Report (NIOSH 2008g), SC&A was not authorized to examine SEC Petition 00106 (SEC-00106/00107 2008), which, according to its author, was prepared based on Rev. 0 of the Site Profile, rather than Rev. 1.[1] As mentioned above, NIOSH purports to have addressed identified Rev. 0 issues in Rev. 1.

[1] SEC-00106 covers the period from November 1, 1947– December 31, 1953, and SEC-00107 from January 1, 1954–July 31, 2006.

2.0 ISSUE RESOLUTION PROCESS

In the time between SC&A's review of the original (Rev. 0) Linde Site Profile and the resolution in concept of all issues,[2] NIOSH, SC&A, the Linde WG, and the ABRWH held several meetings in person or via teleconference, and generated a number of reports and less formal notes on various technical subjects. Furthermore, NIOSH revised the Linde Site Profile twice—Rev. 1, NIOSH 2008a, is the current version, and Rev. 0, PC-1 (NIOSH 2006a), an intermediate, "minor" revision. In order to help sort out the disposition of the issues and determine whether all were finally closed, SC&A felt it would be valuable to document the major events in the issue resolution process, and has done so in Table 1, which presents an annotated chronology of significant events, starting with the original Site Profile. References are cited for each event; these references should be consulted for detailed information.

SC&A went through all the significant documents to trace the disposition of the 22 identified issues from the time they were first raised in SC&A 2006a to the time the last one (the so-called "Burlap Bag" issue) was closed in NIOSH 2008f. Table 2[3] lists the 22 issues by row and the evolution of the resolution process in five columns following the first, ranging from SC&A's initial site profile review (SC&A 2006a) in the second column to closeout of all issues except the Burlap Bag issue at the January 2008 Linde WG meeting, shown in the last column. Unfortunately, as noted in Table 1, NIOSH 2007b, issued November 29, 2007, after the March 26, 2007, Linde WG meeting, which responds to all 22 issues in some detail and is a particularly important document, cannot be placed neatly in a column in Table 2, since it discusses subjects by topic rather than by individual issue. The interested reader must refer to NIOSH 2007b for details.

The Burlap Bag issue, after further discussion and trading of SC&A and NIOSH technical reports, was finally declared closed by the WG at a June 2008 Linde WG meeting (NIOSH 2008f); the relevant events in its closure can be found in Table 1. It will be discussed further in Section 3.0.

It should be noted that the information presented in Tables 1 and 2 is not "new," but a compilation into a compact and useful form of already existing information; it is hoped that the tables also capture some of the flavor of the back-and-forth discussions that went on to resolve the issues.

[2] "Resolution in concept" – Some issues were effectively put in "abeyance" pending further action by NIOSH, such as incorporation into Rev. 1 of the Site Profile.

[3] In recognition of its length and format, Table 2 has been placed for convenience after the body of the report.

Table 1: Linde Issue Resolution Chronology

Date	Documentation	Description	Comment
2005			
5/31	NIOSH 2005a	Linde Exposure Matrix (Site Profile), Rev. 0.	
2006			
1/18	NIOSH 2006a	Linde Exposure Matrix (Site Profile), Rev. 0, PC-1.	
7/14	SC&A 2006a	SC&A Site Profile Review Report.	Review of Rev. 0 Site Profile (NIOSH 2005a). Identified 22 Issues (aka Comments). The issues are listed in Table 2 of this report.
2007			
3/22	NIOSH 2007a	NIOSH response to SC&A's Site Profile Review (SC&A 2006a).	SC&A 2006a Issue Resolution Matrix (Attachment 4), with an additional column showing NIOSH responses to each issue. The responses appear in the third column of Table 2 of this report.
3/26	NIOSH 2007c	First meeting of the Advisory Board Linde Work Group (WG), Cincinnati, Ohio	
3/27	SC&A 2007a	SC&A's informal matrix summarizing the disposition of issues discussed at the 3/26/07 WG meeting.	SC&A's summary for each issue appears in the fourth column of Table 2 of this report.
4/27	SC&A 2007b	SC&A responded to an action item from the 3/26/07 WG meeting by clarifying its comments on items 13, 14, and 18.	OGC reviewed: 5/16/07.
11/29	NIOSH 2007b	NIOSH detailed response to the 22 issues following discussion at the 3/26/07 WG meeting.	Table 1-1 reproduces the summary matrix of SC&A 2007a. Discussion is by topic, rather than by issue, so the issues don't conveniently map into Table 2 of this report.
2008			
1/3	SC&A 2008a	SC&A assessment of NIOSH's response (NIOSH 2007b) to TBD issues.	Table 1 of SC&A 2008a notes whether SC&A considers each issue "closed" or "open." The report then briefly discusses the issues. SC&A 2008a recommended closing 16 of the 22 comments. Still open are 2, 7, 8, 13, 17, and 22. The discussion for each issue appears in the fifth column of Table 2 of this report.
1/8	Roessler 2008	Informal notes of the Linde WG meeting in Las Vegas, 1/8/08.	All open items closed with the exception of 17 and 22, which are combined into the "Burlap Bag" issue. See last column of Table 2 of this report.
11/4	NIOSH 2008a	Linde Exposure Matrix (Site Profile), Rev. 1.	NIOSH claims in the Publication Record to have resolved all WG comments.

Table 1: Linde Issue Resolution Chronology

Date	Documentation	Description	Comment
2/15	SC&A 2008b	SC&A notes from a 2/13/08 technical call with NIOSH and the WG on the Burlap Bag issue.	A former Linde employee and an SEC petitioner also participated in the teleconference.
2/20	NIOSH 2008b	Advisory Board Teleconference Meeting.	The Burlap Bag issue was one of the topics of discussion. NIOSH committed to produce a white paper on the potential exposure from the burlap bags.
3/18	NIOSH 2008c	NIOSH white paper calculating potential dose from exposure to hypothesized burlap bags.	
6/4	SC&A 2008c	SC&A response to NIOSH 2008c on burlap bags. SC&A used MCNPx to calculate exposures from several different scenarios.	Note: Typo on cover of report has the incorrect date of March 29, 2008; the correct date of June 4, 2008 appears in the footer.
6/6	NIOSH 2008d	Linde WG teleconference.	Discussion of Burlap Bag issue focusing on NIOSH 2008c and SC&A 2008c.
6/10	SC&A 2008d	Rev. 1 of SC&A 2008c following the 6/6/08 teleconference.	
6/19	NIOSH 2008e	NIOSH informal response to SC&A 2008d.	The last bullet states, "Assignment of exposures to all Linde employees for what seems to be a highly localized and limited exposure scenario would seem to be inappropriate. If there is indication that such an exposure is likely for a specific claimant, consideration would be made in the dose reconstruction report. In all other cases, the current exposure matrix…provides an ample buffer between the likely exposure conditions and those that, albeit possible, are highly unlikely. In other words, the existing exposure matrix is broad enough to cover all likely exposure scenarios, up to and including the possibilities outlined in the "burlap bag" scenario."
6/23	NIOSH 2008f	Linde WG meeting, St. Louis, Missouri.	The WG voted to accept NIOSH's offer to add a discussion of the potential burlap bag exposure to the next revision of the TBD (Rev. 1) and to apply it to a dose reconstruction, only if there is some evidence of actual exposure to the individual. This action then closed (in concept) all the site profile issues.

3.0 VERIFICATION OF FINAL ISSUE CLOSURE

Several of the issues raised in SC&A's Site Profile Review (SC&A 2006a) were "resolved in concept" by placing them in "abeyance," with NIOSH committing to address them in a future revision of the site profile; i.e., in Revision 1.[4] In order to completely close the issues, it is necessary to verify if NIOSH did indeed address those issues as promised. This also responds to one of the concerns expressed by a petitioner's representative for Special Exposure Cohort (SEC) status in the SEC-00106 and SEC-00107 petitions (SEC-00106/00107 2008) and in several of the representative's communications to the ABRWH and SC&A.

SC&A's Linde Site Profile Review (SC&A 2006a) examined Rev. 0 of the Site Profile (NIOSH 2005a). However, NIOSH subsequently issued Rev. 0, PC-1 (NIOSH 2006a) and Rev. 1 (NIOSH 2008a). The latter states the following in its Publication Record:

> *Approved revision to change from a page change revision (Rev 00 PC-2-B) to a total rewrite (Rev 01-A) as a result of formal NIOSH review. Revised to incorporate: (1) change in facility designation, (2) DOL interpretation of applicability of residual period to Ceramics Plant [Linde], (3) and resolution of Advisory Board Working Group comments, (4) clarified the implementation instructions for SEC00044 for the period October 1, 1942 through October 31, 1947. Incorporates formal internal and NIOSH review comments. Constitutes a total rewrite of the document…*

Item number (3) in the above quotation from the Rev. 1 Site Profile Publication Record clearly states NIOSH's claim to have incorporated "resolution of Advisory Board Working Group comments." SC&A will examine 100% of the issues as a check. In a table in Appendix A of a previous report, SC&A 2009a, looking at SEC Petition-00107 and the NIOSH Petition Evaluation Report, SC&A had presented a detailed comparison of Rev. 1 and Rev. 0 of the Linde Site Profiles; that table is reproduced here as Table 3 for convenience to illuminate the changes NIOSH made and to help assess whether NIOSH incorporated the material resulting from the issues resolution process.[5]

The first step in ascertaining whether NIOSH met its commitments with respect to issue resolution is to identify which issues are affected. This is followed by identifying where in the Rev. 1 Linde Site Profile the commitments are addressed and whether SC&A believes that the NIOSH response is adequate. Table 2 summarizes the issue resolution process, and Table 4 summarizes SC&A's findings with respect to incorporating required changes in the site profile. It should be emphasized that all the tables in this report present only summary information, and that the interested reader should consult the referenced documents to receive a fuller understanding of the issues involved and the issue resolution process.

[4] The terms "resolved in concept" and "in abeyance" were not used at the time of the Linde Site Profile review, but came into common usage in the NIOSH project at a later date.

[5] In recognition of its length and format, Table 3 has been placed after the body of this report.

A "No" in the second column of Table 4 indicates that, after examining the relevant documents of the issue resolution process as summarized in Table 2, SC&A regards a particular issue as closed without committing NIOSH to further action, while a "Yes" indicates that SC&A regards a particular issue as "resolved in concept," pending an action by NIOSH. The last column of Table 4 lists for each issue the "shorthand" title of the issue, presents a short discussion, then closes with SC&A's assessment of NIOSH's action or position.

As can be seen from Table 4, SC&A considered that NIOSH made commitments to "resolve in concept" 12 of the 22 issues,[6] which resulted in those issues being categorized as closed in the issue resolution process. Of those 12 issues requiring verification, SC&A's review in this report suggests that 11 should be reclassified as "closed" without further qualification, with only Issue 17 requiring some further discussion and possible NIOSH action. Item 17 is the so-called Burlap Bag issue, whose resolution at the June 23, 2008, Linde WG meeting (NIOSH 2008f) required that NIOSH make certain modifications in its Rev. 1 Linde Site Profile. As summarized in Table 4, NIOSH, in Attachment E, did include a discussion of the Burlap Bag issue and the potential exposure consequences from an employee during the post-operations period standing near or sitting on a pile of bags during lunch. However, SC&A does not believe that NIOSH's revision with respect to this issue is complete since, as stated in this report's Table 4:

1. *Neither the body or Attachment E of the Site Profile appear to explicitly state that the dose reconstructor should add a dose from post operations burlap bag exposure if there is some evidence of such an exposure; this was part of NIOSH's commitment to resolve this issue.*

2. *The dose reconstructor is not appropriately directed toward Attachment E in the body of the site profile. Section 1.2, Scope, makes the only reference: "Attachment E provides an assessment of dose consequences from uranium ore bag that were stored on the site during the postoperations period." However, Section 6, which treats exposures during the residual period, does not mention Attachment E.*

One further point of SC&A's review should be noted. Several of the issues, beginning with Issue 2, were resolved in concept by NIOSH's commitment to develop a coworker exposure model to be used in the absence of adequate specific applicant data. NIOSH developed such a model, which is described in Attachment D of the Rev. 1 Linde Site Profile (NIOSH 2008a). SC&A, consequently, reclassified the affected issues as closed in Table 4. SC&A, however, did not examine the technical basis of the coworker model for this report; that can be done at a later time, if desired by the Board WG.

[6] Issues: 2, 3, 4, 6, 9, 10, 11, 12, 13, 17, 20, and 22.

Table 4: Verification of NIOSH's Issue Resolution Commitments			
Issue[(a)]	**Verification Required?**	**Closeout**	**Discussion**
1	No	SC&A 2008a	***Unsupported Assumptions and Significant Uncertainties in Information Used*** **SC&A Assessment:** Verification not required.
2	Yes	Roessler 2008	***Use of Air Concentration Data*** Closure of several identified issues relies on resolution of Issue 2. As shown in the last column of Table 2, NIOSH committed to use "coworker data and a bounding procedure for estimating internal doses for unmonitored workers." Attachment D of NIOSH 2008a (Site Profile, Rev. 1), "Linde Uranium Coworker Assessment for November 1947 to January 1950," is a standalone report providing guidance to the dose reconstructor on how to estimate uranium intakes during the specified period. As the attachment states, "Due to the limited availability of bioassay data from the Linde site, it was necessary to conduct a coworker study of all the bioassay data for use to determine intake estimates." Attachment D is referenced in Section 1.2, "Scope;" Section 2.0, "Estimation of Internal Exposure, 1947 to July 7, 1954;" and Section 3.2.1, "Uranium Urinalysis Data" of NIOSH 2008a. Section 3.2.1 states: *Analysis of Coworker Bioassay Data for Internal Dose Assignment (ORAU 2005d) [i.e., ORAUT-OTIB-0019; ORAUT 2005b in this report] describes the general process used for analyzing bioassay data for assigning doses to individuals based on coworker results. Bioassay results described above were analyzed in accordance with this procedure (Attachment D). The results of this analysis are presented in Tables 3-1 and 3-2. Individual uranium urinalysis results should be used to determine internal exposure to the individual when they are available. Where individual results are not available, the coworker data included in Attachment D and summarized in Tables 3-1 and 3-2 are to be used to estimate internal exposures that are favorable to claimants.* **SC&A Assessment:** NIOSH complied with its issue resolution commitment here and for several other issues by virtue of creating a coworker model in accordance with ORAUT-OTIB-0019.
3	Yes	SC&A 2008a	***Urinalysis Data*** NIOSH adopted a coworker model for uranium intakes in Attachment D of the Rev. 1 Site Profile (NIOSH 2008a) (see the discussion for Issue 2). **SC&A Assessment:** NIOSH complied with its issue resolution commitment.

