SEC Petition Evaluation Report
Petition SEC-00195, Addendum

Report Rev #: Addendum Report Submittal Date: April 7, 2014

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Site Expert(s):	N/A

Petition Administrative Summary

Petition Under Evaluation

Petition #	Petition Type	Petition Receipt Date	Qualification Date	DOE/AWE Facility Name
SEC-00195	83.13	October 20, 2011	January 17, 2012	Nuclear Metals, Inc.

Petitioner-Requested Class Definition

All employees who worked in Buildings A, B, C, D, E, the Butler Building, external storage containers, and outside areas immediate to plant grounds at the Nuclear Metals, Inc. facility in West Concord, Massachusetts, during the period from January 1, 1970 through December 31, 1983.

Class Evaluated by NIOSH (Specific to this Addendum)

All employees who worked at the Nuclear Metals, Inc. facility in West Concord, Massachusetts, during the period from January 1, 1980 through December 31, 1990.

NIOSH-Proposed Class to be Added to the SEC

All Atomic Weapons Employees who worked for Nuclear Metals Inc. at its facility in West Concord, Massachusetts, during the period from January 1, 1980 through December 31, 1990, for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more other classes of employees included in the Special Exposure Cohort.

Related Petition Summary Information

SEC Petition Tracking #(s)	Petition Type	DOE/AWE Facility Name	Petition Status
N/A	N/A	N/A	N/A

Related Evaluation Report Information

Report Title	DOE/AWE Facility Name
SEC Petition Evaluation Report for Petition SEC-00195, Rev. 0	Nuclear Metals, Inc.

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SEC Evaluation Approved By:	[Signature on File] *Stuart L. Hinnefeld*	4/8/2014 *Date*

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Addendum to Nuclear Metals, Inc. (SEC-00195) Special Exposure Cohort Evaluation Report

ATTRIBUTION AND ANNOTATION: This is a single-author document. All conclusions drawn from the data presented in this evaluation were made by the ORAU Team Lead Technical Evaluator: Edward D. Scalsky, Oak Ridge Associated Universities. The rationales for all conclusions in this document are explained in the associated text.

NIOSH presented a Special Exposure Cohort (SEC) evaluation report (NIOSH, 2012) regarding Nuclear Metals, Inc. to the Advisory Board on Radiation and Worker Health (Advisory Board) in September 2012. In its report, NIOSH evaluated the feasibility of reconstructing radiation doses of all Atomic Weapons Employer (AWE) employees who worked at the facility owned by Nuclear Metals, Inc. (or a subsequent owner) in West Concord, Massachusetts, during the period from January 1, 1958 through December 31, 1983. While researching for the SEC-00195 evaluation report, NIOSH gained additional information from data capture efforts that warranted further analysis for the post-1979 period. Based on its research completed at that time, NIOSH defined a single class of employees for which it could not estimate radiation doses with sufficient accuracy from October 29, 1958 through December 31, 1979. NIOSH reserved its full assessment of the available post-1979 data and continued to evaluate the feasibility of sufficiently accurate dose reconstruction for the period from January 1, 1980 through December 31, 1983. On September 20, 2012, the Advisory Board voted to recommend adding a class to the SEC for the period from October 29, 1958 through December 31, 1979, due to a lack of internal dosimetry data for enriched uranium, uranium progeny, thorium, and thorium progeny.

Further consideration of foundry operations, DU manufacturing, UF4 processing, and thorium operations at Nuclear Metals, Inc. for the post-1979 period has led NIOSH to conclude that some of the same conditions that initially led NIOSH to determine it could not perform dose reconstruction prior to December 31, 1979, continued on through December 31, 1990 (end of AWE operations). This Evaluation Report Addendum details NIOSH's recommendation that there is insufficient information to perform sufficiently accurate dose reconstructions for potential exposures to thorium and thorium progeny for the period from January 1, 1980 through December 31, 1990.

