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ADVISORY BOARD ON RADIATION AND WORKER HEALTH

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

A REVIEW OF NIOSH'S PROGRAM EVALUATION REPORT DCAS-PER-045, "ALIQUIPPA FORGE TBD REVISION"

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S. COHEN & ASSOCIATES: ***Technical Support for the Advisory Board on Radiation & Worker Health Review of NIOSH Dose Reconstruction Program***	Document No. SCA-TR-PR2014-0045 Effective Date: Draft – August 20, 2014
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Project Manager: _____ Date: _____ John Stiver, MS, CHP	Reviewer: John Stiver

Record of Revisions

Revision Number	Effective Date	Description of Revision
0 (Draft)	08/20/2014	Initial issue

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ABBREVIATIONS AND ACRONYMS

Advisory Board or Board	Advisory Board on Radiation and Worker Health
AEC	Atomic Energy Commission
AWE	Atomic Weapons Employer
BNI	Bechtel National, Inc.
cm^2	square centimeter
d/y	day per year
D&D	Decontamination and Decommissioning
DCF	dose conversion factor
DOE	(U.S.) Department of Energy
dpm/m^3	disintegration per minute per cubic meter
DR	dose reconstruction
FUSRAP	Formerly Utilized Sites Remedial Action Program
HEPA	high-efficiency particular air
µCi/m	microcurie per meter
µCI/mL	microcurie per milliliter
$\mu g/m^3$	microgram per cubic meter
m	meter
MED	Manhattan Engineering District
mR/hr	milliroentgen per hour
mrem	millirem
m/s	meter per second
NIOSH	National Institute for Occupational Safety and Health
NRC	(U.S.) Nuclear Regulatory Commission
NYOO	(AEC) New York Operations Office
OCAS	Office of Compensation and Support
ORAUT	Oak Ridge Associated Universities Team
pCi/d	picocurie per day
PEP	Program Evaluation Plan
PER	Program Evaluation Report
POC	probability of causation

rem	roentgen equivalent man
RF	resuspension factor
SC&A	S. Cohen and Associates (SC&A, Inc.)TBD technical basis document
TIB	technical information bulletin
U	uranium
wd	work day

1.0 STATEMENT OF PURPOSE

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

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

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

During a teleconference by the Advisory Board's Procedures Review Subcommittee meeting on April 16, 2014, SC&A was tasked by the Board to conduct reviews of three PERs. Included among the PERs is DCAS-PER-045*, Aliquippa Forge TBD Revision*. In conducting a PER review, SC&A is committed to perform the following five subtasks, each of which is discussed in this report:

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

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

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

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

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

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

2.0 RELEVANT BACKGROUND INFORMATION PERTAINING TO FACILITY OPERATIONS, HEALTH PHYSICS PRACTICES AND EPISODIC EFFORTS TO DECONTAMINATE ALIQUIPPA FORGE

The following statements are taken verbatim from ORAUT-TKBS-0021, Rev. 01, *Basis for the Development of an Exposure Matrix for Aliquippa Forge, Pennsylvania, Period of Operation: January 1, 1947 through February 28, 1950* (ORAUT 2004). These statements provide a summary as well as a timeline of events that relate to SC&A's review of DCAS-PER-045 (DCAS 2013) and its primary technical support document ORAUT-OTIB-0070, Rev. 01, *Dose Reconstruction during Residual Radioactive Periods at Atomic Weapons Employer Facilities* (ORAUT 2012b).

*(1) The Aliquippa Forge radiological source term consisted primarily of **natural uranium metal**, **uranium oxides**, and **natural uranium's short-lived progeny**. Long-lived progeny prevent significant ingrowth past ^{234}U in the ^{238}U decay series and beyond ^{231}Th in the ^{235}U decay series.* [Emphasis added.]

(2) *Vulcan Crucible Steel Company operated Aliquippa Forge to produce uranium rods for the AEC from billets primarily by rolling. Operations with uranium at the forge began when a trial rolling occurred on July 23, 1948. The AEC contract for production work was initiated on **August 16, 1948**, and was extended through **February 28, 1950*** [AEC 1948]. *The **rolling operation ended on March 30, 1949** with decontamination consuming the rest of the contract's term. . . .* [Emphasis added.]

(3) *This analysis assumed that the **residual** contamination period extended from **March 1, 1950, through December 31, 1987**, and from **January 1, 1989, to December 31, 1992**.* [Emphasis added.]

(4) *The site* [Aliquippa Forge] *consisted of about 19 buildings. The majority of the AEC work occurred in Building 3, the rolling mill.*

(5) *Decontamination was completed by Vulcan Crucible in **1950** in accordance with **then-current** AEC guidelines.* [Emphasis added.]

(6) After the war [WWII] *. . . The Medical Division of the AEC New York Operations Office (NYOO) felt that a "maximum permissible level" was unknown and should be based on human data. Therefore, the 50-$\mu g/m^3$ level was referred to as the "preferred level" (AEC 1949b).*

(7) *As of the September 1, 1948* [AEC] *visit, there were few health physics controls in place.*

*(8) Air samples were taken during the **September 1948** visit; one sample (during the third pass in back of the mill) showed an air concentration as*

*high as 1,800 times the preferred level (i.e., 50 μg/m^3). Although peak values need to be considered, the fact that work tasks and worker locations were constantly changing resulted in time-weighted exposures that were typically much lower than the peak values. The other air sampling results for **September 1 and 2, 1948**, showed concentrations in the range of 2.6 to 510 times the preferred level, . . .* [Emphasis added.]

(9) *A NYOO report of an AEC visit to the Aliquippa Forge on **February 15 and 16, 1949**, described **time-weighted** radioactive dust exposures between 2.7 and 5,300 times the preferred level depending on the type of job*. [Emphasis added.]

(10) *The AEC record indicates that there were **no rolling** operations after **March 1949** and that only **cleanup** operations were taking place (Kelley 1949).* [Emphasis added.]

(11) *In **July of 1949**, a **survey** was performed to determine forge cleanup requirements (Belmore 1949c). **Additional** AEC **assessments** and **surveys** were made throughout the cleanup process. Although AEC noted that the **cleanup** personnel had **no monitoring equipment**, the assessments concluded that a sufficient job of cleanup had been done (Eisenbud 1950; Belmore 1950)*. [Emphasis added.]