Table 4: Verification of NIOSH's Issue Resolution Commitments			
Issue[(a)]	**Verification Required?**	**Closeout**	**Discussion**
4	Yes	SC&A 2008a	***Time-weighted Averages*** NIOSH adopted a coworker model for uranium intakes in Attachment D of the Rev. 1 Site Profile (NIOSH 2008a) (see the discussion for Issue 2). **SC&A Assessment:** NIOSH complied with its issue resolution commitment.
5	No	SC&A 2007a	***Breathing Rate*** **SC&A Assessment:** Verification not required.
6	Yes	SC&A 2008a	***Ingestion Rate*** NIOSH 2008a treats ingestion in Section 3.7, which states: *In the case where inhalation intakes are calculated from air concentrations, ingestion intakes are also to be considered. NIOSH (2004) [NIOSH 2004a in this report] indicates that the ingestion rate, in terms of dpm for an 8-hour workday, can be estimated by multiplying the air concentration in dpm per cubic meter by a factor of 0.2…* This site-wide practice, as adopted in NIOSH 2004a (OCAS-TIB-009), bases ingestion rates on air concentrations, not on inhalation intakes, as noted in NIOSH 2007a. **SC&A Assessment:** NIOSH has addressed SC&A concerns of SC&A 2006a about this observation. ***N.B.*** NIOSH 2008a, Section 3.7 appears to have a typo; SC&A believes the two highlighted values should be the same in the following: "…so the uranium ingestion rate based on an air concentration of 7 alpha dpm/m^3 would be **0.563** dpm/wd. To adjust this to ingestion intake per calendar day, **0.685** dpm/wd was multiplied by 250 wd/yr and divided by 365 d/yr, which equals 0.469 dpm/d." Note that 0.685 times 250 and divided by 365 does equal 0.469 as written.
7	No	Roessler 2008	***Radon Exposure and Concentration*** **SC&A Assessment:** Verification not required.
8	No	Roessler 2008	***Raffinate Trace Radionuclides*** **SC&A Assessment:** Verification not required. ***N.B.*** Section 3.4 of NIOSH 2008a covers uranium progeny, and includes in Table 3-3 the isotopes Th-230, Ra-226, Po-210, Ac-227, and Pa-231, which are, typically, found in trace amounts in raffinates.

Table 4: Verification of NIOSH's Issue Resolution Commitments			
Issue[(a)]	**Verification Required?**	**Closeout**	**Discussion**
9	Yes	SC&A 2008a	***Assigned Work Hours*** NIOSH's coworker model in NIOSH 2008a Attachment D (see Issue 2) is based on bioassay data, which automatically "integrates" dose rates over time to obtain exposures. **SC&A Assessment:** NIOSH has addressed SC&A concerns of SC&A 2006a about this observation.
10	Yes	SC&A 2008a	***Surrogate Air Concentration Data*** NIOSH adopted a coworker model for uranium intakes in Attachment D of the Rev. 1 Site Profile (NIOSH 2008a) (see the discussion for Issue 2). **SC&A Assessment:** NIOSH has addressed SC&A concerns of SC&A 2006a.
11	Yes	SC&A 2008a	***Use of Geometric Mean Values*** NIOSH agreed (SC&A 2008a) "…that the estimated co-worker external doses should be revised based on the guidance of ORAUT-OTIB-0020 [ORAUT 2005a in this report] rather than the geometric mean of a distribution approach..." **SC&A Assessment:** NIOSH 2008a (Rev. 1 Site Profile) uses a coworker model (although the Rev. 1 Site Profile does not appear to reference ORAUT-OTIB-0020); NIOSH has addressed SC&A concerns of SC&A 2006a.
12	Yes	SC&A 2008a	***Lack of Comprehensive Uncertainty Analysis*** NIOSH adopted a coworker model for uranium intakes in Attachment D of the Rev. 1 Site Profile (NIOSH 2008a) (see the discussion for Issue 2). **SC&A Assessment:** NIOSH complied with its issue resolution commitment.
13	Yes	Roessler 2008	***Complex Missed External Dose Surrogate System*** SC&A had made several comments and "subcomments" through several rounds of review; the only one that requires verification that NIOSH took an action was Subcomment 5 of Roessler 2008. NIOSH committed to making the 14 footnotes of Table 36 of the Rev. 0 Site Profile (NIOSH 2005a) clearer in the next revision of the site profile. **SC&A Assessment:** Table 36 of NIOSH 2005a became Table 4-24 of NIOSH 2008a. The 14 footnotes became 18, and provide clearer explanations; thus, NIOSH complied with its issue resolution commitment.
14	No	SC&A 2008a	***Film Badge Data*** **SC&A Assessment:** Verification not required.
15	No	SC&A 2008a	***Survey Measurement Data*** **SC&A Assessment:** Verification not required.

Table 4: Verification of NIOSH's Issue Resolution Commitments			
Issue[(a)]	**Verification Required?**	**Closeout**	**Discussion**
16	No	SC&A 2008a	***Time-Weighted Averages*** **SC&A Assessment:** Verification not required.
17	Yes	NIOSH 2008f	***Contaminated Burlap Bags*** The Rev. 1 Site Profile report (NIOSH 2008a) includes a new section, Attachment E, entitled: "Focused Assessment of Dose Consequences from Uranium Ore Bags on the Site During the Postoperations Period." The section recapitulates the issue and its development from the original SC&A site profile review identification (SC&A 2006a) through subsequent discussions and documents. Page 4 of Attachment E summarizes NIOSH's position: *Based on the weight of the available evidence (tabulated below), it is unlikely that two pallets of uranium ore (which was last processed at Linde in 1946) would have been in Building 30 in 1951 (5 years after the cessation of processing of uranium ore). The current external exposure model for the period in question incorporates uncertainty in the external dose assignment by application of a lognormal distribution with a GM of 1.85 and a GSD of 4.04. This assumed distribution (with a 95th-percentile value of 18.5 R/yr) accounts for possible deviation of the actual worker exposure of the magnitude that would result from the assumption that two pallets of uranium ore were in Building 30 in 1951.* **SC&A Assessment:** SC&A acknowledges that NIOSH has addressed the burlap bag issue (although, perhaps not completely) in its Rev. 1 Site Profile. However, while Attachment E treats potential burlap bag exposure during the post operations period: 1. Neither the body nor Attachment E of the Site Profile appear to explicitly state that the dose reconstructor should add a dose from post-operations burlap bag exposure if there is some evidence of such an exposure; this was part of NIOSH's commitment to resolve this issue. 2. The dose reconstructor is not appropriately directed toward Attachment E in the body of the site profile. Section 1.2, Scope, makes the only reference: "Attachment E provides an assessment of dose consequences from uranium ore bags that were stored on the site during the post-operations period." However, Section 6, which treats exposures during the residual period, does not mention Attachment E.
18	No	SC&A 2008a	***Surrogate External Exposure Data*** **SC&A Assessment:** Verification not required.
19	No	SC&A 2008a	***Assigned Work Hours*** **SC&A Assessment:** Verification not required.

Table 4: Verification of NIOSH's Issue Resolution Commitments			
Issue[(a)]	**Verification Required?**	**Closeout**	**Discussion**
20	Yes	SC&A 2008a	***Geometric Values*** NIOSH committed to apply a coworker model; this model appears in Attachment D of NIOSH 2008a. **SC&A Assessment:** NIOSH complied with its issue resolution commitment.
21	No	SC&A 2008a	***Lack of Comprehensive Uncertainty Analysis*** **SC&A Assessment:** Verification not required.
22	Yes	NIOSH 2008f	***Outdoor Doses/SC&A Assessment*** **SC&A Assessment:** The review process found that the only significant outdoor dose pathway that may have been missed is the hypothesized burlap bag exposure in the post-operations period. This is covered by Issue 17 and does not have to be tracked here as well.

Notes:
(a) Refer to Table 2 for a summary of the issues

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Table 2: Linde Issue Resolution Tracking Matrix

Issue/ Finding [a],[b]	SC&A Site Profile Review[c] (SC&A 2006a)	NIOSH Initial Response (NIOSH 2007a)	SC&A Summary of Actions per 3/26/07 Advisory Board Linde WG Meeting (SC&A 2007a)	SC&A Assessment of (NIOSH 2007b)[d] (SC&A 2008a)	Notes of the Linde Board Work Group Meeting, Las Vegas, NV, 1/1/08 (Roessler 2008)
1/1	**(Section 5.1.1, p. 38) Unsupported Assumptions and Significant Uncertainties in Information Used:** SC&A has identified numerous assumption or values used in missed dose estimations (both internal and external) in the Linde Site Profile that are not either supported or adequately supported by explanation, available data, technical study, or references. Many of these parametric assumptions are made arbitrarily without adequate technical basis. In some cases, an assumption was made or a value was selected from a range of estimated values in order to bound a dose parameter that is not entirely justified or explained in the document. In other cases, the assumption or value selected is not deemed by SC&A as bounding. This is a serious flaw that significantly affects	This comment is too general to warrant a specific response, except to say that the site profile development process has undergone a number of modifications since dose reconstruction startup, and that what might have been reasonable at the beginning of the project might not be deemed so now. Although the goal is sometimes to bound parameters, parameters can also be defined as distributions.	None required.	Open/Closed: **Closed** Comment: SC&A accepts NIOSH's response.	

Table 2: Linde Issue Resolution Tracking Matrix

Issue/ Finding (a),(b)	SC&A Site Profile Review[c] (SC&A 2006a)	NIOSH Initial Response (NIOSH 2007a)	SC&A Summary of Actions per 3/26/07 Advisory Board Linde WG Meeting (SC&A 2007a)	SC&A Assessment of (NIOSH 2007b)[d] (SC&A 2008a)	Notes of the Linde Board Work Group Meeting, Las Vegas, NV, 1/1/08 (Roessler 2008)
	the credibility and validity of the assigned missed dose estimates in this Linde Site Profile.				
2/2	**(Section 5.1.2.2, p. 42) Use of Air Concentration Data:** The use of airborne uranium dust concentration data (air concentration) as the sole basis for missed occupational internal dose estimation is not defensible or claimant favorable, because there are significant uncertainties regarding using air concentration data to estimate worker inhalation intakes at uranium processing facilities. Several technical studies, including the 2003 Y-12 study, *Practical Use of Personal Air Sampling (PAS) Data in the Internal Dosimetry Program at the Y-12 National Security Complex* (Snapp 2003), and the Nuclear Regulatory Commission's NUREG 1400, *Air Sampling in the Workplace* (Hickey 1993), demonstrate	1. Air concentration data are not used to assign "missed" internal dose, rather they are used to provide reasonable estimates of internal doses received by unmonitored workers. 2. Air concentration data have been used in a number of instances to assign intakes for the purpose of estimating internal dose, and are commonly used in environmental, chemical and nuclear, and emergency response evaluations to estimate exposures. 3. We agree that measurements and models for equating air concentration measurements to intakes have uncertainties, but don't believe this negates the use of air sample data to estimate intakes.	NIOSH will develop a new exposure model derived from the 700 newly found bioassays; the results of the new model will supersede the use of air concentration data as the basis for occupational internal dose estimation.	Open/Closed: **Open** Comment: NIOSH 2007 [NIOSH 2007b in this report] notes that NIOSH was mistaken in identifying 700 newly found (as of the March 26, 2007, WG meeting) urinalysis data as belonging to Linde. NIOSH appears to have met SC&A's objection to using air concentration data to estimate internal doses received by unmonitored workers by conducting a coworker study using the available urine samples, the details of which are provided in Attachment 1 of NIOSH 2007 [NIOSH 2007b in this report]. Data were analyzed according to the	**Closed:** NIOSH explained that it will use coworker data and a bounding procedure for estimating internal doses for unmonitored workers. SC&A accepted the bounding procedure.