NOTE: This Evaluation Report Addendum only addresses those sections in the Nuclear Metals, Inc. Evaluation Report that require discussion/revision; therefore, the section numbering is not contiguous. For context, some of the original surrounding text may be included with the revised text. The sections requiring additional discussion begin below.

Petition Evaluation Report Addendum Summary

Class Evaluated by NIOSH (in this SEC-00195 Addendum)

The feasibility of reconstructing doses received from exposures to uranium and thorium, and their progeny, during the period from January 1, 1980 through December 31, 1983 was reserved for further consideration in the original SEC-00195 Evaluation Report. During NIOSH's subsequent analysis of the January 1, 1980 through December 31, 1983 period, it was determined that thorium operations continued beyond 1983 based on worker outreach meetings and interviews with senior Nuclear Metals Incorporated (NMI) personnel and workers in addition to the 25,000 kg of thorium on the NRC license that NMI maintained. Thus, this SEC-00195 Addendum details NIOSH's evaluation of all AWE employees who worked at the facility owned by Nuclear Metals, Inc. in West Concord, Massachusetts, during the period beginning January 1, 1980, and extending through December 31, 1990.

NIOSH-Proposed Class to be Added to the SEC

In its September 2012 SEC-00195 Evaluation Report, NIOSH defined a single class of employees for which NIOSH could not estimate radiation doses with sufficient accuracy. The NIOSH-proposed class became effective on January 6, 2013, and includes all Atomic Weapons Employees who worked at the facility owned by Nuclear Metals, Inc. in West Concord, Massachusetts during the period from October 29, 1958 through December 31, 1979. During the original SEC-00195 evaluation, the feasibility of reconstructing doses received from exposures to uranium and thorium, and their progeny from January 1, 1980 through December 31, 1983, was reserved for further consideration. During its subsequent review, NIOSH obtained additional process data and conducted additional interviews with former workers. Based on its analysis of these available resources, including newly identified data indicating that thorium operations occurred during the period between January 1980 and December 1990, NIOSH found it cannot estimate radiation doses with sufficient accuracy for thorium and thorium progeny during the reserved and expanded period of operations from January 1, 1980 through December 31, 1990. As a result, NIOSH recommends adding a second NMI class to the SEC to include the period from January 1, 1980 through December 31, 1990. The second NIOSH-proposed class includes all Atomic Weapons Employees who worked for Nuclear Metals Inc. at its facility in West Concord, Massachusetts during the period from January 1, 1980 through December 31, 1990, for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more other classes of employees included in the Special Exposure Cohort.

Feasibility of Dose Reconstruction

Per EEOICPA and 42 C.F.R. § 83.13(c)(1), NIOSH has established that it does not have access to sufficient information to: (1) estimate the maximum radiation dose, for every type of cancer for which radiation doses are reconstructed, that could have been incurred in plausible circumstances by any member of the class; or (2) estimate radiation doses of members of the class more precisely than an estimate of maximum dose. Information available from the site profile and additional resources is not

sufficient to document or estimate the maximum internal and external potential exposure to members of the proposed class under plausible circumstances during the specified period.

The NIOSH dose reconstruction feasibility findings are based on the following:

- Principal sources of internal radiation for members of the proposed class included exposures to natural and depleted uranium, thorium oxides and metals, and uranium and thorium progeny during foundry, machining, extrusion, welding, grinding, and reduction operations. The primary modes of exposure were likely inhalation and ingestion, with entry through wounds also being possible during the processing of these metals.

- Many Concord site operations from the mid-1970s were continued during the 1980-1990 period to support large-scale production, including the manufacture of depleted uranium shields, counter-weights, and armor penetrators; the manufacture of metal powders, including thorium; and foundry and machining activities with specialty metals.