(12) *The Formerly Utilized Sites Remedial Action Program (FUSRAP) began in **1976**. Perry (1993) stated*:

> *A radiological **survey in 1978** identified contamination (primarily uranium-238) in and around onsite buildings. The site was designated for further remediation under FUSRAP, and the small operation was shut down and the building evacuated*. [Emphasis added.]

(13) *In August 1983, the Aliquippa Forge site was designated for remedial action under FUSRAP (DOE 1996a). In **December 1987**, storage activities began in **Building 3**. **Interim remedial actions** were taken from October to December 1988 to enable additional restricted use of Building 3 for expansion of a small forging operation . . . **Controlled areas** were established to prevent **access** to **contamination** (Seay 1988; DOE 1996a)*. [Emphasis added.]

(14) ***Final remedial** activities occurred from about **June 1993 to September 1994** (Abelquist 1995; DOE 1996a)*. [Emphasis added.]

SC&A's Comments

Based on the above-cited statements that were taken from ORAUT-TKBS-0021, Rev. 01 (ORAUT 2012a), the following conclusions may be drawn:

- For a substantial fraction of the facility's rolling operation period, little effort was made to limit personnel exposures and contamination levels. Even the most basic health physics practices and facility engineering designs/controls were lacking.

- Correspondingly, air concentrations during rolling operations were orders of magnitude above the AEC recommended "preferred level" of 50 μg/m^3 (70 dpm/m^3).

- Following the operational rolling period that ended on March 30, 1949, some "attempt" was made by Vulcan Crucible Steel to decontaminate the facility, which was completed in 1950. As noted by the AEC, however, ". . . the cleanup personnel had **no monitoring equipment**" [emphasis added]. Thus, there are no survey data that would quantify residual airborne/surface contamination levels.

- Under FUSRAP, the following activities occurred:
  - A radiological survey of the Aliquippa site was conducted in **1978**
  - **Interim remedial** actions were taken to decontaminate the facility in **1988**
  - Final site remedial activities occurred between June 1993 and September 1994

3.0 SUBTASK 1: IDENTIFY THE CIRCUMSTANCES THAT NECESSITATED THE NEED FOR DCAS-PER-045

DCAS-PER-045 was prompted by changes introduced to ORAUT-TKBS-0021, Rev. 00 (ORAUT 2004), which had been issued on December 21, 2004.

Revision 01 of ORAUT-TKBS-0021 (ORAUT 2012a) was issued on April 26, 2012, and included changes that impacted both internal and external doses that assumedly reflect new facility-specific information/data that principally pertain to the residual period of Aliquippa Forge and a revision to ORAUT-OTIB-0070, *Dose Reconstruction during Residual Radioactivity Periods at Atomic Weapons Employer Facilities* (ORAUT 2012b). (Note: Neither Rev. 00 nor Rev. 01 of ORAUT-TKBS-0021 had previously been reviewed by SC&A.)

In brief, changes in Rev. 01 of ORAUT-TKBS-0021 (ORAUT 2012a) included the elimination of assigned occupational medical x-ray dose; revised time periods that define the residual contamination period; an internal dose model, which accounts for exposures during Decontamination and Decommissioning (D&D) operations in 1988 and 1993/1994 under FUSRAP; and additional data capture information pertaining to survey(s).

As part of our review of DCAS-PER-045, SC&A compared Rev. 00 (ORAUT 2004) to Rev. 01 (ORAUT 2012a) of ORAUT-TKBS-0021 to identify all revisions and their consistency with stated changes identified in Section 2.0 "Issue Evaluation" of DCAS-PER-045.

SC&A's Comments Pertaining to the Development of PER-045 and Supporting Documents

DCAS-PER-045 states the following:

> . . . *Revision 1* [of the Aliquippa Forge technical basis document (TBD) ORAUT-TKBS-0021] *revised the dose estimate in the* ***residual period*** *starting 3/1/1950. The revision included both internal and external dose and was the result of both new data and a* ***revision*** *to* ***ORAUT-OTIB-0070***. [Emphasis added.]

The statement that this was ". . . the result of . . . a revision to ORAUT-OTIB-0070" is misleading/incorrect based on the following dates when documents were issued:

- Rev. 00 of ORAUT-TKBS-0021, **December 21, 2004 (ORAUT 2004)**
- Rev. 00 of ORAUT-OTIB-0070, **March 10, 2008 (ORAUT 2008)**
- Rev. 01 of ORAUT-OTIB-0070, **March 5, 2012 (ORAUT 2012b)**
- Rev. 01 of ORAUT-TKBS-0021, **April 26, 2012 (ORAUT 2012a)**

Based on these dates, Rev. 00 of ORAUT-TKBS-0021 **predates** Rev. 00 of ORAUT-OTIB-0070 by more than 3 years, which implies the following:

- Rev. 00 of ORAUT-OTIB-0070 played **no role** for defining estimates of internal and external doses in Rev. 00 of ORAUT-TKBS-0021. A review of ORAUT-TKBS-0021,

Rev. 00, shows that internal and external dose estimates were based on assumptions and methodologies, which had little in common with ORAUT-OTIB-0070.

- Thus, it was not the **revisions** that were introduced in Rev. 01 of ORAUT-OTIB-0070, but the existence and substitution of guidance contained in Rev. 01 of ORAUT-OTIB-0070 for earlier assumptions stated on page 20 of ORAUT-TKBS-0021, Rev. 00.

Observation #1. NIOSH should rephrase the role of ORAUT-OTIB-0070 in Section 2.0 of DCAS-PER-045

Observation #2. Review of records indicates that neither Rev. 00 nor Rev. 01 of the Aliquippa Forge TBD (ORAUT-TKBS-0021) was ever reviewed/audited by SC&A

Based on a comparison of estimated internal and external doses in Rev. 00 (ORAUT 2004) and Rev. 01 (ORAUT 2012a) of ORAUT-TKBS-0021 (see Section 4.0 of this report), SC&A sees no value in a formal retroactive review/audit of Rev. 00 of ORAUT-TKBS-0021. However, as part of our audit of DCAS-PER-045, there is a need to critically review Rev. 01 of ORAUT-TKBS-0021 with regard to the methodology by which exposures were derived during the residual period for the Aliquippa Forge facility.

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

In instances where the PER involves a technical issue that is supported by a document that has been formalized and previously subjected to a review by SC&A, Subtask 2 will simply provide a brief summary/conclusion of this review process.