Table 2: Linde Issue Resolution Tracking Matrix

Issue/ Finding [a],[b]	SC&A Site Profile Review[c] (SC&A 2006a)	NIOSH Initial Response (NIOSH 2007a)	SC&A Summary of Actions per 3/26/07 Advisory Board Linde WG Meeting (SC&A 2007a)	SC&A Assessment of (NIOSH 2007b)[d] (SC&A 2008a)	Notes of the Linde Board Work Group Meeting, Las Vegas, NV, 1/1/08 (Roessler 2008)
	that using air concentration data would lead to underestimating the worker intakes and, subsequently, the internal exposures. The Y-12 study shows as high as 10 times difference (underestimation) between intakes derived from bioassay data and intakes derived from air concentration data.	4. At this time, we were unable to locate the Snapp 2003 reference, but note that NUREG 1400 does not indicate that air sampling cannot be used to estimate internal exposures. 5. Another Y-12 reference previously cited by SC&A, *Y-12 Uranium Exposure Study* (Eckerman and Kerr 1999 [Ref ID 11600]), supports the intake estimation method proposed in the TBD as reasonable; in the Y-12 study, the ratios of air concentration to bioassay-derived intakes range from 0.11 to 1.38, with an average of 0.49 in Table 11 of the Y-12 study, indicating that if bioassay is the gold standard, Y-12 intakes derived from bioassay might be low in some cases by up to a factor of 9. However, the intakes in the Y-12 study were reduced to account for		methodology of ORAUT-PROC-0095, "Generating Summary Statistics for Coworker Bioassay Data," culminating in the Table 2-1 and 2-2 chronic intake rates for Type M and Type S uranium respectively, at the 50% and the 84th percentiles (ORAUT 2006). SC&A supports this approach; however, the NIOSH response states that "the intakes calculated using co-worker data extending through January 1950 (during Step III operations) were extended through the end of the operations period (currently listed as 12-31-53 by DOL) because these intakes are believed to be bounding during the final decontamination phases at the site" (NIOSH 2007, Sect. 2.0) [NIOSH 2007b	

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		respiratory protection factors ranging from 1 (no respirator) to 50, but typically in the 25 to 50 range. For Linde, there is no proposal to apply a respiratory protection factor, although some workers did wear respiratory protective devices.		in this report]. SC&A would like NIOSH to explain why it believes these intakes are bounding.	
3/3	**(Section 5.1.2.3, p. 45) Urinalysis Data:** Using air concentration data only, but neglecting urinalysis data, to estimate worker inhalation intakes in the Linde Site Profile is not in full compliance with 42 CFR 82 requirements. There are 8 sets of urinalysis data for over 100 uranium workers in the ORAU Database for the period between December 16, 1947, and January 30, 1950. The air concentration data used in the site profile are not complete either, and are deemed inadequate (see Finding 2). However, NIOSH decided to	Although we agree that air concentration data were used to estimate intakes for unmonitored workers, we disagree that uranium urinalysis data were ignored. A set of Linde bioassay data including uranium urinalyses were compiled and the data were reviewed in relation to the air concentration exposure data, as briefly noted in Section 3.8 of the site profile. NIOSH has always advocated using individual monitoring data when adequate and complete, and nothing in the Linde site profile precludes the	See Comment 2. Consideration of the 700 bioassays will also resolve Comment 3.	Open/Closed: **Closed** Comment: SC&A accepts NIOSH's response (Comment 2).	

Table 2: Linde Issue Resolution Tracking Matrix

Issue/ Finding (a),(b)	SC&A Site Profile Review[c] (SC&A 2006a)	NIOSH Initial Response (NIOSH 2007a)	SC&A Summary of Actions per 3/26/07 Advisory Board Linde WG Meeting (SC&A 2007a)	SC&A Assessment of (NIOSH 2007b)[d] (SC&A 2008a)	Notes of the Linde Board Work Group Meeting, Las Vegas, NV, 1/1/08 (Roessler 2008)
	use these air concentration data only for dose reconstruction. This approach is not in full compliance with the hierarchy approach stipulated in 42 CFR 82.	use of the individual dosimetry data. 42 CFR 82.10(j) notes, "an occupational exposure matrix, using the general hierarchical approach discussed in § 82.2." 42 CFR 82.2 notes that individual monitoring, if complete and accurate, is given the highest priority, but in 42 CFR 82(b), preference is not assigned to either coworker or air monitoring data for estimating internal dose for unmonitored individuals, although these methods are given preference over exposures analytically derived from process descriptions. 42 CFR 82.17 also mentions the types of analyses that can be done, but again, preference is not given to estimating internal dose from either coworker or air monitoring data.			
4/4	**(Section 5.1.2.2, p. 42) Time-Weighted Averages:** Time-weighted averages of internal and external exposure values	Although we agree that air concentration data were used to estimate intakes for unmonitored workers, we	The validation of 33 MAC as the upper-bound time-weighted average air concentration or its	Open/Closed: **Closed** Comment: SC&A accepts NIOSH's	

Table 2: Linde Issue Resolution Tracking Matrix

Issue/ Finding (a),(b)	SC&A Site Profile Review[c] (SC&A 2006a)	NIOSH Initial Response (NIOSH 2007a)	SC&A Summary of Actions per 3/26/07 Advisory Board Linde WG Meeting (SC&A 2007a)	SC&A Assessment of (NIOSH 2007b)[d] (SC&A 2008a)	Notes of the Linde Board Work Group Meeting, Las Vegas, NV, 1/1/08 (Roessler 2008)
	contain significant uncertainties and frequently fail to capture dose to workers in areas of high uranium dust concentration. The site profile uses time-weighted calculations to determine average dose values for both internal and external pathways. In the internal dosimetry section, NIOSH determines the time-weighted average air concentration value of 33 MAC by time weighting the air concentration data with average worker exposure times and summing to determine daily time-weighted average air concentrations by job categories. This calculational approach would potentially underestimate the average air concentrations for high-dose or high-risk tasks that a claimant might have participated in at the Linde Site.	disagree that uranium urinalysis data were ignored. A set of Linde bioassay data, including uranium urinalyses, were compiled and the data were reviewed in relation to the air concentration exposure data, as briefly noted in Section 3.8 of the site profile. NIOSH has always advocated using individual monitoring data when adequate and complete, and nothing in the Linde site profile precludes the use of the individual dosimetry data. 42 CFR 82.10(j) notes, "an occupational exposure matrix, using the general hierarchical approach discussed in § 82.2." 42 CFR 82.2 notes that individual monitoring, if complete and accurate, is given the highest priority; but in 42 CFR 82(b), preference is not assigned to either coworker or air monitoring data for estimating internal dose for unmonitored individuals,	replacement by the new bioassay data (Comment 2) would resolve this comment.	response (Comment 2).	

Table 2: Linde Issue Resolution Tracking Matrix

Issue/ Finding (a),(b)	SC&A Site Profile Review[c] (SC&A 2006a)	NIOSH Initial Response (NIOSH 2007a)	SC&A Summary of Actions per 3/26/07 Advisory Board Linde WG Meeting (SC&A 2007a)	SC&A Assessment of (NIOSH 2007b)[d] (SC&A 2008a)	Notes of the Linde Board Work Group Meeting, Las Vegas, NV, 1/1/08 (Roessler 2008)
		although these methods are given preference over exposures analytically derived from process descriptions. 42 CFR 82.17 also mentions the types of analyses that can be done, but again, preference is not given to estimating internal dose from either coworker or air monitoring data.			
5/O	**(Section 5.1.2.4, p. 45) Breathing Rate:** The Linde Site Profile assumed a breathing rate of 1.2 m^3/hour for worker intake. This value implies that workers were primarily involved in light exercise during the course of the day. A single value may not be consistent with the working conditions in the facility, especially during the early years of operation, and is inconsistent with other NIOSH site profiles, such as Mallinckrodt, Bethlehem Steel, Y-12, INL, SRS, and Hanford.	This is not a site-specific issue, and the Linde site profile breathing rate assignment is consistent with the Mallinckrodt site profile. (We are not aware of any inconsistencies with breathing rate assumptions in the Y-12, SRS, INEL, and Hanford site profiles either, and are also unaware of changes in breathing rate estimates for different years.)	None required. Decided that breathing rate isn't a material issue.	Open/Closed: **Closed** Comment: SC&A accepts NIOSH's response.	
6/O	**(Section 5.1.2.5, p. 45) Ingestion Rate:** The Linde	This is a not a site-specific issue. The ingestion intake	None required. New bioassay data (Comment	Open/Closed: **Closed**	

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	Site Profile determines the worker ingestion intake by multiplying the inhalation intake by 0.2 (20%). Since the inhalation intake is estimated by using air concentration data, SC&A believes that the NIOSH approach would lead to the underestimation of ingestion intake and eventual missed ingestion doses for Linde workers.	rate is based on OCAS-TIB-009, and is based on multiplying the air concentration (activity per cubic meter) by 0.2 to estimate daily ingestion activity (the ingestion intake is not calculated directly from the inhalation intake, as stated in the review comment).	2) supersedes assumption that the ingestion rate is 20% of the inhalation rate.	Comment: SC&A accepts NIOSH's response.	
7/O	**(Section 5.1.2.6, p. 46) Radon Exposure and Concentration:** The Site Profile used the "lowest indoor concentrations measured at the Ceramics Plant during African ore processing" as the upper limit to both indoor and outdoor radon concentrations. The assumed indoor radon concentration of 10 pCi/L is based on the lower limit of detection. SC&A believes these assumed radon concentration values based on the GM of measurements are not claimant favorable or representative of the actual	The site profile developed a stratified approach to assigning radon exposures for the entire operational period. In July 1946, work with African ore ceased and a standby period began. Records indicate that processing after this period started with UO_2 and the uranium ore receipts (the primary source of the radium that produced the radon) had been discontinued. The quote (out of context) applied only to the period prior to Ceramics Plant start-up	NIOSH will look at radon data and treatment more closely, including investigating the location, content, and disposition of tailings piles that may have exposed workers to radon.	Open/Closed: **Open** Comment: NIOSH refers to its discussion on Comment 8 (Section 4.0, Raffinates) [of NIOSH 2007b] to treat this comment, noting that "…raffinates were removed from the Linde site prior to the current non-SEC period (11-01-47)." However, it is not clear that NIOSH fulfilled its commitment to "…look at radon data and treatment more closely	**Closed.** SC&A was concerned about radon doses from sources other than the ores. NIOSH says the material of concern was not present during the period of interest and, therefore, 10 pCi/L airborne radon would be used to estimate bounding doses. SC&A accepted.

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	exposure conditions that the Linde workers experienced during the period of operation from 1942 to 1954.	(which is now an SEC period [designated December 2005]), and the cited levels were used to estimate possible exposures to Ceramics Plant employees from the radon at the Tonawanda Laboratory, which began research and development operation prior to the initiation of uranium ore processing at the Linde Ceramics Plant. The assumed indoor radon concentration was not based on the detection threshold, which was 1 pCi/L, not 10 pCi/L. In December 2005, an SEC class for Linde Ceramics employees (which we interpret to include Tonawanda Laboratory personnel) was established for October 1, 1942, through October 31, 1947, so radon exposures are not considered for that period.		including investigating the location, content, and disposition of tailings piles that may have exposed workers to radon," and estimated potential radon exposures (Table 1, Comment 7, Disposition).	
8/5	**(Section 5.1.2.7, p. 46) Raffinate Trace**	We concur that there might be issues with assigning non-	NIOSH agreed in its written response to review	Open/Closed: **Open**	**Closed.** SC&A did not see the relationship

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	Radionuclides: The dose consequences of raffinate trace radionuclides have not been adequately addressed in the Linde Site Profile**.** Raffinate contains Ac-227 and Pa-231, which are in the U-235 decay chain, as well as Th-230. Possible doses from raffinate-related exposures have not been evaluated in the site profile. Inhalation of even small quantities of some raffinates, such as filter cake (one of the waste products at Linde Site), could result in significant doses to the workers. The issue of potential airborne contamination of raffinates must be more carefully assessed.	uranium intakes that have not been adequately addressed. This will be reviewed further.	further its treatment of raffinate trace material.	Comment: NIOSH performed an extensive review of raffinate characterization and disposition to estimate potential airborne exposures. Table 4-2 in NIOSH 2007 [NIOSH 2007b in this report] presents isotopic data for soils and sediments in various site locations, and Table 4-3 presents progeny/U (total) ratios for several isotopes. The Linde Site Profile (NIOSH 2006) [NIOSH 2006a in this report] Table 5 presents uranium intake fractions for several nuclides, determined by assuming secular equilibrium of the uranium progeny. It is not clear to SC&A how Table 4-2 in the NIOSH response (NIOSH 2007) [NIOSH 2007b in this report] relates to Table 5 in the TBD and how the	between a table in the NIOSH response and a table in the TBD with regard to raffinates. SC&A agreed that because any residue after the SEC period would be of a magnitude that is not of concern, that the use of the ratios given in Table 4-3 in the NIOSH November document would give claimant-favorable results.

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				former values are intended for use in dose reconstruction.	
9/6	**(Section 5.1.2.8, p. 47) Assigned Work Hours:** The number of work hours used in calculating occupational internal and external doses for workers is inconsistent for different periods of Linde operations and, therefore, not claimant favorable. The site profile represents in Table 4 (Davidson 2005, p. 24), and in many other places, that workers at Linde had longer workweeks than 40 hours per week, and, in some cases, the workweeks were as long as 9 hours per day for 6 days a week and 50 weeks per year. But in most instances, NIOSH uses the standard 40 hours per week assumption for the missed dose estimation. This approach is not only inconsistent, but also not claimant favorable.	The work periods in Table 4 include lunch periods and other non-operational periods during which exposures are likely to be lower. Parameters used in deriving exposure estimates are included in the site profile and can be modified, based on claim-specific details, by dose reconstructors. The assumption that unmonitored workers were exposed to what were judged as favorable estimates of intakes and exposure rates appeared to adequately balance this concern when the site profile was developed, but this issue will be reviewed in conjunction with other items noted in these responses.	NIOSH's new exposure model based on the bioassay data (Comment 2) will resolve this issue (bioassay data automatically integrates dose over time to obtain exposure).	Open/Closed: **Closed** Comment: SC&A accepts NIOSH's response (Comment 2).	
10/7	**(Section 5.1.2.9, p. 47)**	The intake rate at Linde was	See Comment 4.	Open/Closed: **Closed**	

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	Surrogate Air Concentration Data: Using the GM of air concentration data of seven AWE facilities in New York from a 1949 AEC/NYOO report (AEC 1949a) as surrogate data to develop Linde site-specific worker inhalation intakes for the entire period of Linde Operation from 1942 to 1954 is over-reaching and may, potentially, underestimate the missed occupational internal dose to workers. This approach is inappropriate, because the surrogate data are very limited and not representative of the actual Linde operation condition because, at Linde, ventilation was poor or non-existent, and adequate radiation protection practices had not yet been developed in the earlier years of operation.	based on the greatest time-weighted average air concentration reported for Linde Ceramics in the AEC/NYOO report for the period 1947 to 1954. This intake was not applied to the period 1942 to 10/31/1947, and was not based on the GM of the seven AWE facilities included in the NYOO report. [It's not clear why it is thought that data in the NYOO report are very limited for the seven listed facilities, nor why it is thought that ventilation was worse at Linde than at other facilities of the period.] There is much evidence that radiation protection practices were in use and being further developed at Linde Ceramics, and that practices were in place to limit air concentrations and exposures. Note that Linde Ceramics is included in the SEC through October 31, 1947.		Comment: SC&A accepts NIOSH's response (Comment 2).	

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11/11	**(Section 5.1.2.10, p. 48) Use of Geometric Mean Values:** The statistical analysis approach used in the Linde Site Profile is not bounding and, most importantly, not claimant favorable. In Table 6 of the Occupational Internal Dose Section (Davidson 2005, p. 33), the site profile lists the GM or the GSD values for measured radon concentrations during African ore processing. First, there are no supporting calculations or data to show how these geometrical quantities are calculated. Second, the use of GMs and GSDs of airborne radon concentrations as default values could be considered claimant neutral and not claimant favorable. Unless there is good reason to believe that a given worker was exposed to the full distribution of the measured concentrations and could not have experienced protracted exposures to higher than average radon	Data and calculations are available and will be provided to the reviewer. Whether a parameter is claimant favorable or not is only an issue if that parameter cannot be defined. The use of distributions to define parameters is judged reasonable in general by NIOSH, and the regulations and guidance governing this project refer to the use of distributions. In preparing the site profile, the sentiment was that workers would not likely have been exposed to the higher end of the distributions for the extended periods under consideration, so assigning the whole distribution for exposure periods of 2,040 hours per year was (and is) believed to be claimant favorable for an operation that no longer processed ore.	NIOSH agreed (Comment 20) that the estimated coworker external doses should be revised based on the guidance of ORAUT-OTIB-0020, rather than the geometric mean of a distribution approach, and that estimated internal doses would be considered on a case-by-case basis to determine whether to use GM or 95th percentile data.	Open/Closed: **Closed** Comment: SC&A accepts NIOSH's response. As noted in the NIOSH response for this comment in Table 1, "NIOSH agreed…that the estimated co-worker external doses should be revised based on the guidance of ORAUT-OTIB-0020 [ORAUT 2005a] rather than the geometric mean of a distribution approach…"	

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	concentrations, it may be more appropriate to use the upper 95th percentile as the default exposure level.	We will look again at the available radon data and the information used to estimate exposures. We will make the compiled radon data and its subsequent re-analysis available for review.			
12/9	**(Section 5.1.2.11, p. 48) Lack of Comprehensive Uncertainty Analysis:** There are no uncertainties or potential errors estimated for different assumed parameters and factors used in the estimation of occupational internal dose in the site profile. An assessment of uncertainties, as required by OCAS-IG-001 and OCAS-IG-002, has not been adequately developed for air concentration and radon measurement data used in lieu of the absence of adequate bioassay data to assign internal dose.	We do not believe the information gathered to create the site profile is "inaccurate and uncertain," as stated in the review; however, we do acknowledge that dose reconstructions are based on the ability to define the exposure conditions and apply the appropriate measurement data. We further acknowledge that all measurements have some uncertainty associated with them, but note that this does not invalidate the measurements. Words such as "probably," "likely," and "assume" allow the reader to clearly see what was based on an author's judgment versus what was based on another record, and do not imply that	See Comment 4.	Open/Closed: **Closed** Comment: SC&A accepts NIOSH's response (Comment 2).	

Table 2: Linde Issue Resolution Tracking Matrix

Issue/ Finding (a),(b)	**SC&A Site Profile Review**[c] (SC&A 2006a)	**NIOSH Initial Response** (NIOSH 2007a)	**SC&A Summary of Actions per 3/26/07 Advisory Board Linde WG Meeting** (SC&A 2007a)	**SC&A Assessment of (NIOSH 2007b)**[d] (SC&A 2008a)	**Notes of the Linde Board Work Group Meeting, Las Vegas, NV, 1/1/08** (Roessler 2008)
		the resulting analysis is thought to be inaccurate and uncertain. University of Rochester and AEC's Health and Safety Laboratory (HASL) provided (or oversaw) the dosimetry measurements used in the internal dosimetry section of the site profile. OCAS-IG-001 does not generally apply to air concentration and radon measurements. OCAS-IG-002 discusses uncertainty, but states in Section 8.7. "It is important to remember at this point that if the preliminary overestimate or underestimate is conclusive, no uncertainty analysis is required since the estimate is already a bounding case." The site profile uranium intakes for unmonitored workers represent what we believed to be a bounding case. The uncertainty associated with the			

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		radon exposure assignments is encompassed by the defined parameters for the lognormal distribution. Detection thresholds are listed for the uranium urinalyses. Project documentation (OTIB-0060) [ORAUT 2007 in this document] provides generic information regarding assignment of bioassay uncertainties when fitting data with IMBA and when assigning doses in IREP. Further uncertainty analysis discussion is not likely to influence dose estimates. After another careful review of 42 CFR 81, 42 CFR 82, and OCAS-IG-002, we do not see that the assessment of uncertainties, which are encompassed by the distributions (including overestimates) of dose, are inadequately described in the site profile.			
13/8	**(Section 5.1.3, p. 49) Complex**	We agree that the evaluation of	SC&A will produce	Open/Closed: **Open**	**Closed**. SC&A had

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	Missed External Dose Surrogate System: The Linde Site Profile uses a very complex scheme to evaluate missed occupational external dose to Linde workers from 1942 to the present time. In this scheme, NIOSH/ORAU used a combination of film badge data, solid sample analysis results, and facility field measurements to estimate missed external doses to workers in different periods of the Linde operations. These data are, however, limited and, most importantly, not facility/building specific. Furthermore, the Linde Site Profile uses different sets of data to estimate worker beta and gamma doses separately.	unmonitored external dose is complicated, but note this is because of the different processes and monitoring data available for different eras of the Linde Ceramics operation. Although there was an early attempt to further complicate the analysis by incorporating building-specific information into the analyses, it was decided that for most unmonitored workers and unmonitored periods, it would not be feasible to associate specific workers for specific periods with specific buildings at a level that is even further refined (and more complicated) than is found in the current site profile.	specific questions to NIOSH to clarify/explain external dose model (as summarized in TBD Table 36).	Comment: SC&A had raised several questions about NIOSH's external dose model and summarized them in its draft report, SC&A 2007 [SC&A 2007b in this report]. Section 6.0 of the NIOSH response (NIOSH 2007) [NIOSH 2007b in this report] reproduces and responds to the six SC&A comments: Comment 1: NIOSH satisfactorily explains how it derived the factor of 3 and elaborates on why it chose that value, rather than a factor of 4. NIOSH notes that "the single value of 3 for both beta and gamma components was selected for simplicity of application. Since the predominant external radiation at Linde was from beta, use of 3 for the	six subcomments about NIOSH's external dose model. Three of NIOSH's responses were accepted. The three remaining ones were resolved as follows: *Subcomment 1*: In reference to factors for back-converting doses to an earlier stage in the cleanup process, SC&A (January review) concluded that it would be more accurate to use separate multiplication factors (4.01 for gamma and 1.29 for beta), rather than using a simplified 3.0 for both beta and gamma. NIOSH contends that any underestimate for gamma is overwhelmed by the overestimate for the dominant beta dose.

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				gamma component (as opposed to 4.01) is overshadowed by its application for the beta component (as opposed to 1.29)" (NIOSH 2007, Section 6.0) [NIOSH 2007b in this report]. SC&A still believes that, not withstanding some gain in simplicity from choosing a single multiplication factor, it would be more accurate to use separate multiplication factors for the beta and gamma components. Comment 2: SC&A accepts NIOSH's response. Comment 3: SC&A accepts NIOSH's explanation of why the 1976 survey was used. However, it is still not clear how the TBD (NIOSH 2006) [NIOSH 2006a in this report]	SC&A agreed that the simplified approach will be acceptable, since it produces the higher overall estimated dose. **Closed.** *Subcomment 3*: It was not clear to SC&A how one goes from Table 13 to Table 14 in the TBD. NIOSH explained it. SC&A accepted the explanation and said it is reasonable. **Closed.** *Subcomment 5*: SC&A said footnotes need to be clearer in TBD Table 36. NIOSH will address the footnotes. **Closed.**

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				Table 13 estimated beta and gamma dose rates referred to in table footnote *d* are derived from Table 14 Building 30 radiation survey values. Comment 4: SC&A accepts NIOSH's response. Comment 5: SC&A accepts NIOSH's response that "unfortunately, the footnotes are not clear enough to allow the reader to easily reproduce the listed values. It is recognized that this table will need to be clarified in any document revision" (NIOSH 2007, Section 6.0, Comment 5) [NIOSH 2007b in this report]. Comment 6: SC&A accepts NIOSH's response.	
14/8	**(Section 5.1.3.4, p. 58) Film**	To develop external dosimetry	See Comment 13. NIOSH	Open/Closed: **Closed**	

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	Badge Data: The use of the 1948 weekly film badge data for assigning both beta and gamma doses during the removal of equipment in Building 30 is not appropriate for the entire period from 1949 to 1954. These beta and gamma dose assignments in Table 36 contain median weekly photon doses and weekly median electron doses for use of unmonitored workers from 1942 to 1954. These dose assignments are not likely to capture the full range of external exposures during that time period. Table 36 is hardly representative of various facilities and job functions that defined Linde operations and processes. Another problem in Table 36 is that some of the beta and gamma doses cannot be reproduced or traced back to the original sources. For example, there is no explanation or discussion on how the 1947 and 1949 (beta/gamma/neutron) doses	models for unmonitored coworkers, the available film badge data from 1948–1949 (note there was a standby period from 8/1/46–9/14/47 and production did not start up until 11/1/1947) were initially considered by job category (more than 50 categories for the gamma results and more than 10 categories for beta). Because this scheme was judged to be generally too complicated for application, the work categories were then combined to obtain low, medium, and high groups according to job title. Note that when the work category cannot be determined, the high value would be used. This comment seems to ask for further assumptions (complications) to be considered, and to further break down the data to apply it to yet smaller work groups. Although the fact that this site is included in an SEC through	will also look at the application of ORAUT-OTIB-0020.	Comment: SC&A accepts NIOSH's response. NIOSH answered SC&A's comment on the use of film badge data by referring to its response to SC&A's Comment 13, and by stating in Table 1 that "NIOSH will relook at consistency with ORAUT-OTIB-20," *Use of Coworker Dosimetry Data for External Dose Assignment* (ORAUT 2005)[ORAUT 2005a in this report]. NIOSH discusses application of ORAUT-OTIB-0020 in Section 7.0 of its response (NIOSH 2007) [NIOSH 2007b in this report]. SC&A agrees that the OTIB should be applied appropriately to assign beta and gamma external doses where there is a lack of claimant-specific exposure data; any issues	

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	were calculated, since they are all based on 1947–1949 weekly film badge data presented in Table 29 and Table 31 of the site profile.	October 31, 1947, does not imply that our methods to assign individual doses from the available data should be less than rigorous, it does color our judgment regarding how much more detail needs to be (and can be supported) in the analyses. In addition, we feel that an unmonitored worker during the 1947–1949 period had a reduced likelihood of exposure from his/her monitored coworker. Table 36 does contain median beta and gamma values, but the instructions prior to the table state these values are to be used with a GSD of 3 (which produce a 95th percentile dose that is a factor of 6 greater than the median). The neutron doses are assumed to be constant. The derivation of the 1947–1949 beta and gamma doses is explained in the text of the sections with Tables 29 and		that may have arisen from SC&A's review of the OTIB itself are not considered here.	

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		31. The neutron doses are separately estimated and defined as upper bounds, and explained in Section 4.3 (although we now note that spontaneous fission was not specifically considered).			
15/8	**(Section 5.1.3.5, p. 60) Survey Measurement Data:** Several sets of survey measurement data were used in the Linde Site Profile to calculate the missed beta and gamma doses for workers from 1942 to 1954. These survey measurements do not cover the entire period of Linde operation. SC&A believes that NIOSH should improve the use of these film badge data, because significant gaps exist for time periods when workers were not monitored for external or internal exposure. In addition, NIOSH did not evaluate or attempt to evaluate the adequacy, uncertainty, and accuracy of these data. This	The Linde Ceramics source term consisted of uranium ore and its progeny, which is readily characterized and fairly straightforward to measure. Instrument surveys are almost always biased (unless particular measurement points are defined in advance), due to the fact that surveyors typically attempt to find and report values that represent the greatest exposure rate or contamination level. We believe that the application of a GSD of 3 to estimate unmonitored worker exposures adequately accounts for bias and uncertainty. A rigorous analysis of instrument accuracy, bias, and uncertainty	NIOSH will relook at consistency with ORAUT-OTIB-0020.	Open/Closed: **Closed** Comment: SC&A accepts NIOSH's response to "relook at consistency with ORAUT-OTIB-0020" (Table 1). NIOSH discusses application of ORAUT-OTIB-0020 (ORAUT 2005a in this report) in Section 7.0 of its response (NIOSH 2007) [NIOSH 2007b in this report].	

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	further weakens the assigned missed worker beta and gamma doses for the Linde workers.	[if such a rigorous study could be done for these instruments from the 1940s and 1950s] is unlikely to change compensability outcomes. [The comment in this matrix appears to confuse the subject by mentioning both survey instruments and film badge data, and it is not clear which film badge data are being referenced in the third sentence of this comment.]			
16/4	**(Section 5.1.3.6, p. 61) Time-Weighted Averages:** Time-weighted averages of external exposure values contain significant uncertainties and frequently fail to capture doses to workers in areas of high beta or gamma fields. In the external dosimetry section of the Site Profile, NIOSH determines the time-weighted average beta and gamma radiation dose rates during the standby period from 1946 to 1947 by time-weighting the dose rates with average worker	At this time, we are not aware of any such high-dose or high-risk tasks performed during the standby period. Time-weighting of exposures is common practice and does capture doses to workers in high beta and gamma exposure areas. Dosimetry worn by individuals "automatically" time-weights exposures. OCAS-IG-001 states for unmonitored workers, "At some facilities, radiation surveys were conducted and this data, in conjunction with	See Comment 4. Also, NIOSH will relook at whether there were any "high-risk"/"high-dose" tasks that were not considered.	Open/Closed: **Closed** Comment: SC&A accepts NIOSH's assessment of available records to identify any workers engaged in "high exposure tasks" during the standby period (1946–1947).	