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

SC&A reviewed Rev. 00 of ORAUT-OTIB-0070 in August 2008. Our review identified a total of 15 findings that included 4 conditional findings. In behalf of these findings, it was SC&A's opinion that surrogate models/data and specific default values recommended in Rev. 00 of ORAUT-OTIB-0070 (ORAUT 2008) for the derivation of air concentrations were likely to underestimate inhalation doses. Surrogate models of concern included those identified in NUREG-1400 and in Attachment B of ORAUT-OTIB-0070 and **assumed default values** pertaining to the **source term depletion rate of 1% per day** and to the **resuspension of residual contamination of 1×10^{-6} m^{-1}**.

Revision 01 of ORAUT-OTIB-0070 (issued on March 5, 2012) deleted the NUREG-1400 source term approach and Attachment B, as well as revised the source term depletion rate from 0.01 d^{-1} to 0.00067 d^{-1}. **With the exception of the footnote in Table 5-1, the resuspension factor of 1×10^{-6} m^{-1}, however, remained unchanged**.

In total, Rev. 01 of OTIB-0070 identifies the following six recommended methods that may be used to estimate inhalation dose resulting from residual contamination. Selection from among the following six methods is based on **availability of data** involving air sampling and surface contamination levels:

> Method #1: Use of air sampling data taken during facility operations and post-facility operations allows for the determination of the exponential decline in air concentration defined by the surface contamination depletion factor coefficient (i.e., λ).
>
> Method #2: Use of operational air sampling data that are adjusted by a source term depletion factor to determine post-operational air concentrations from residual contamination.
>
> Method #3: Use of exponential data fitting that are based on empirical post-operational air sampling data and estimated air activities during the facility's operational period.
>
> Method #4: Use of surface contamination data taken during facility operations and post-facility operations. Air concentrations from residual contamination are derived for any given year by means of an empirically derived surface contamination source term depletion constant (i.e., λ) and an assumed resuspension factor.
>
> Method #5: Use of surface contamination data taken during the operational period and the application of the resuspension factor $1 \times 10\text{-}6$ m^{-1} provides the basis for estimating

air concentrations during the operational period. To estimate air concentrations during any post-operational year, the previously derived operational air concentration is reduced by the source term depletion factor defined by $\lambda = 0.00067$ per day.

Method #6: Use of surface contamination data taken during the post-operational period and the application of the resuspension factor $1 \times 10\text{-}6\ m^{-1}$ provides an estimate of the post-operational air concentration. For the operational period, a default air concentration is assigned, which, in combination with the derived post-operation air concentration, permits an exponential fit.

These six methods are summarized in Table 5-1 of OTIB-0070 (ORAUT 2012b) and reproduced herein as Table 1. The choice of method used to derive internal dose is based on the availability data, and the sequence of methods cited in Table 1 identifies the order of preference.

Table 1. Recommended Methods

Air Sample		Surface Contamination		Recommended Methodology
Operational	**Post-Operational**	**Operational**	**Post-Operational**	
X	X			Exponential fit of operational and post-operational data.
X				Calculate annual intake quantities based on a source term depletion factor of 0.00067 d^{-1} (Section 3.5).
	X			Exponential fit of post-operational data and estimate of operational airborne radioactivity based on ORAUT (2006) or Battelle (2011).
		X	X	Conversion of surface activity to airborne concentrations using resuspension factor* or $1 \times 10^{-6}\ m^{-1}$ followed by an exponential fit of derived levels.
		X		Conversion of surface activity to airborne concentrations using resuspension factors. Calculate annual intake quantities based on a source term depletion factor of 0.00067 m^{-1} (Section 3.5).
			X	Conversion of post-operational surface activity data to airborne concentrations using resuspension factor* of $1 \times 10^{-6}\ m^{-1}$. Estimate of operational airborne radioactivity based on ORAUT (2006) or Battelle (2011). Exponential fit of two quantities.

*** In cases where the contaminated area is still involved in active operations, a site-by-site analysis of the appropriateness of the $1 \times 10^{-6}\ m^{-1}$ resuspension factor should be done.**

Thus, from among the six recommended methods, SC&A regards **Method #**1 as likely to yield inhalation estimates that most closely correspond to actual inhalation.[1] This is due to the fact that no assumptions/default values are required (e.g., an **assumed** resuspension factor, an **assumed** source term depletion factor, representative surface contamination levels, building ventilation rates, etc.). However, for Method #1 to yield credible results, the following conditions must apply:

(1) Operational air sampling data should reflect representative work locations

[1] SC&A notes that Method #1 was identified as the method of choice for bounding internal exposures from residual contamination in behalf of the Dow Chemical Company/Madison Site (NIOSH 2008).

(2) Operational air sampling data should correspond to time(s) that approach the end of facility operations

(3) Post-operational air sampling data should not be compromised by facility operations that involve the processing of commercial sources of uranium or thorium, which are not included in 42 U.S.C. § 7384(n)(4)

(4) Post-operational air sampling data should not post-date any known **decommissioning/decontamination** efforts that would compromise the credibility of these data

Based on data availability, Method #1 derives airborne contamination from residual contamination during the post-operational period by means of representative empirical site-specific air monitoring data obtained during operations and post-operations. Implicit in this method is that the post-operational airborne activity and the operational airborne activity are related through time that accounts for the exponential source term depletion factor (i.e., λ), as given in the following equation:

$$\text{Air Activity}_{\text{Post Operation}} = \text{Air Activity}_{\text{Operation}}\, e^{-\lambda t} \qquad \text{Eq. 1}$$

When solving for λ, the source term depletion factor provides estimates of airborne activity values for any post-operational period.

For **Method #2**, when available data are restricted to air sampling during facility operations or end of facility operations, there is a need to derive air concentration(s) in behalf of the post-operational period that accounts for source term depletion. Variables that affect depletion include physical dimensions of the facility, ventilation rate, and resuspension of surface contamination.

For a default value of source term depletion, Rev. 01 of OTIB-0070 derived the average value of 0.00067 d^{-1} from empirical data representing four Atomic Weapons Employer (AWE) facilities as cited in Table 4-1 and calculated corresponding source term depletion factors presented in Table 4-2 of ORAUT-OTIB-0070, along with the recommendation that ". . . This average depletion rate should be used for facilities without specific data."

For convenience to the reader, Table 4-2 of ORAUT-OTIB-0070, Rev. 01 is enclosed herein as Table 2.