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	exposure times and summing to yield annual time-weighted averages by job category (Davidson 2005, p. 41). This approach would certainly underestimate the dose rates for high-dose or high-risk tasks in which a claimant might have participated at the Linde Site.	frequency of exposure, should be used to estimate the annual dose," which means exposures should be time-weighted.			
17/O	**(Section 5.1.3.7, p. 61) Contaminated Burlap Bags:** During the interview in Buffalo, Linde site experts and past workers indicated that there were many thousands of used burlap bags stacked up in the open bay area behind Building 30 (see Attachment 3 of this review report). These burlap bags were used for transporting uranium ore to the Linde site for processing. After the end of the operation period, these contaminated burlap bags were stored behind Building 30 awaiting disposal. Many Linde workers, operation staff, and administrative personnel sat on these	Doses from relatively lightly contaminated burlap bags would not compare to the doses derived for the other sources at Linde. Consideration of exposures to the burlap bags was included in the dose calculations during the ore processing period, and the presence of these bags was noted and can be considered in individual dose reconstructions. Note that receipt of ore bags would not have occurred at Linde after July 31, 1946, although it's possible that the UO_2 (lower dose rate) would have been received in similar bags.	• NIOSH to investigate details of used burlap bags—which bags (formerly containing African or domestic ore) were stored at which location and during which periods of time. This may affect both internal and external exposures. Even though African ores were processed only during the SEC period (pre-10/31/1947), empty bags that had contained African ore may have been around longer (i.e., after	Open/Closed: **Open** Comment: Section 5.0 of the NIOSH response discusses the "burlap bag issue." NIOSH concludes that, "Based on the reviewed historical records, and considering the fact that the period during which the burlap bags were staged and burned is within the current SEC period, a revision to the current dose reconstruction methodology is not warranted" (NIOSH 2007, Section 5.0) [NIOSH 2007b in this report].	**Open.** SC&A has a concern that comes from a site expert interview, which states that the burlap bags used to bring "materials" to Linde were stored behind Building 30, and that workers would sit on these bags while resting or eating lunch. Other documents indicate that the bags had been removed after the SEC period. The WG decided that there is not enough information at this time to validate the site

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	contaminated bags during breaks and lunch periods over a period of many years. They definitely had been exposed at close distance to beta and gamma radiation sources left over in those uranium contaminated bags. The Linde Site Profile does not estimate the missed beta and gamma doses to workers resulting from sitting or standing next to those contaminated burlap bags.		1950). • NIOSH to determine whether there was an on-site incinerator to burn used burlap bags and, if so, the possible effects on internal and external exposures.	This, however, does not adequately respond to the site expert interview assertion that thousands of burlap bags were still stacked behind Building 30 after 1950; as stated in the SC&A site profile review: "During the MED period, they stacked all the contaminated burlap bags in storage area of Building 30. These contaminated burlap bags were kept in there until they were removed to be burned in the incinerator in the late 1950s. Many of the people working in Building 30, including operation personnel, secretaries, and maintenance workers, would sit on those bags resting or eating their lunch. This went on for many years" (SC&A 2006, Attach. 3, p. 112) [SC&A 2006a in this	expert's statement. NIOSH was asked to summarize all the facts on this issue and meet with SC&A to resolve it. A technical call will be set up as soon as possible between SC&A and NIOSH. WG members can participate.

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				report].	
18/7	**(Section 5.1.3.8, p. 62) Surrogate External Exposure Data:** The lack of complete film badge data for the period from 1942 to 1954 at Linde Site represents a period for which the potential for unaccounted beta and gamma doses is greatest. NIOSH's use of pre-cleanup survey data for the pre-production period from 1942 to 1943, the use of eight solid ore samples data for the period from 1943 to 1946, the use of a 1-day survey data in six locations in Building 30 for the period from 1946 to 1947, the use of two 1-day pre-cleanup survey data after vacuuming and flushing in Building 30 for 1949, and the use of post-decontamination survey data for 1950 is complex, over-reaching, inadequately supported, and, likely, not claimant favorable. In addition, the use of the 1948 film badge data collected	We believe this comment does not accurately reflect the basis or the considerations that went into developing the exposure estimates for unmonitored workers. Although the assigned doses are, in some cases, based on a single study, it is important to realize that many records were reviewed before these studies were selected to derive unmonitored worker dose estimates. In addition, it should be noted that the estimates of doses are assumed to be central estimates in a lognormal distribution with a GSD of 3. During the period 1942 to May 1943, production had not yet started at the Ceramics Plant, but because there was a possibility of spread of contamination from the Tonawanda Laboratories, estimates of exposure levels from contamination measured	See Comment 13.	Open/Closed: **Closed** Comment: SC&A accepts NIOSH's response, covered under Section 6.0, on the external dose model.	

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	during the removal of equipment in Building 30 for assigning both beta and gamma doses for the period from 1949 to 1954 is not appropriate, because these data do not account for external exposures to contaminated burlap bags, contaminated soil, and other contaminated sources during the clean-up activities.	in later years were made. The eight-sample contact measurements used as the basis of beta dose estimates are samples of materials generated or used in different parts of the uranium processing and are not all ores. These contact measurements provide actual information regarding potential exposures in different parts of the process. We believe the estimates of doses for unmonitored workers are reasonable and tend to be claimant favorable.			
19/6	**(Section 5.1.3.9, p. 62) Assigned Work Hours:** The Linde Site Profile states in Table 4 (Davidson 2005, p. 24) and several other sections that workers had longer workweeks than the standard 40 hours; as high as 9 hours per day, 6 days a week, and 50 weeks per year. However, in calculating external exposure values,	Because work hours changed over time, and because workers did not all work the same number of hours, and because exposure hours are not always the same as work hours, we don't agree with this comment. As noted in the response to Comment 9, the work periods	See Comment 9.	Open/Closed: **Closed** Comment: SC&A accepts NIOSH's response.	

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	NIOSH uses different work-hour values. SC&A believes that applying these different work-hour values to the missed occupational external dose estimation would underestimate the eventual missed dose or exposure assignments. NIOSH should use a set of consistent and claimant-favorable work hours for use in the dose reconstruction.	in Table 4 include lunch periods and other non-operational periods during which exposures are likely to be lower. Parameters used in deriving exposure estimates are included in the site profile and can be modified based on claim-specific details. The assumption that unmonitored workers were exposed to what were judged as favorable estimates of intakes and exposure rates appeared to adequately balance this concern when the site profile was developed, but this issue will be reviewed in conjunction with other items noted in these responses.			
20/11	**(Section 5.1.3.10, p. 63) Geometric Values:** The geometrical approach used in the Linde Site Profile is not bounding and, most importantly, not claimant favorable. In Tables 13, 14,	1. Although the reviewers did not have access to the data and calculations to support the resulting quantities, this should not be a basis for inference that such information	NIOSH will review the GM vs. 95th percentile model based on the guidance of ORAUT-OTIB-020 (see also Comments 11 and 15).	Open/Closed: **Closed** Comment: SC&A accepts NIOSH's response to apply the coworker model in ORAUT-OTIB-0020	

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	15, 17, 18, 21, 23, 24, 25, 26, 29, 30, 31, 32, and 33, the site profile lists the GM or the GSD values for various assigned default assumptions. First, there are no supporting calculations or data to show how these geometrical quantities are calculated. Second, the geometrical approach does not provide maximized default values to arrive at claimant-favorable worker doses. Third, NIOSH does not provide a comparison of this geometrical approach with NIOSH-prescribed 95th percentile values. NIOSH should re-evaluate the uncertainties associated with this geometrical approach.	does not exist. 2. There is no requirement that we can find to estimate maximum doses for unmonitored workers. The regulations, guidance, procedures, and the IREP input sheet allow for dose distributions to be assigned. 3. At the time the Linde external exposure coworker model was initially issued (May 2005), ORAUT-OTIB-0020 (October 2005) was not issued). After reviewing this reference, we note that for coworker studies there are three categories of exposure to be considered: "the 50th percentile doses are to be applied if the worker was likely exposed intermittently, and the 95th percentile doses are to be applied if the		(ORAUT 2005).	

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		worker was likely exposed routinely. External on-site ambient doses are to be used instead of external coworker doses if the worker was unlikely to have been exposed." We agree, based on this 'new to the site profile team' information, that the estimated coworker doses in the Linde site profile should be revisited.			
21/9	**(Section 5.1.3.11, p. 63) Lack of Comprehensive Uncertainty Analysis:** An assessment of uncertainties, as required by OCAS-IG-001 and OCAS-IG-002, has not been adequately developed for air concentration and radon measurement data used in lieu of bioassay data to assign internal dose; and, for external exposure data (including film badge beta and gamma measurements, and survey measurements) used to assign	We do not believe the information gathered to create the site profile is "uncertain" as stated in the review; however, we do acknowledge that dose reconstructions are based on the ability to define the exposure conditions and apply the appropriate measurement data. We further acknowledge that all measurements have some uncertainty associated with them, but note that this does not invalidate the	See Comment 12.	Open/Closed: **Closed** Comment: SC&A accepts NIOSH's response.	

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	external dose.	measurements. Words such as "probably," "likely," and "assumes" allow the reader to clearly see what was based on an author's judgment versus what was based on another record, and do not imply that the resulting analysis is thought to be inaccurate and uncertain. OCAS-IG-001 does not generally apply to air concentration and radon measurements. Further uncertainty analysis/discussion is not likely to influence dose estimates. After another careful review of 42 CFR 81, 42 CFR 82, and OCAS-IG-001, we do not see that the assessment of uncertainties, which are encompassed by the lognormal distributions and GSDs of 3 for beta and gamma doses, and in the overestimating nature of the neutron doses, are			

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Issue/ Finding [a],[b]	SC&A Site Profile Review[c] (SC&A 2006a)	NIOSH Initial Response (NIOSH 2007a)	SC&A Summary of Actions per 3/26/07 Advisory Board Linde WG Meeting (SC&A 2007a)	SC&A Assessment of (NIOSH 2007b)[d] (SC&A 2008a)	Notes of the Linde Board Work Group Meeting, Las Vegas, NV, 1/1/08 (Roessler 2008)
		inadequately assessed for the purpose of compensation determination.			
22/10	**(Section 5.1.4.1, p. 64) Outdoor Doses:** The Linde Site Profile does not address missed occupational environmental doses to workers. NIOSH did evaluate several potential outdoor beta and gamma exposures to workers, but, in some cases, NIOSH ignores the outdoor doses (Section 4.1.3.1.2, p. 46; Section 4.1.3.2.2, p. 54) after the doses are calculated.	Estimates of external exposures that might have been received outdoors are included in the Linde Ceramics site profile, and these estimates are specifically added to dose estimates for the exposure periods prior to production in 1943 and after production in 1946. The outdoor exposure estimates for the 1943–1946 period are 0.1 rem/y beta and 0.02 R/y gamma, as compared to the assigned medians of 3 to 74 rem/y beta and 5.35 R/y gamma, which are both assigned a GSD of 3 (which means the 95th percentile is a factor of 6 times the median). Further, it is noted that outdoor exposures are not typically included separately in estimated external dose totals in other site profiles, because these are typically either monitored by dosimetry or	NIOSH will investigate whether it has accounted for all outdoor sources (e.g., waste piles, ore piles, incinerators, burlap bags).	Open/Closed: **Open** Comment: SC&A asked NIOSH to investigate further outdoor (environmental) doses to workers. Section 9.0 notes that "raffinates were moved off site (see Section 4.0)" (NIOSH 2007, Section 9.0) [NIOSH 2007b in this report]. However, SC&A would like further consideration given to the burlap bag issue raised in Comment 17.	**Open**. SC&A agreed that this Comment can be closed when Comment 17 is closed.

Table 2: Linde Issue Resolution Tracking Matrix

Issue/ Finding (a),(b)	**SC&A Site Profile Review**[c] (SC&A 2006a)	**NIOSH Initial Response** (NIOSH 2007a)	**SC&A Summary of Actions per 3/26/07 Advisory Board Linde WG Meeting** (SC&A 2007a)	**SC&A Assessment of (NIOSH 2007b)**[d] (SC&A 2008a)	**Notes of the Linde Board Work Group Meeting, Las Vegas, NV, 1/1/08** (Roessler 2008)
		considered to be within the assigned uncertainty of the dose estimate.			

Notes:

(a) "Issues" are referred to as "Comments" in some documents.

(b) "O" denotes Observation.

(c) SC&A 2006a (SC&A's Site Profile Review) examined NIOSH 2005a (NIOSH's Rev. 0 Site Profile).

(d) NIOSH 2007b, which SC&A 2008a responds to, is not included in this table, since NIOSH addresses the issues by topic rather than issue number.