Table 2. Adjustment Factors to Account for Depletion of Source Term during the Residual Period

Year	Factor
1	1.00E+00
2	
3	6.13E-01
4	4.80E-01
5	3.76E-01
6	2.94E-01
7	2.31E-01
8	1.81E-01
9	1.41E-01
10	1.11E-02
11	8.67E-02
12	6.79E-02
13	5.32E-02
14	4.16E-02
15	3.26E-02
16	2.55E-02
17	2.00E-02
18	1.56E-02
19	1.23E-02
20	9.60E-03
21	7.51E-03
22	5.88E-03
23	4.61E-03
24	3.61E-03
25	2.83E-03
26	2.21E-03
27	1.73E-03
28	1.36E-03
29	1.06E-03
30 on	8.32E-04

4.2 A FOCUSED REVIEW OF ORAUT-TKBS-0021, REV. 01, PERTAINING TO THE RESIDUAL PERIOD

4.2.1 Estimates of Residual External Exposure

To reconstruct external exposure to residual radioactivity, NIOSH states that:

> *To reconstruct external exposure to residual radioactivity, the maximum reported exposure rate of 0.014 mR/hr (Adams and Payne 1992a) was* ***back-extrapolated*** *using the source term depletion rate calculated from the internal data* [i.e., 1.15×10^{-4}/d or 0.042/yr]. . . . [and] *by assuming that workers were exposed for 2,000 hr/yr.* [Emphasis added.]

Thus, for the year **1992**, Table 5-1 of ORAUT-TKBS-0021 identifies the annual dose of 0.0028 rem (0.014 mR/hr × 2,000 hr/y × 0.001 rem/mrem = 0.028 rem). By extrapolating the

annual 1992 dose of 0.028 rem to the start of the residual period in 1950, Table 5-1 identifies the annual dose of 0.157 rem ($A_{1950} = A_{1992}$ ($e^{6.042/y)(41\ y)}$) = (0.028 rem)(5.6) = 0.157 rem).

SC&A's Comments/Findings

While SC&A was able to reproduce the residual external penetrating doses cited in Table 5-1 of ORAUT-TKBS-0021, these values may have been compromised by two independent errors, one of which would have **overestimated** doses, while the other would have **underestimated** the dose, as explained in Findings #1 and #2.

Finding #1. Failure to account for a previous D&D Effort.

As previously noted in Section 2.0 above and in Section 5.0 of ORAUT-TKBS-0021, Rev. 01:

> *The Aliquippa Forge site was included in the DOE FUSRAP in August 1983. In December 1987, Bechtel National, Inc. (BNI) surveyed Aliquippa Forge for the purpose of allowing the use of portions of Building 3 for storage.* ***Interim remedial*** *activities were conducted by BNI in* ***1988 by removing contaminated materials and equipmen****t and placing a barricade around the remaining contaminated area.*
>
> *. . . The 1988 effort was limited in Building 3 and occurred in November and December of 1988. Vacuums were fitted with high-efficiency particular air (HEPA) filters to clean the* ***floors*** *and* ***walls****. Contaminated bricks and soil were removed as necessary.* [Emphasis added.]

It is therefore reasonable to conclude that the 1988 "interim remedial activities" (in and around Buildings 3 and 8; see Finding #3 below) could have significantly reduced the observed dose rate of 0.014 mR/hr taken in 1992. Thus, any backward extrapolation to years **prior to 1988** (i.e., years 1950 through 1987) would have **underestimated** external doses.

Finding #2. Backward extrapolation by means of the NIOSH-derived source term depletion factor is inappropriate due to impacts associated with the "interim remedial activities" of 1988.

The NIOSH-derived source term depletion factor of 1.15×10^{-4} d^{-1} principally reflects **removable** surface contamination that is subject to repeated resuspension and removal by building ventilation and other removal mechanisms that contribute to source term depletion.

For most surface contaminations, however, it is **fixed** contamination that overwhelmingly represents total (fixed and removable) contamination, as suggested by the following statements cited in Section 5.0 of ORAUT-TKBS-0021, Rev. 01:

> *In 1992 and 1993, areas in and adjacent to* ***Buildings 3*** *and 8 were further characterized (Abelquist 1994; Adams and Payne 1992a,b). The maximum reported exposure rate at 1 m was* ***0.014 mR/hr*** *(Adams and Payne 1992a). The maximum removable surface* ***contamination was 350 dpm*** *alpha/100 cm^2.*

> ***The decontamination techniques in 1993 and 1994 were much more aggressive than in 1988***. *In addition to HEPA vacuuming, which was the main method in 1988, mechanical shot blasting, concrete saws, and jack-hammering were employed (DOE 1996b). The maximum air concentration during the 1993 to 1994 cleanup was 1.1 × 10^{-10} µCi/mL.* [Emphasis added.]

The above-cited value of 1.1 × 10^{-10} µCi/m is equivalent to 110 dpm/m^3. Thus, SC&A concludes (1) the use of the NIOSH-derived source term depletion factor principally reflects the minor or removable portion of the total contamination; and (2) the empirically obtained 1992 dose rate of 0.014 mR/hr principally reflects the larger fixed contamination component, which is **not** likely to have significantly changed since the beginning of the residual period in 1950. This implies that the use of the source term depletion rate overestimated external doses for all years prior to 1992.

4.2.2 Estimates of Residual Internal Exposure

For reconstruction of internal exposures to residual contamination, NIOSH provided the following information in Section 5.0 of ORAUT-TKBS-0021, Rev. 01:

> ***After the end of AEC rolling operations, a July 1949 survey*** *was performed. The survey indicated that the* ***maximum*** *air dust concentration,* ***taken during normal operations in the Furnace area, was 5.9 µg/m^3 or 8.94 dpm/m^3*** *(assuming a specific activity of 1.516 dpm/µg for natural uranium) (Belmore 1949b).*
>
> ***To calculate internal exposure from residual activity the analysis assumed that all buildings had an air concentration of 8.94 dpm/m^3 in 1950***. *This operational air concentration was assumed to have occurred for 1 year with no cleanup. An indoor* ***deposition velocity of 0.00075 m/s*** *was applied to calculate a 2.11 × 105 dpm/m^2 surface contamination level at the end of operations/start of the residual period. A* ***resuspension factor of 1 × 10-6 m^{-1}*** *was applied to the surface contamination level, resulting in an air concentration of* ***0.211 dpm/m^3***. *A* ***source term depletion rate was calculated based on a starting air concentration in 1950 and the air concentration calculated based on the 1992 survey data (ORAUT 2012b)***. *The 1992 calculated air concentration* ***of 0.035 dpm/m^3*** *was based on applying a resuspension factor of 1 × 10^{-6} m^{-1} (Abu-Eid et al. 2002) to the maximum removable surface contamination of* ***350 dpm alpha/100 cm^2***. *Using these two air concentrations, a source term depletion rate of* ***1.15 × 10^{-4} d^{-1} was calculated***. *The ingestion intake rates were calculated using the method described in Section 3.0. The estimated daily inhalation and ingestion intake rates to residual radioactivity from AEC operations at the site (****Table 5-1****), were calculated by assuming that workers were exposed for 2,000 hr/yr.* [Emphasis added.]

As a convenience to the reader, Table 5-1 in ORAUT-TKBS-0021, Rev. 01, is reproduced below as Table 3. Inspection of Table 3 shows the following inhalation rates:

Year	Inhalation (pCi/d)
1950	0.627
1992	0.112

Table 3. Annual Internal and External Exposure to Residual Radioactivity

Year	Inhalation[a] (pCi U/d)	Ingestion[b] (pCi U/d)	Penetrating[c] (rem)	Nonpenetrating[c] (rem)
1950[d]	0.627	0.029	0.157	0.784
1951	0.627	0.029	0.157	0.784
1952	0.601	0.028	0.150	0.751
1953	0.576	0.027	0.144	0.720
1954	0.552	0.026	0.138	0.691
1955	0.530	0.024	0.132	0.662
1956	0.508	0.023	0.127	0.635
1957	0.487	0.023	0.122	0.609
1958	0.467	0.022	0.117	0.584
1959	0.448	0.021	0.112	0.560
1960	0.429	0.020	0.107	0.537
1961	0.412	0.019	0.103	0.515
1962	0.395	0.018	0.099	0.494
1963	0.379	0.018	0.095	0.473
1964	0.363	0.017	0.091	0.454
1965	0.348	0.016	0.087	0.435
1966	0.334	0.015	0.083	0.417
1967	0.320	0.015	0.080	0.400
1968	0.307	0.014	0.077	0.384
1969	0.294	0.014	0.074	0.368
1970	0.282	0.013	0.071	0.353
1971	0.270	0.013	0.068	0.338
1972	0.259	0.012	0.065	0.324
1973	0.249	0.012	0.062	0.311
1974	0.238	0.011	0.060	0.298
1975	0.229	0.011	0.057	0.286
1976	0.219	0.010	0.055	0.274
1977	0.210	0.010	0.053	0.263
1978	0.202	0.009	0.050	0.252
1979	0.193	0.009	0.048	0.242
1980	0.185	0.009	0.046	0.232
1981	0.178	0.008	0.044	0.222
1982	0.170	0.008	0.043	0.213
1983	0.163	0.008	0.041	0.204
1984	0.157	0.007	0.039	0.196
1985	0.150	0.007	0.038	0.188
1986	0.144	0.007	0.036	0.180
1987	0.138	0.006	0.035	0.173
1988[e]	0.132	0.006	0.033	0.166
1989	0.127	0.006	0.032	0.159
1990	0.122	0.006	0.030	0.152
1991	0.117	0.005	0.029	0.146
1992	0.112	0.005	0.028	0.140

Table 3. Annual Internal and External Exposure to Residual Radioactivity

Year	Inhalation[a] (pCi U/d)	Ingestion[b] (pCi U/d)	Penetrating[c] (rem)	Nonpenetrating[c] (rem)
1993[e]	0.107	0.005	0.027	0.134
1994[e]	0.103	0.005	0.026	0.129
1995	0.099	0.005	0.025	0.123

a. Absorption Types M and S are possible.
b. Choose same f1-value as used for inhalation per NIOSH (2004).
c. External doses should be assessed using Exposure (R) DCFs.
d. The operational period ends on February 28, 1950. Therefore, the residual period is extended from 1951 back to March 1, 1950.
e. See text below for additional exposure scenarios from clean-up activities.

SC&A's Comments and Findings

Before addressing the methodology employed for the reconstruction of internal exposure, the first step of our audit is to reproduce the values cited in Table 3, using NIOSH's given data:

Verification of Daily Inhalation Rates (1950)

(1) 1949 Air Concentration: 5.9 µg U/m^3 = 8.94 dpm/m^3 = 4.027 pCi/m^3

(2) Resultant Surface Contamination (1950) = (4.027 pCi/m^3)(0.00075 m/s)(3.1536 × 10^7 s/y)
= 9.5246 pCi/m^2

(3) Resultant Air Concentration (1950) = (95,246 pCi/m^2)(1 × 10^{-6} m^{-1})
= 0.0952 pCi/m^3

(4) Intake per day (1950) = (0.0952 pCi/m^3)(1.2 m^3)(8 hr/d)(250 wd/365 d/y)

= 0.627 pCi/d

SC&A's calculated daily intake of 0.627 pCi/d matches NIOSH's value of 0.627 pCi/d.

Verification of Daily Inhalation Rate (1992)

(1) Surface Contamination (1992) = 350 dpm100 cm^2 = 3.5 × 10^4 dpm/m^2

(2) Air Concentration (1992) = (3.5 × 10^4 dpm/m^2))(1 × 10^{-6} m^{-1})
= 0.035 dpm/m^3
= 0.0157 pCi/m^3

(3) Intake per day (1992) = (0.0157 pCi/m^3)(1.2 m^3)(8 hr/d)(250 wd/365 d/y)

= 0.103 pCi/d

SC&A's calculated daily intake of 0.103 pCi/d is slightly lower and does not match NIOSH's value of 0.112 pCi/d.

Verification of Daily Ingestion Intakes

Section 5.0 of the TBD states that ". . . the ingestion intake rates were calculated using the method described in Section 3.0 [of the TBD]." In turn, Section 3.0 states ". . . When inhalation intakes are calculated from air concentrations . . . the daily ingestion rate in picocuries can be estimated by multiplying the daily air concentration in picocuries per cubic meter by a factor of 0.2 for an 8-hour workday."