Table 3: Comparison of an Exposure Matrix for Linde Ceramics Plant (Including Tonawanda Laboratory), ORAUT-TKBS-0025, Rev. 1 (NIOSH 2008a) to Rev. 0 (NIOSH 2005a) (reproduced from SC&A 2009a)			
Item Description	**Comment**	**ORAUT-TKBS-0025 Rev. 0 Text**	**ORAUT-TKBS-0025 Rev. 1 Text**
Publication Record	Additional information on revisions to Document 01		Approved revision to change from a page change revision (Rev. 00 PC-2-B) to a total rewrite (Rev. 01-A) as a result of formal NIOSH review. Revised to incorporate (1) change in facility designation, (2) DOL interpretation of applicability of residual period to Ceramics Plant, (3) resolution of Advisory Board Working Group comments, and (4) clarified the implementation instructions for SEC00044 for the period October 1, 1942 through October 31, 1947. Incorporates formal internal and NIOSH review comments. Constitutes a total rewrite of the document. Training required: As determined by the Task Manager. Initiated by Joseph S. Guido.
1.0 Introduction	Rev. 01 has additional language indicating disclaimers to designations of DOE/Atomic Weapons Facilities.	N/A	In this document, the word "facility" is used as a general term for an area, building, or group of buildings that served a specific purpose at a site. It does not necessarily connote an "atomic weapons employer facility" or a "Department of Energy [DOE] facility" as defined in the Energy Employees Occupational Illness Compensation Program Act [EEOICPA; 42 U.S.C. § 7384l(5) and (12)]. EEOICPA defines a DOE facility as "any building, structure, or premise, including the grounds upon which such building, structure, or premise is located … in which operations are, or have been, conducted by, or on behalf of, the Department of Energy (except for buildings, structures, premises, grounds, or operations … pertaining to the Naval Nuclear Propulsion Program)" [42 U.S.C. § 7384l(12)]. Accordingly, except for the exclusion for the Naval Nuclear Propulsion Program noted above, any facility that performs or performed DOE operations

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Item Description	**Comment**	**ORAUT-TKBS-0025 Rev. 0 Text**	**ORAUT-TKBS-0025 Rev. 1 Text**
			of any nature whatsoever is a DOE facility encompassed by EEOICPA. For employees of DOE or its contractors with cancer, the DOE facility definition only determines eligibility for a dose reconstruction, which is a prerequisite to a compensation decision (except for members of the Special Exposure Cohort). The compensation decision for cancer claimants is based on a section of the statute entitled "Exposure in the Performance of Duty." That provision [42 U.S.C. § 7384n(b)] says that an individual with cancer "shall be determined to have sustained that cancer in the performance of duty for purposes of the compensation program if, and only if, the cancer … was at least as likely as not related to employment at the facility [where the employee worked], as determined in accordance with the POC [probability of causation1] guidelines established under subsection (c) …" [42 U.S.C. § 7384n(b)]. Neither the statute nor the probability of causation guidelines (nor the dose reconstruction regulation, 42 CFR Part 82) define "performance of duty" for DOE employees with a covered cancer or restrict the "duty" to nuclear weapons work (NIOSH 2007a). The statute also includes a definition of a DOE facility that excludes "buildings, structures, premises, grounds, or operations covered by Executive Order No. 12344, dated February 1, 1982 (42 U.S.C. 7158 note), pertaining to the Naval Nuclear Propulsion Program" [42 U.S.C. § 7384l(12)]. While this definition excludes Naval Nuclear Propulsion Facilities from being covered under the Act, the section of EEOICPA that deals

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Item Description	Comment	ORAUT-TKBS-0025 Rev. 0 Text	ORAUT-TKBS-0025 Rev. 1 Text
			with the compensation decision for covered employees with cancer [i.e., 42 U.S.C. § 7384n(b), entitled "Exposure in the Performance of Duty"] does not contain such an exclusion. Therefore, the statute requires NIOSH to include all occupationally derived radiation exposures at covered facilities in its dose reconstructions for employees at DOE facilities, including radiation exposures related to the Naval Nuclear Propulsion Program. As a result, all internal and external occupational radiation exposures are considered valid for inclusion in a dose reconstruction. No efforts are made to determine the eligibility of any fraction of total measured exposure for inclusion in dose reconstruction. NIOSH, however, does not consider the following exposures to be occupationally derived (NIOSH 2007a): • Background radiation, including radiation from naturally occurring radon present in conventional structures • Radiation from x-rays received in the diagnosis of injuries or illnesses or for therapeutic reasons Under EEOICPA, employment at an AWE facility is categorized as either (1) during the DOE contract period (i.e., when the AWE was processing or producing material that emitted radiation and was used in the production of an atomic weapon), or (2) during the residual contamination period (i.e., periods that NIOSH has determined there is the potential for significant residual contamination after the period in which weapons-related production occurred). For contract period employment, all occupationally derived radiation exposures at covered facilities must be included in dose

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Item Description	**Comment**	**ORAUT-TKBS-0025 Rev. 0 Text**	**ORAUT-TKBS-0025 Rev. 1 Text**
			reconstructions. This includes radiation exposure related to the Naval Nuclear Propulsion Program and any radiation exposure received from the production of commercial radioactive products that were concurrently manufactured by the AWE facility during the covered period. NIOSH does not consider the following exposures to be occupationally derived (NIOSH 2007a): • Background radiation, including radiation from naturally occurring radon present in conventional structures • Radiation from x-rays received in the diagnosis of injuries or illnesses or for therapeutic reasons For employment during the residual contamination period, only the radiation exposures defined in 42 U.S.C. § 7384n(c)(4) [i.e., radiation doses received from DOE-related work] must be included in dose reconstructions. Doses from medical x-rays are not reconstructed during the residual contamination period (NIOSH 2007a). It should be noted that under subparagraph A of 42 U.S.C. § 7384n(c)(4), radiation associated with the Naval Nuclear Propulsion Program is specifically excluded from the employee's radiation dose. This exclusion only applies to those AWE employees who worked during the residual contamination period. Also, under subparagraph B of 42 U.S.C. § 7384n(c)(4), radiation from a source not covered by subparagraph A that is not distinguishable through reliable documentation from radiation that is covered by subparagraph A is considered part of the employee's radiation dose. This site profile covers only exposures resulting from nuclear weapons-related

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Item Description	**Comment**	**ORAUT-TKBS-0025 Rev. 0 Text**	**ORAUT-TKBS-0025 Rev. 1 Text**
			work. Exposures resulting from non-weapons-related work, if applicable, will be covered elsewhere.
1.1	Purpose Added to Rev. 1 Also disclaimers on infeasibility of dose reconstruction prior to 1947		This site profile document provides an exposure matrix for workers at the Tonawanda Laboratory and Linde Ceramics Plant facilities of the Linde Air Products Company (LAPC) in Tonawanda, New York. NIOSH has determined, and the Secretary, Health and Human Services has concurred, that it is not feasible to reconstruct internal radiation dose for "Atomic weapons employees who worked at the Linde Ceramics Plant from October 1, 1942, through October 31, 1947, and who were employed for a number of work days aggregating at least 250 work days either solely under this employment or in combination with work days occurring within the parameters (excluding aggregate work day requirements) established for other classes of employees included in the SEC" (HHS 2005). Subsequent correspondence (Elliott 2006) confirms that the Tonawanda Laboratory (as well as all other buildings on the Linde Site) are included in this class designation (cohort). Reconstruction of external exposure (including medical x-ray examinations) has been determined to be feasible (HHS 2005). For any claim referred to NIOSH regarding an employee, (1) who was employed during the Cohort period, but because of limited employment during this period, is not a member of the Cohort, or (2) who is a member of the Cohort and whose cancer is not defined as a specified cancer under EEOICPA

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Item Description	Comment	ORAUT-TKBS-0025 Rev. 0 Text	ORAUT-TKBS-0025 Rev. 1 Text
			(and so is not eligible for compensation under EEOICPA without a dose reconstruction), NIOSH will continue to attempt to complete a dose reconstruction for the exposure period based solely on external and medical x-ray radiation sources. However, because of the SEC determination (HHS 2005) that it is infeasible to adequately reconstruct internal dose during the period October 1, 1942 through October 31, 1947, dose estimates for this period are considered partial dose estimates.
1.2	Scope Added to Rev. 1		This document covers both facilities. The information in this site profile supports the assumed operational and residual contamination periods listed below. DOL has determined that the residual contamination period for the Tonawanda Laboratory is also applicable to the Ceramics Plant (Turcic 2008). Although cleanup activities at the Ceramics Plant continued into July of 1954, the designated covered period for this facility ends in 1953. Post-1953 exposures are also covered under the EEOICPA, but this period is termed the residual exposure period. Because the activities and exposure potential at the Ceramics Plant during the first part of 1954 (January 1 through July 7) are the same as in the immediately previous period (1950 to 1953), information on reconstruction of dose for the period from January 1 through July 7 is included in the operational period section of this document. The instructions in this document for reconstruction of dose at the Ceramics Plant during the residual period (as defined by DOL as starting on January 1, 1954) pertain to exposures starting after July 7, 1954. July 7, 1954 is used as the definitive end of the

Table 3: Comparison of an Exposure Matrix for Linde Ceramics Plant (Including Tonawanda Laboratory), ORAUT-TKBS-0025, Rev. 1 (NIOSH 2008a) to Rev. 0 (NIOSH 2005a) (reproduced from SC&A 2009a)			
Item Description	**Comment**	**ORAUT-TKBS-0025 Rev. 0 Text**	**ORAUT-TKBS-0025 Rev. 1 Text**
			decontamination period at the Ceramics Plant, based on the date of the final survey of the facility, which is documented in a memorandum from the New York Operations Office (NYOO) to Union Carbide that asserts that the decontamination requirements of the contract were fulfilled (Eisenbud 1954). Section 2.0 describes the site and its operational history. Sections 3.0 and 4.0 describe estimation of internal and external exposure from 1942 to July 7, 1954, respectively. Section 5.0 describes occupational medical exposure. Section 6.0 provides information on exposures during the residual contamination period after 1953. Attributions and annotations, indicated by bracketed callouts and used to identify the source, justification, or clarification of the associated information, are presented in Section 7.0. Attachment A contains data that was used in analyzing exposures of workers to beta radiation. Attachment B lists codes and special terminology in the LAPC records. Attachment C shows data sources on uranium progeny concentrations, and Attachment D provides a uranium coworker assessment for November 1947 to January 1950. Attachment E provides an assessment of dose consequences from uranium ore bag that were stored on the site during the post-operations period.
2.6	Additional Narrative on Decontamination During MED/AEC contract period doesn't appear in Rev. 1	This document assumes the end date of the Ceramics Plant cleanup period to be the date of turnover of the four Ceramics Plant production buildings to Linde for its use. This date is sometimes stated as 1953 (see, for example, ACE Buffalo 2004a, Response to Question 4).	

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Item Description	**Comment**	**ORAUT-TKBS-0025 Rev. 0 Text**	**ORAUT-TKBS-0025 Rev. 1 Text**
		However, Harris (1954) indicates that the decontamination of Building 38 was not complete as of April 1954. For dose reconstruction, it is assumed that turnover did not occur until December 31, 1954.	
3.0	Change in estimation of Internal exposure to remove dates prior to 11-1-1947. Also change in last sentence.	This section develops parameters for reconstruction of doses due to internal exposures from October 1, 1942, the assumed start date of MED work at Linde, until December 31, 1954, the assumed date of initial cleanup completion and building turnover from MED/AEC to Linde. …..Continued lower level exposures to uranium progeny and to radon are assumed, because some radioactive waste was disposed on site and because initial cleanup was not completed until the end of 1954; however, for the Ceramics Plant, the uranium exposures would have dominated during the 1947 to 1954 period.	This section develops parameters for reconstruction of doses due to internal exposures from November 1, 1947, until July 7, 1954. HHS has determined, and NIOSH has concurred, that it is not feasible to reconstruct internal exposure prior to November 1, 1947 (HHS 2005). …Continued lower-level exposures to uranium progeny and to radon were assumed, because some radioactive waste was disposed of on the site, and because initial cleanup was not completed until the end of 1954; however, for the Ceramics Plant, the uranium exposures would have dominated during the post-1946 period.
3.1	Detail from Rev. 00 removed from Rev. 01, including dose reconstruction standards.	As of this writing, the pre-1947 operational period intakes are reserved. Therefore, the pre-1947 information is provided only as a description of what the likely upper bound exposures might have been, and is not currently planned for use in Linde dose reconstruction. Document No. ORAUT-TKBS-0025 Revision 00, Effective Date: 05/31/2005 Page 28 of 94 for the pre-1947 period, the MAC would have been assumed to be based on inclusion of uranium's alpha emitting progeny. Although short-term exposures might have exceeded 300 MAC, it is very unlikely that long-term exposures would have. A review of the predicted urinalyses, kidney	After the ore processing, Linde began a standby period. It was assumed that exposures decreased to 0.1 MAC at the Tonawanda Laboratory after cleanup in 1946 until December 31, 1953. Based on reviews of later air concentrations at Linde and reviews of air concentration data from other sites, most workers' exposures would have been much lower during these periods. The standby period at Linde Ceramics was assumed to end on September 14, 1947. Rehabilitation of the Step III process was assumed to begin on September 15, 1947, and continue through October 31, 1947.