- For 1950, NIOSH derived an air concentration of 0.211 dpm/m^3 or 0.095 pCi/m^3. When multiplied by 0.2 and 250 wd/365 d/y, the daily ingestion of **0.013 pCi/d** is obtained.

  SC&A's daily ingestion rate of 0.013 pCi/d for 1950 does **not** match NIOSH's value of 0.029 pCi/d.

- For 1992, NIOSH derived an air concentration of 0.035 dpm/m^3 or 0.0158 pCi/m^3. When multiplied by 0.2 and 250 wd/365 d/y, the daily ingestion of **0.00216 pCi/d** is obtained.

  SC&A's daily ingestion rate of 0.00216 pCi/d for 1992 is less than half of NIOSH's value of 0.005 pCi/d.

Finding #3. Using NIOSH's approach for deriving inhalation and ingestion rates during the residual period, SC&A was unable to match values cited in Table 3 above (Table 5-1 of ORAUT-TKBS-0021).

4.2.3 A Critical Assessment of NIOSH's Methodology for Deriving Inhalation Exposures during the Residual Period

As stated above, NIOSH's methodology for deriving inhalation exposures was explained in Section 5.0 of ORAUT-TKBS-0021 with the following statements:

> *After the end of AEC rolling operations, a July 1949 survey was performed. The survey indicated that the **maximum** air dust concentration, taken during normal operations in the Furnace area, was 5.9 µg/m^3 or **8.94 dpm/m^3** (assuming a specific activity of 1.516 dpm/µg for natural uranium) (Belmore 1949b).*
>
> *To calculate internal exposure from residual activity the analysis assumed that **all buildings had an air concentration of 8.94 dpm/m^3 in 1950**. This operational air concentration was assumed to have occurred for 1 year with no cleanup. An indoor deposition velocity of 0.00075 m/s was applied to calculate a 2.11 × 10^5 dpm/m^2 surface contamination level at the end of operations/start of the residual period. A resuspension factor of **1 × 10^{-6} m^{-1}** was applied to the surface contamination level, resulting in an air concentration of **0.211 dpm/m^3**.*
> [Emphasis added.]

Comments Pertaining to the Derivation of Air Concentration. Important to note here is that NIOSH identified an **air concentration of 8.94 dpm/m^3** for **all buildings** at Aliquippa Forge facility in **1950**. SC&A reviewed the reference for the cited **air concentration** of 8.94 dpm/m^3 in Belmore 1949b, which is enclosed herein as Attachment #1. Highlighted on page 2 of Attachment #1 is the referenced air sample value of 5.9 µg/m^3 (or 8.94 dpm/m^3), which was taken in the **Furnace Area** and characterized by NIOSH as the "maximum air dust concentration."

Referenced on page 2 of Attachment #1, however, is another **air sample** that at 119 µg/m^3 (or 180 dpm/m^3) was 20-fold higher and characterized by the following statement:

> *During floor sweeping of the **mill area** the sample showed **119 micrograms per m^3**, this being the only sample in excess of the **preferred level**.* [Emphasis added.]

Finding #4. Failure to acknowledge and use a reported air sample that at 180 dpm/m^3 was ~20-fold higher than the cited value of 8.94 dpm/m^3, which NIOSH described as "the maximum air dust concentration taken during normal operations."

In addition to NIOSH's failure to acknowledge the much higher air sample, there is the illogical/inexplicable method by which the **empirically** obtained **air concentration** of **8.94 dpm/m^3** was converted to a **modeled** value of **0.211 dpm.m^3** by means of the two **unsupported** model parameters that include (1) the indoor deposition velocity of 0.00075 m/s and (2) a resuspension factor of 1×10^{-6} m^{-1} as described in the above-cited excerpt from Section 5.0 of ORAUT-TKBS-0021, Rev. 01.

In summary, NIOSH started with an **empirically obtained air concentration of 8.94 dpm/m^3 in 1950**, and rather than using this value, NIOSH inexplicably converted this to a "modeled" air concentration value that at 0.211 dpm/m^3 is 42.4 times lower.

The 42.4-fold error/discrepancy between the observed air concentration of 8.94 dpm/m^3 and the modeled value of 0.211 dpm/m^3 also suggests a serious flaw in the NIOSH model; that is to say that if the deposition and resuspension of contaminants were truly known, the modeled value would have equaled/approximated the observed value of 8.94 dpm/m^3.

SC&A concludes that the 42-fold discrepancy reflects deposition and/or resuspension values that are too low and inappropriate for Aliquippa Forge during operational periods that did **not** involve AEC contract work.

In our review of OTIB-0070, Rev. 0 issued in August 29, 2008 (SC&A 2008), SC&A questioned NIOSH's recommended resuspension value of **Finding #13**, which is reproduced below.

> *Indoor resuspension factors cited in the **scientific literature** that involve substantial industrial activities (as would be expected in an AWE facility that may continue to operate **after** operations were performed for the MED or AEC) may experience air concentrations corresponding to RF values of 10^{-4} m^{-1} to 10^{-3} m^{-1}.*

> *The recommended RF value of 1 × 10^{-6} m^{-1} by the NRC is limited to facilities that have previously been subjected to extensive decontamination efforts in anticipation of license termination. A principal objective of such decontamination efforts is to minimize any removable surface contamination that would contribute to the resuspension of surface contaminant. NRC's criteria that include the recommended RF value of 10^{-6} m^{-1} have only recently been established, and have limited relevance to AWE facilities that operated decades ago and were never subjected to the stringent D&D criteria that separated the AWE's operational period from its post-operational period.*

Perhaps in response to SC&A's Finding #13, NIOSH added the following footnote to Table 5-1 of ORAUT-OTIB-0070, Rev. 01, (enclosed herein as Table 1 above):

> [*] *In cases where the contaminated area is still involved in active operations, a site-by-site analysis of the appropriateness of the 1 × 10^{-6} m^{-1} resuspension factor should be done.*

With regard to post-AEC contract operations at Aliquippa Forge, the following statements were cited in Section 1.0 of ORAUT-TKBS-0021, **Rev. 00** (but **not** in Rev. 01 of ORAUT-TKBS-0021):

> *. . . At the time of U.S. Atomic Energy Commission (AEC) contract operations, Aliquippa Forge was known as Vulcan Crucible Steel Company. Vulcan Crucible was primarily involved with the rolling of natural uranium. Sometime after AEC operations ended, the facility became known as Universal Cyclops. The facility is now owned by the Beaver County Corporation for Economic Development.*

Finding #5. NIOSH's "conversion" of the empirically measured air concentration of 8.94 dpm/m^3 that was reduced more than 42-fold to a "modeled air concentration" represents a major error as the starting point for deriving internal dose for the inhalation and ingestion and for all years from 1950 to 1995.

Finding #6. Inappropriate use of the resuspension factor 1 × 10^{-6} m^{-1} for post-AEC work, but nevertheless active operations at the Aliquippa Forge facility as specified in the footnote of Table 5-1 in ORAUT-OTIB-0070.

In behalf of Finding #6, NIOSH had the obligation to conduct a site-specific analysis of available survey data that would have suggested a different resuspension value. Presented below are examples of data that could have been used to conduct a site-specific analysis of credible resuspension values that comply with ORAUT-OTIB-0070.

Sample Calculations of Resuspension Factors at the Aliquippa Forge Facility Based on Survey Data

The July 28, 1949, AEC survey data at the Aliquippa Forge facility (Belmore 1949b) support SC&A's contention of a higher resuspension factor. For example, page 1 of Attachment #1

identifies alpha activities on the Furnace Area Floor of **5,000** to **10,000 dpm** that were taken with a **Zeuto survey** instrument, which has a chamber window of 3" × 4" on bottom (or with an effective area of 12 inches^2) (see Attachment #2). It was in the furnace area that yielded the above-cited air concentration of 5.9 µg/m^3 or 8.94 dpm/m^3.

Thus, a Zeuto average measurement of 7,500 dpm for a 12-inch^2 window corresponds to 967,500 dpm/m^2. Applying NIOSH's recommended resuspension factor of 1×10^{-6} would yield an air concentration of 0.967 dpm/m^3, which is 9.24-fold lower than the **measured** air concentration of 8.94 dpm/m^3. Thus, a resuspension factor of 1×10^{-5} would represent a more realistic value; and for the observed air concentration of 119 µg/m^3 or 180 dpm/m^3 [that corresponded to the "mill floor" contamination levels of about 3,500 dpm during a survey on May 9, 1949 (see Attachment #3)], a resuspension factor of about 4×10^{-4} would have applied during post-AEC facility operations that included (or was equivalent to) "floor sweeping."

Comments Pertaining to NIOSH's Assessment of the Source Term Depletion Rate. To derive internal exposure for years 1951 through 1995, NIOSH used the following approach:

> *A source term depletion rate was calculated based on a starting air concentration in 1950 and the air concentration calculated based on the **1992 survey data** (ORAUT 2012b). The 1992 calculated air concentration of **0.035 dpm/m^3** was based on applying a resuspension factor of 1×10^{-6} m^{-1} (Abu-Eid et al. 2002) to the maximum removable surface contamination of 350 dpm alpha/100 cm^2. Using these two air concentrations, a source term depletion rate of **1.15×10^{-4} d^{-1}** was calculated. . . . The estimated daily inhalation and ingestion intake rates to residual radioactivity from AEC operations at the site (Table 5-1) were calculated by assuming that workers were exposed for 2,000 hr/yr.* [Emphasis added.]

A second error in the methodology for estimating internal exposures was the selection of the 350 dpm/100 cm^2 removable surface contamination value taken during a **1992** survey. From this survey measurement, NIOSH derived two critical values for the estimation of inhalation/ ingestion doses:

(1) The air concentration of 0.035 dpm/m^3 for the year 1992; and
(2) A source term depletion rate of 1.15×10^{-4} d^{-1} for deriving internal doses between 1950 and 1995.

Finding #7. NIOSH's choice of the 1992 survey measurement of 350 dpm/100 cm^2 removable alpha contamination is compromised by the fact that it post-dates the "interim decontamination efforts" conducted from October to December 1988.

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

Section 3.0 of DCAS-PER-045 identified the set of criteria used to identify 21 DRs that had been completed under Rev. 00 of ORAUT-TKBS-0021 and required re-evaluation under the revised guidance in Rev. 01 of ORAUT-TKBS-0021. All 21 reworked claims resulted in POCs below 45%.

SC&A's Comments and Findings

Revisions to ORAUT-TKBS-0021, which mandated DCAS-PER-045, exclusively impacted internal and external dose estimates associated with a **residual period** between 1950 and 1995, as summarized in Table 5-1 of the TBD.

SC&A's audit of ORAUT-TKBS-0021, Rev. 01, and other pertinent documents not only identified significant errors, but more importantly questioned the inexplicable approach used by NIOSH to redefine air concentration values for estimates of inhalation and ingestion exposures. In combination, errors and flawed methodology essentially invalidated all values cited in Table 5-1; contrary to Section 2.0 of DCAS-Per-045, which states that ". . . The revision [to ORAUT-TKBS-0021] . . . was the result of . . . a **revision** to ORAUT-OTIB-0070," [emphasis added], guidance as defined in OTIB-0070 was, in fact, ignored

As shown in Table 1 of Section 4.1 above, prioritization of approaches recommended in OTIB-0070 for internal dose assessment would have given priority to Method #2 with the following available data:

(1) The **measured air concentration** of 8.94 dpm/m^3 at the end of the rolling period/ beginning of the residual period; and
(2) The **revised** source term depletion factor of 0.00067 d^{-1} and values cited in Table 4-2 of ORAUT-OTIB-0070.

Alternatively, second and third tier options would have included Methods #1 and #3, respectively.

Finding #8. NIOSH's methodology for deriving internal inhalation and ingestion dose does not comply with the use of available data and the prioritization of recommended methods defined in ORAUT-OTIB-0070, Rev. 01.

6.0 SUBTASK 4: CONDUCT AUDITS OF A SAMPLE SET OF DRs AFFECTED BY DCAS-PER-043

Based on the potential magnitude and scope of Findings identified in this audit, SC&A believes that any audit of reworked DRs is premature at this time and must await a full review and resolution of said Findings.

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ATTACHMENT #1: BELMORE MEMO (1949B)

File
Vulcan

W. H. Belmore, Director, Production Division — July 28, 1949

M. Eisenbud, Chief, Health and Safety Branch

DECONTAMINATION OF VULCAN CRUCIBLE STEEL CO AT WEST ALIQUIPPA PENNA.