Table 3: Comparison of an Exposure Matrix for Linde Ceramics Plant (Including Tonawanda Laboratory), ORAUT-TKBS-0025, Rev. 1 (NIOSH 2008a) to Rev. 0 (NIOSH 2005a) (reproduced from SC&A 2009a)			
Item Description	**Comment**	**ORAUT-TKBS-0025 Rev. 0 Text**	**ORAUT-TKBS-0025 Rev. 1 Text**
		burdens, and lung burdens, indicate that it is highly unlikely that an individual would have sustained exposures like these for any length of time. Evidence of sustained exposure to the more soluble uranium compounds might have shown up in the medical urinalyses, as increases in proteins and glucose in the urine (note that other conditions can also account for these increases). The assumption of air concentrations at 300 MAC seems adequate to provide a quick estimate of exposure, and although the Type F uranium bioassay results are high, they do not seem inconceivable for some workers during this early period. However, it is also likely that Linde workers were exposed to a mixture of uranium absorption types. The analysis of radium exposures in Section 3.8 is partially based on the assumption of alpha activity air concentrations of 300 MAC during Linde's ore processing period. After the ore processing, Linde began a standby period. It was initially and arbitrarily assumed that exposures decreased to 1 MAC during the standby period at the Ceramics Plant, and that exposures decreased to 0.1 MAC at the Tonawanda Laboratory after cleanup in 1946 until the end of cleanup at the Ceramics Plant in 1954. Based on reviews of later air concentrations at Linde, and reviews of air concentration data from other sites, it is believed that most workers' exposures would have been much lower during these periods. The standby period at Linde Ceramics was assumed to end on September 14, 1947. Rehabilitation of the Step III process was assumed	

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Item Description	**Comment**	**ORAUT-TKBS-0025 Rev. 0 Text**	**ORAUT-TKBS-0025 Rev. 1 Text**
		to begin on September 15, 1947 and continue through October 31, 1947. Intakes from the standby and rehabilitation periods are reserved. Beginning November 1, 1947 at Linde Ceramics, workers were assumed to be exposed to 33 MAC and it was assumed this exposure continued through cleanup in 1954. Uranium progeny are not included in this later period, because only refined uranium was used and because the dose from intakes of contamination left from earlier work would have been insignificant compared to the dose to uranium during operations. To simplify calculations, it assumed that the workweek was 40 hours long during all years, although it is likely that the workweek for many was in excess of 40 hours especially during the earlier years. The assumed air concentrations are sufficiently large to account for any differences in actual hours exposed. Dose reconstructions should assume International Commission on Radiological Protection (ICRP) Publication 66 default parameters for particle deposition (ICRP 1994).	
3.2.1	Rewording of sentence	Note that it is possible that the January 1948 determination level of 0.1 mg/L is a typographical error, because this is the same as the determination level reported for (nonradioactive) fluoride urinalysis, and because there seems to be no change in the format of the numbers reported.	The January 1948 determination level of 0.1 mg/L is assumed to be a typographical error because this is the same as the determination level reported for (nonradioactive) fluoride urinalysis and because there seems to be no change in the format of the reported numbers.
3.2.1	Additional data in Rev. 01	NA	Analysis of Coworker Bioassay Data for Internal Dose Assignment (ORAU 2005d) describes the

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Item Description	Comment	ORAUT-TKBS-0025 Rev. 0 Text	ORAUT-TKBS-0025 Rev. 1 Text
			general process used for analyzing bioassay data for assigning doses to individuals based on coworker results. Bioassay results described above were analyzed in accordance with this procedure (Attachment D). The results of this analysis are presented in Tables 3-1 and 3-2. Individual uranium urinalysis results should be used to determine internal exposure to the individual when they are available. Where individual results are not available, the coworker data included in Attachment D and summarized in Tables 3-1 and 3-2 are to be used to estimate internal exposures that are favorable to claimants. Table 3-1. Chronic intake rate for Type M uranium (pCi/d). Start date | End date | 50th-percentile value | GSD 11/01/1947 | 07/07/1954 | 74 | 4.0 Table 3-2. Chronic intake rate for Type S uranium (pCi/d). Start date | End date | 50th-percentile value | GSD 11/01/1947 | 07/07/1954 | 1884 | 4.3
3.3	Disclaimer on Radium in Rev. 01	All radium compounds are lung absorption Type M. Radon breath analyses have been used to provide information on the amount of radium in the body and are available for some Linde workers. Assignment of radium exposures when radon breath analyses are not available or cannot be interpreted is addressed below in Section 3.4.	HHS has determined, and NIOSH has concurred that it is not feasible to reconstruct internal exposure prior to November 1, 1947 (HHS 2005). Information on radon exposure prior to November 1, 1947, is provided only as a basis for extrapolation afterwards and is not intended to be used during the period in which reconstruction of internal dose has been determined to be infeasible.

Table 3: Comparison of an Exposure Matrix for Linde Ceramics Plant (Including Tonawanda Laboratory), ORAUT-TKBS-0025, Rev. 1 (NIOSH 2008a) to Rev. 0 (NIOSH 2005a) (reproduced from SC&A 2009a)

Item Description	Comment	ORAUT-TKBS-0025 Rev. 0 Text	ORAUT-TKBS-0025 Rev. 1 Text
3.4	Data on Uranium Progeny in Rev. 00 deleted and replaced by disclaimer in Rev. 01.	In the absence of data on exposures to uranium progeny, their intake rates are determined by assuming secular equilibrium. Table 5 lists equilibrium-based ratios for uranium progeny of particular interest in dose reconstruction. Absorption types for their likely chemical forms are also shown. The intake ratios provide reasonably realistic estimates of intakes of progeny due to dust from African ore. The uranium activity fractions overestimate relative intakes of most progeny when the dust is from preprocessed domestic ore. They may underestimate intakes of progeny when the dust is from filter cakes or waste products that contain uranium progeny, but very little uranium. The ratios in Table 5 are for use for the entire 1943–1946 production period for all workers, even though only about 70% of the ore processed was African ore (see Section 2.3.2) and many workers handled only refined uranium materials. This, along with the claimant-favorable assumptions made in the estimation of worker dust exposures, is judged to provide sufficient overestimation to balance any underestimation associated with the handling of waste products. Note that the uranium fractions are applied when the activity of uranium is known. The activity fractions for gross alpha are applied to data measured as alpha activity. Table 5. Intake ratios and absorption types for uranium progeny. Nuclide | Uranium activity fractions | Gross alpha activity fractions | Absorption type U-natural | 1 | 4.02E-01 | F, M, S Th-230 | 4.89E-01 | 1.96E-01 | M, S Ra-226 | 4.89E-01 | 1.96E-01 | M Po-210 | 4.89E-01 | 1.96E-01 | F,M Pa-231 | 2.28E-02 | 9.16E-03 | M, S Ac-227 | 2.28E-02 | 9.16E-03 | F, M, S	**<u>Ceramics Plant 1943 to 1946 Production, and Tonawanda Laboratories</u>** HHS has determined, and NIOSH has concurred, that it is not feasible to reconstruct internal exposure prior to November 1, 1947 (HHS 2005).

Table 3: Comparison of an Exposure Matrix for Linde Ceramics Plant (Including Tonawanda Laboratory), ORAUT-TKBS-0025, Rev. 1 (NIOSH 2008a) to Rev. 0 (NIOSH 2005a) (reproduced from SC&A 2009a)

<table>
<tr><th>Item Description</th><th>Comment</th><th>ORAUT-TKBS-0025 Rev. 0 Text</th><th>ORAUT-TKBS-0025 Rev. 1 Text</th></tr>
<tr><td>3.4</td><td>More detail on production and cleanup in Rev. 01</td><td><u>Ceramics Plant 1947–1949 Step III Production, and Subsequent Initial Cleanup</u>
During this period, refined uranium materials were handled. None of the progeny listed in Table 5 would have been present in significant quantities, compared to the uranium at the Ceramics Plant.</td><td><u>Ceramics Plant 1947 to 1949 Step III Production and Subsequent Initial Cleanup</u>
During this period, refined uranium materials were handled. None of the uranium progeny would have been present in significant quantities in the refined uranium materials but, to account for uranium progeny potentially present from past activities and resuspended during decontamination and decommissioning (D&D) activities, data from the postoperations period was reviewed to determine bounding activity ratios (Attachment E). Table 3-3 presents bounding indoor uranium progeny ratios.
Document No. ORAUT-TKBS-0025 Revision No. 01 Effective Date: 11/04/2008 Page 32 of 102 for use for dose reconstruction for the period from November 1, 1947, through July 7, 1954. The values in this table were the highest observed values from the indoor and storm sewer sampling locations.
Table 3-3. Progeny to uranium ratios.
<table><tr><th>Progeny/U (total)</th><th>Ratio to uranium</th></tr><tr><td>Th-230/U</td><td>0.26</td></tr><tr><td>Ra-226/U</td><td>0.21</td></tr><tr><td>Po-210/U[a]</td><td>0.21</td></tr><tr><td>Ac-227/U</td><td>0.29</td></tr><tr><td>Pa-231/U</td><td>0.01</td></tr></table>a. Po-210 activity not reported, assumed to be the same as parent (Ra-226)</td></tr>
<tr><td>3.5</td><td>Disclaimer on Radon added to Rev. 01</td><td></td><td>HHS has determined, and NIOSH has concurred that it is not feasible to reconstruct internal exposure prior to November 1, 1947 (HHS 2005). Information on radon exposure prior to November 1, 1947 is provided only as a basis for extrapolation afterwards and is not intended to be used during the period in</td></tr>
</table>

Table 3: Comparison of an Exposure Matrix for Linde Ceramics Plant (Including Tonawanda Laboratory), ORAUT-TKBS-0025, Rev. 1 (NIOSH 2008a) to Rev. 0 (NIOSH 2005a) (reproduced from SC&A 2009a)

Item Description	Comment	ORAUT-TKBS-0025 Rev. 0 Text	ORAUT-TKBS-0025 Rev. 1 Text
			which reconstruction of internal dose has been determined to be infeasible.
3.5.1	Detail on analysis methodology not carried through to Rev. 01	To simplify, this analysis assumes that workers, who were likely to spend the majority of their time in process areas, or in boxcars (where some of the highest radon levels were measured, about 200 times tolerance), or whose jobs were unknown, were exposed to 99.3 pCi/L of radon for 2,040 hours (12 work-months) per year prior to standby. Workers who did not work or have their offices in the process buildings are assumed to have been exposed to 22.4 pCi/L of radon prior to standby. Because a job in current times might not be in or near a process area, does not mean the same held true 60 years ago. Nurses, some stenographers, launderers and seamstresses, and some clerical workers had jobs or locations that put them in contact with the uranium and progeny (Homes 1944b). The initial period of African ore processing was followed by a second period of domestic ore processing. Thirteen measurements of radon concentration during the domestic ore processing were available. The GM of the measurements, assuming the <LOD values were equal to the LOD, was 9.1 pCi/L. To estimate exposure during this domestic ore processing period, both indoor and outdoor radon concentrations were assumed to be 10 pCi/L.	N/A

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Item Description	Comment	ORAUT-TKBS-0025 Rev. 0 Text	ORAUT-TKBS-0025 Rev. 1 Text
		Table 7. Ceramics Plant worker radon exposures rates, 1942-1954. Period/work location | Time-weighted concentration (pCi/L) | Exposure rate (WLM/y) 10/1/1942 to 7/31/1946 In process and research areas | 99.3 | 4.76 Not in process and research areas | 22.4 | 1.08 8/1/1946 to 12/13/1954 All workers | 10.0 | 0.480	
3.5.1	Pre-1947 Radon rates deleted from table in Rev. 01	Table 8 summarizes the assumed radon concentrations and resulting exposures. Table 8. Tonawanda Laboratory radon exposure rates, 1942-1954 Period (Start | End) | Time-weighted concentration pCi/L | Exposure rate (WLM/y) R&D and cleanup 10/01/42 | 12/31/46 | 42.5 | 2.04 Post-cleanup 01/01/47 | 12/31/54 | — | 0.202	Table 3-5. Ceramics Plant worker radon exposures rates, 1947 to 1954. Period/work location | Time-weighted concentration (pCi/L) | Exposure rate (WLM/yr) 11/01/1947–07/07/1954 All workers | 10.0 | 0.480
3.6	Pre-1947 Inhalation Intake Estimates of Particulates Removed from Rev. 01	Table 9. Assumed airborne concentrations used to estimate intakes. Start | End | Activity description | # MAC | alpha dpm/m³ | Source Ceramics plant 10/1/1942 | 7/31/1946 | Uranium ore processing | Reserved | Reserved | Uranium and progeny 8/1/1946 | 9/14/1947 | Standby | Reserved | Reserved | Uranium and progeny 9/15/1947 | 10/31/1947 | Rehabilitation | Reserved | Reserved | Reserved 11/1/1947 | 12/31/1954 | Step III processing | 33 | 2,310 | Uranium Tonawanda plant 10/1/1942 | 12/31/1946 | Uranium ore research | Reserved | Reserved | Uranium and progeny 1/1/1947 | 12/31/1954 | Post | 0.1 | 7 | Uranium and progeny	Table 3-7. Assumed airborne concentrations used to estimate intakes at the Tonawanda Laboratory. Start | End | Activity description | # MAC | α dpm/m³ | Source 11/01/1947 | 12/31/1953 | Postcleanup | 0.1 | 7 | Uranium and progeny
3.6	Different constants in alpha fraction of uranium resulting in difference in annual inhalation intake calculations	For example, the annual uranium inhalation intake due to chronic exposure at 0.1 MAC is estimated by multiplying the air concentration of 7 dpm/m^3 by the alpha fraction of uranium, 0.402; the ICRP 66 (ICRP 1994) recommended breathing rate of 1.2 m3/h; and the assumed 2000 work-hours per calendar year. This results in an annual chronic inhalation intake of 6.75E+03 dpm, which is equal to a daily intake rate of 18.5 dpm/day. For the assumed exposure at 33 MAC, no alpha activity is apportioned to progeny, so the daily uranium intake would be 1.52E+04 dpm/day.	For example, the annual uranium inhalation intake due to chronic exposure at 0.1 MAC was estimated by multiplying the air concentration of 7 dpm/m^3 by the alpha fraction of uranium (0.489), the ICRP Publication 66 (ICRP 1994) recommended breathing rate of 1.2 m^3/hr, and the assumed 2,000 workhours per calendar year. This results in an annual chronic inhalation intake of 8..215 × 103 dpm, which is equal to a daily intake rate of 22.5 dpm/d.
3.7	Ingestion Intake Estimates at Tonawanada Laboratories have different computation.	In the case where inhalation intakes are calculated from air concentrations, ingestion intakes are also to be considered. NIOSH (2004) indicates that the ingestion rate, in terms of dpm for an 8-hour	In the case where inhalation intakes are calculated from air concentrations, ingestion intakes are also to be considered. NIOSH (2004) indicates that the ingestion rate, in terms of dpm for an 8-hour