REFER TO SYMBOL: DH:HB

At the request of the Production Division, a visit was made to the Vulcan Plant on July 21, 1949 for the purpose of determining the effectiveness of the decontamination program outlined in the memorandum of May 9, 1949, and also to decide as to the scrapping or transfer of certain contaminated equipment.

Measurements made with the Geiger Muller survey meter #1031 and a Zeuto #948 indicated the following radiation levels:

Location	Alpha d/m (Zeuto)	Beta Gamma mrep/hr
Rolls		
#1	5,000	5
#2	10,000	10-20
#3	8,000	5-10
#4	9,000	5-10
#5	9,000	10
Under Vacuum Cleaner	nil	1-1.5
Pits Under Mills		
#1 (West)		5
#2		5-6
#3		5-7
#4 (East)		Less than 1
I Beams Over Mills (dusty)		0.7-1.0
Steel Floor (front of mills)		Less than 0.5
Small Brick Section of Floor (see text)	5,500	
Furnace Area Floor (Steel)	5,000 to 10,000	1-5
Wipe Test (12 sq. in)	nil	
Top of Furnaces (dusty)	3,500-5,000	5-10
Wipe Test	500-1,000	

Attachment #1 – Belmore Memo (1949b) (continued)

- 2 -

F. M. Belmore July 28, 1949

M. Eisenbud

DECONTAMINATION OF VULCAN CRUCIBLE STEEL CO. AT WEST ALIQUIPPA PENNA.

Location	Alpha d/m (Zeuto)	Beta Gamma mrep/hr
Winter Rest Area (Brick Floor)	3,000-4,500	5
Hearth Protection Plates	15,000-25,000	5-7
Guide Plates (2)	20,000	more than 20
Wooden Tool Cabinet	4,200	0.4
Small Wooden Bench	2,000-3,000	3-5
Vent Hoods	900-5,000	6-10
Ducts (Sheet Metal)		
Wipe Test - 12 sq. in.	nil	
Inside Vacuum System Pipe		0.8-1.0

Dust samples were taken during normal operations with the following results:

Rolling Area (south end)	4.7	micrograms per m^3
Near Mill	4.7	" " "
Furnace Area	5.9	" " "

During floor sweeping of the mill area the sample showed 119 micrograms per m^3, this being the only sample in excess of the preferred level.

The sample from the mill cooling water sump measured 219 micrograms per liter which is of the order of a small multiple of background.

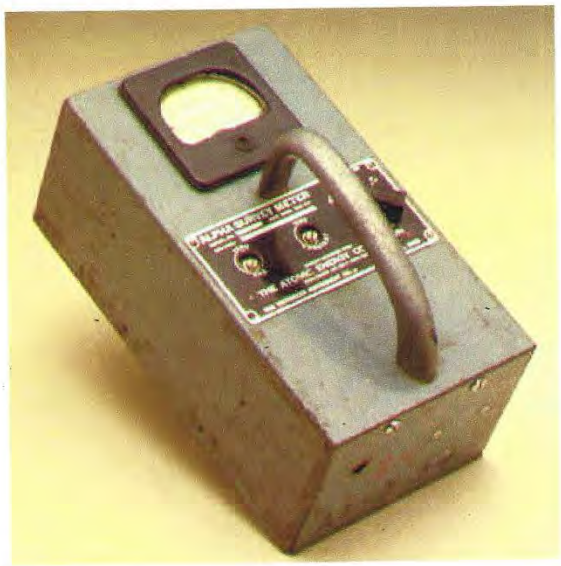
The above readings indicated that in general the decontamination procedures had been quite effective. Certain further steps should be taken and Mr. Flower agreed to have these taken care of right away, as follows:

1. Vacuum clean the tops of the furnaces used for the uranium work.

2. Remove dirt from top and vacuum clean the small brick floor area south of the rolling mills adjacent to the vacuum cleaning collector.

ATTACHMENT #2 – ZEUTO SURVEY INSTRUMENT

Victoreen Model 356 "Zeuto" (ca. 1950)



The Zeuto was a portable ionization chamber used to measure surface alpha contamination. Unfortunately, it also had the undesirable characteristic of responding to beta particles and gamma rays. By the early 1950s, proportional counters and scintillators had pretty much replaced ionization chambers for measuring alpha contamination.

This particular instrument was used at the AEC facility in Weldon Springs Missouri where uranium and thorium were processed.

Courtesy of Riasp Medora, Rod Nelson, and Glen Newtown

Chamber: 475 cc aquadag coated.

Chamber Window: 0.2 mil nylon screen (ca. 3" x 4" on bottom)

Range: 0 - 20 microamperes which equates to 4,000 dpm or 4 mR/hr (radium)

0 - 200 microamperes which equates to 40,000 dpm or 40 mR/hr (radium)

Size: 9.5" x 5" x 4"

ATTACHMENT #3 – BELMORE MEMO (1949A)

Klevin:ss

F. H. Belmore, Production Division — May 9, 1949

Dr. B. S. Wolf, Medical Director

APRIL 26 VISIT TO VULCAN CRUCIBLE STEEL CO., WEST ALIQUIPPA, PA.

REFER TO SYMBOL: IH:FBK

Paul B. Klevin, of the Industrial Hygiene Section, visited the above company for the purpose of making a radiation survey of the contamination to the mill areas created by the past rolling operations.

In general the rolling mill area appeared to be clean and orderly. The steel plated floors had the semblance of having been freshly cleaned with a vacuum before Mr. Klevin's arrival. There was no visible dust or material on the floors except under the dust collector. This material undoubtedly came as a result of the cleaning out of the collector. It was packaged together with a piece of uranium metal found by Vulcan personnel and sent to Mr. Gustavsson of the Metals Accountability Section.

The following radiation measurements were made with a Zeute:

Location	Floor	Alpha (c/m)	Beta-Gamma (mr/hr.)
Shipping and receiving room.	Concrete	5,000-9,000	0
North mill floor.	Steel plate	3,500	0
South mill floor.	Steel plate - cracks between plates	3,500-5,000 1,500-5,000	0
Quenching and stamping rod area.	Steel plate	50,000	26
West of finishing roll.	Brick and concrete	1,000-4,000	0.5
Bench west of finishing roll.	Wood	5,000	0
Shear pit area.	Steel plate	1,500-5,000	0
Furnace area.	Sand and cinders	6,000	0.5
North of furnace area.	Cobblestone and brick	600-1,500	0
Rest area (directly south of furnace).	Sand and cinders	5,000-10,000	1.1