Table 3: Comparison of an Exposure Matrix for Linde Ceramics Plant (Including Tonawanda Laboratory), ORAUT-TKBS-0025, Rev. 1 (NIOSH 2008a) to Rev. 0 (NIOSH 2005a) (reproduced from SC&A 2009a)

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		workday, can be estimated by multiplying the air concentration in dpm per cubic meter by a factor of 0.2, so the uranium ingestion rate based on an air concentration of 7 alpha dpm/m^3 would be 0.563 dpm/workday. To adjust this to ingestion intake per calendar day, 0.563 dpm/workday is multiplied by 250 workdays per year and divided by 365 days per year, which equals 0.385 dpm/day. For the assumed exposure at 33 MAC, no alpha activity is apportioned to progeny, so the daily uranium intake would be 316 dpm/day. In accordance with NIOSH 2004, the f1-value used for inhalation dose calculations is to be used for ingestion dose calculations.	workday, can be estimated by multiplying the air concentration in dpm per cubic meter by a factor of 0.2, so the uranium ingestion rate based on an air concentration of 7 alpha dpm/m^3 would be 0.563 dpm/wd. To adjust this to ingestion intake per calendar day, 0.685 dpm/wd was multiplied by 250 wd/yr and divided by 365 d/yr, which equals 0.469 dpm/d. In accordance with NIOSH (2004), the f1-value used for inhalation dose calculations is to be used for ingestion dose calculations.
3.8	Consideration of Bioassay Data removed from Rev. 01.	Predicted uranium urinalysis results, provided in Table 10, were calculated for the last day of assumed chronic intake periods of 30 and 60 days, 0.5 years, 1 year and extended annually thereafter through the end of operations, assuming the estimated inhalation and ingestion intakes of natural uranium were based on a uranium air concentration of 33 MAC. A cursory review of the highest uranium urinalysis data from facilities that handled uranium in large quantities (Mallinckrodt, Harshaw, Hanford, ORNL, K-25, Paducah, and Portsmouth) indicates that results exceeding 10 mg/L are rare and that most results are less than 1 mg/L. At the Ceramics Plant, where the first Linde uranium bioassays were performed after standby, [**Redact**] of the available urinalysis results exceeded 1 mg/L. Subsequent results from these individuals were much lower. From November 1947 through January 1950, most	N/A

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		Linde uranium urinalyses (about 95%) were less than 0.1 mg/L, but it is notable that exposures would likely have been lower during this period than in the earlier days of operations. The predicted results in Table 10 do not seem inconsistent with the limited Linde urinalyses. Table 10. Predicted uranium urinalyses from Ceramics Plant assumed inhalation and ingestion chronic uranium intake from November 1, 1947 to December 31, 1954 based on 33 MAC in air. Bioassay date / Type M dpm/d / Type M mg/L / Type S dpm/d / Type S mg/L 12/[redacted]/1948 566 0.3 18 0.01 12/[redacted]/1948 661 0.3 20 0.01 5/[redacted]/1949 853 0.4 28 0.01 11/[redacted]/1948 961 0.5 36 0.02 11/[redacted]/1949 1,013 0.5 48 0.02 11/[redacted]/1950 1,022 0.5 57 0.03 11/[redacted]/1951 1,026 0.5 64 0.03 11/[redacted]/1952 1,028 0.5 70 0.03 11/[redacted]/1953 1,031 0.5 74 0.03 11/[redacted]/1954 1,033 0.5 77 0.04 12/[redacted]/1954 1,033 0.5 78 0.04 *Mass results assume natural uranium exposure Given a chronic exposure to uranium and its alpha emitting progeny at 300 MAC, the activity fraction of Ra-226 would be 0.196, which means that the chronic inhalation rate would be 2.7E+04 dpm/d. This gives a whole-body activity of 2.6E+05 dpm at one year, and about 4.0E+05 dpm at 4 years (calculated using IMBA Expert (OCAS), Version 3.2.20). The Ra-226 body activity was estimated using the largest breath radon result found for Linde, 2.2 pCi/L, by multiplying the radon result by a conversion factor of 2.52E+05 pCi/(pCi/L) (ORAUT 2005) [ORAUT 2005a in this report].	

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		This gives a body activity of 5.5 E+05 pCi, which is equal to 1.2 E+06 dpm, and is within a factor of 3 of the estimated intake from a 4-year chronic exposure to 300 MAC. Because other Linde radon breath analyses are lower, and because a chronic exposure scenario may not best represent a worker's exposure pattern, the assumption of 300 MAC chronic exposure was believed to be adequate for reconstructing doses in the pre-1947 research and production period, but at this time this period is reserved.	
3.8	**Occupational Internal Dose Reconstruction Assumptions and Summary** Disclaimer added in Rev. 01.		HHS has determined, and NIOSH has concurred, that it is not feasible to reconstruct internal exposure prior to November 1, 1947 (HHS 2005).
3.8	Summary table for 00 starts at 1942, Rev. 01 starts at 1947.		
4.0	ESTIMATION OF EXTERNAL EXPOSURE, 1942–1954 Dislaimer for pre-1947 data in Rev. 01		Because of the SEC determination (HHS 2005) that it is infeasible to adequately reconstruct internal dose during the period October 1, 1942 through October 31, 1947, dose estimates for this period are considered partial dose estimates.
4.0	Additional statement on measurement assumptions for Beta Radiation in Rev. 01		For the purpose of calculation of organ dose, all exposure geometries are assumed to be anteriorposterior (AP).
4.1.1	Differing titles, subparagraph (typo?)	**4.1.1 Post-production Radiation in Building 30** Little information was available on radiation levels in Ceramics Plant buildings during periods of nonproduction. Estimates for these periods were based on measurements made after the end of production in Building 30, the main processing	**4.1.1 Preproduction, 1942 to 1943**

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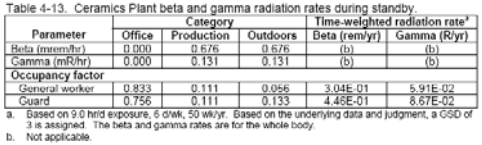
Item Description	Comment	ORAUT-TKBS-0025 Rev. 0 Text	ORAUT-TKBS-0025 Rev. 1 Text
		building.	
4.1.2.3	Cleanup section placed at end of section in Rev. 01		
4.1.2.2	New information in Rev. 01 for "Gamma"		Film badges were provided by the Medical Section of the MED (presumably the University of Rochester).
4.1.3	Standby Section only in Rev. 01		**4.1.3 Standby, 1946 to 1947** Little information is available about the status of activities during the standby period. It is likely that the onsite staff consisted primarily of a small number of management and janitorial personnel— both of whom worked primarily in an office environment— and guards. For dose reconstruction, each worker during standby was classified as either a guard or a general worker, and worker time was assumed to have been spent in an office building, in production buildings, and outdoors. Averaged over the entire standby period, each worker's allocation of time was assumed to have been as indicated by the occupancy factors in Table 4-13.  Table 4-13. Ceramics Plant beta and gamma radiation rates during standby. Parameter | Category: Office, Production, Outdoors | Time-weighted radiation rate[a]: Beta (rem/yr), Gamma (R/yr) Beta (mrem/hr): 0.000, 0.676, 0.676, (b), (b) Gamma (mR/hr): 0.000, 0.131, 0.131, (b), (b) Occupancy factor General worker: 0.833, 0.111, 0.056, 3.04E-01, 5.91E-02 Guard: 0.756, 0.111, 0.133, 4.48E-01, 8.67E-02 a. Based on 9.0 hr/d exposure, 6 d/wk, 50 wk/yr. Based on the underlying data and judgment, a GSD of 3 is assigned. The beta and gamma rates are for the whole body. b. Not applicable. Measurements were made at 1 in. from the surface of interest. The results were reported as 0 R/8 hr for four of the locations and 0.005 R/8 hr (0.625 mR/hr) for the other two locations (each near an ore dumping grill) (Howland 1946). Because the dumping grill was one of the most contaminated spots in the plant, the exposure rate there was not

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			considered typical of the conditions that would have been encountered upon occasional entry during standby. Instead, the indoor gamma and beta levels for a production building were taken as the values in Table 4-1 before vacuum cleaning and flushing. Outdoor gamma and beta levels were taken as equal to the indoor rates based on the reasoning used above in the discussion of the preproduction period. The gamma and beta radiation rates in an office building were assumed to be zero. Table 4-13 summarizes the calculation of annual radiation rates based on the above parameters. Because there would have been little need for direct handling of radioactive materials by Ceramics Plant workers in this period, beta dose rate to the hands and forearms was taken as equal to the beta dose rate to the remainder of the body.
4.4	**External Dose Reconstruction Summary, October 1, 1942, to July 7, 1954**, disclaimer in Rev. 01 about dosages prior to Oct. 31, 1947		Because of the SEC determination (HHS 2005) that it is infeasible to adequately reconstruct internal dose during the period October 1, 1942 through October 31, 1947, dose estimates for this period are considered partial dose estimates.
5.0	**Occupational Medical Exposure** disclaimer on dose estimates prior to Oct. 31, 1947		Because of the SEC determination (HHS 2005) that it is infeasible to adequately reconstruct internal dose during the period October 1, 1942 through October 31, 1947, dose estimates for this period are considered partial dose estimates.
5.1.1	**Bases of Assumptions.** Slightly different wording on one sentence under "Applicability"	Therefore, the general assumption for dose reconstruction is that all employees were subject to the same chest x-ray imaging requirements.	Therefore, the general assumption for dose reconstruction is that all employees were subject to the same chest x-ray requirements.

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Item Description	**Comment**	**ORAUT-TKBS-0025 Rev. 0 Text**	**ORAUT-TKBS-0025 Rev. 1 Text**
5.1.1	**Bases of Assumptions** "Period." Different dates between Rev. 00 and Rev. 01	Production work at the Ceramics Plant is assumed to have ended on June 30, 1949; cleanup work is assumed to have ended on December 31, 1954.	Production work at the Ceramics Plant is assumed to have ended on June 30, 1949; cleanup work is assumed to have ended on December 31, 1953.
5.1.3	**X-ray Dose Reconstruction Guidelines.** Markedly different wording in introductory paragraphs	Dose reconstruction should be based on information specific the subject to the extent that it is available and adequate. The guidelines in this section are for use when the records for an individual worker are not available or are incomplete. The guidelines are for use only to the extent that they are not inconsistent with the worker's records. For example, if the medical records are complete and indicate a lower or higher examination frequency than stated in the assumptions provided above, the data in the medical records should be used. X-ray doses shall be determined in accordance with the latest revision of the project technical information bulletin, *Dose Reconstruction from Occupationally Related Diagnostic X-ray Procedures* (current version is ORAU Team 2003) [ORAUT 2005a in this report] when applicable.	Dose reconstruction should consider information specific to the subject to the extent that it is available, adequate, and is representative of x-ray screening examinations covered under the EEOICPA (i.e., dose from x-ray examinations conducted as a result of occupational injuries are not to be included in dose reconstructions). The guidelines in this section are for use when the records for an individual worker are not available or are incomplete. The guidelines are for use only to the extent that they are not inconsistent with the worker's records. For example, if the medical records are complete and indicate a lower or higher examination frequency than stated in the assumptions provided above, the data in the medical records should be used. X-ray doses shall be determined in accordance with the latest revision of the project technical information bulletin, *Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures* (current version is ORAUT 2005b) [ORAUT 2005a in this report] when applicable.
6.0	**Estimation of Exposures from Residual Contamination after 1954** (**1953 in Rev. 01**) Different dates.	This section develops parameters for reconstruction of doses due to internal and external exposures of Ceramics Plant and Tonawanda Laboratory workers after December 31, 1954, the assumed completion date of cleanup at the Ceramics Plant. Both facilities were on Linde's Tonawanda, New York, site. Initial cleanup of the Tonawanda Laboratory is assumed to have been	This section develops parameters for reconstruction of doses due to internal and external exposures at the Ceramics Plant starting July 8, 1954, and Tonawanda Laboratory starting January 1, 1954. Initial cleanup of the Tonawanda Laboratory was assumed to be complete on December 31, 1946. Tonawanda Laboratory worker radiation exposures from January 1, 1947, to December 31, 1953, are

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Item Description	**Comment**	**ORAUT-TKBS-0025 Rev. 0 Text**	**ORAUT-TKBS-0025 Rev. 1 Text**
		completed on December 31, 1946. Tonawanda Laboratory workers' radiation exposures from January 1, 1947 to December 31, 1954 are discussed in Sections 3.0 and 4.0. The assumed Ceramics Plant initial cleanup date is December 31, 1954. Beginning on January 1, 1955, It is assumed that Linde employees could have been exposed to residual contamination for 2000 hours per year.	discussed in Sections 3.0 and 4.0. It was assumed that beginning on January 1, 1954, Tonawanda Laboratory employees could have been exposed to residual contamination for 2,000 hr/yr.
6.1.2	**External Beta and Gamma Exposure** different dates	The total number of readings ≥25 µR/h reported by BNI was 16. The net readings (after subtraction of 8 µR/h to correct for background) had a GM of 94.0 µR/h and a GSD of 3.95. This was taken as an estimate of worker exposure rate when outdoors. This estimate was assumed to apply from January 1, 1955 to the present (2005).	The total number of reported readings ≥25 µR/hr was 16. The net readings (after subtraction of 8 µR/hr to correct for background) had a GM of 94 µR/hr and a GSD of 3.95. This was taken as an estimate of worker exposure rate when outdoors. This estimate was assumed to apply starting January 1, 1954, at the Tonawanda Laboratory and July 8, 1954, at the Ceramics Plant.
Attachment C	Not in Rev. 0		**Attachment C** **Data Sources on Uranium Progeny Concentrations in Linde Materials**
Attachment D	Not in Rev. 0		**Attachment D** **Linde Uranium Coworker Assessment for November 1947 to January 1950**
Attachment E	Not in Rev. 0		**Attachment E** **Focused Assessment of Dose Consequences from Uranium Ore Bags on the Site During the Post-Operations Period**