- Internal exposure monitoring data available to NIOSH include:

  - A single thorium urine bioassay sample result in 1983. Although NIOSH has obtained uranium urine bioassay results for most years in the AWE operations period (with the number of urinalysis results increasing dramatically from 1978 through 1990), NIOSH has found no indication that NMI had implemented a routine or process-driven *in vitro* bioassay program to monitor for thorium exposures.

  - A single *in vivo* lung count specific to natural thorium performed in 1982. Although NIOSH has obtained approximately 800 uranium lung-counting results beginning in 1982, NIOSH has found no indication that NMI had implemented a routine or process-driven *in vivo* bioassay program to monitor for thorium exposures.

  - Although NIOSH has obtained over 29,000 breathing zone gross activity air sample results during the period 1980 through 1990, NIOSH has found no indication that isotopic studies on air samples were performed, and has found no air monitoring results attributed to thorium during the period 1980 through 1990.

- Possibly due to the compartmentalized work assignments and work protocols, NIOSH has been unable to find a consolidated information source regarding thorium operations during the period from 1980 through 1990. Former worker interviewees appear to have greatly differing levels of knowledge regarding thorium operations through the AWE period. Information from worker outreach meetings, interviews with senior NMI personnel and workers, and the 25,000 kg of thorium maintained on the site's NRC license indicate that thorium operations were performed through varying periods of the 1980 and 1990s; however, NIOSH has been unable to verify the specific dates of such thorium operations, or any dates during the AWE period associated with the clean-up of thorium operations.

- NIOSH has been unable to obtain sufficient internal monitoring data specific to thorium and thorium progeny for the period from January 1, 1980 through December 1990. NIOSH has not found an indication that the site's routine air sampling program was directed at assessing potential thorium exposures, and cannot show that sampling locations were chosen to include thorium-handling work areas. In the absence of a complementary thorium-specific bioassay program, the gross-alpha air results available to NIOSH for the period from 1980 through 1990 are insufficient to support efforts to bound the internal dose from thorium and thorium progeny. Consequently, NIOSH has determined that it does not have access to sufficient personnel monitoring, workplace monitoring, or source term data to estimate with sufficient accuracy internal exposures to thorium and thorium progeny for Nuclear Metals, Inc. workers during the period from January 1, 1980 through December 1990. NIOSH found that it is feasible to reconstruct internal doses from natural and depleted uranium for employees during the recommended SEC period using available claimant data, site monitoring data, and information in procedure *Internal Coworker Dosimetry Data for Nuclear Metals, Inc.*, ORAUT-OTIB-0084.

- Principal sources of external radiation for members of the proposed class included exposures to gamma and beta radiation associated with handling of radioactive materials in production or research activities. Thorium, uranium metal, and uranium compounds constituted the principal external radiation dose-producing material sources for members of the class. The modes of exposure were direct radiation, submersion in potentially-contaminated air, and exposure to contaminated surfaces.

- External monitoring data available to NIOSH consist of film badge and thermoluminescent dosimeter results covering the entire AWE operational period. NIOSH has determined that reconstruction of monitored external doses, and occupational medical doses, is feasible for the period from January 1, 1980 through December 1990.

- Pursuant to 42 C.F.R. § 83.13(c)(1), NIOSH determined that there is insufficient information to either: (1) estimate the maximum radiation dose, for every type of cancer for which radiation doses are reconstructed, that could have been incurred under plausible circumstances by any member of the class; or (2) estimate the radiation doses of members of the class more precisely than a maximum dose estimate.

- Although NIOSH found that it is not possible to completely reconstruct radiation doses for the proposed class, NIOSH intends to use any internal and external monitoring data that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures). Therefore, dose reconstructions for individuals employed at Nuclear Metals, Inc. during the period from January 1, 1980 through December 1990, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

Health Endangerment Determination

Per EEOICPA and 42 C.F.R. § 83.13(c)(3), a health endangerment determination is required because NIOSH has determined that it does not have sufficient information to estimate dose for the members of the proposed class.

NIOSH did not identify any evidence supplied by the petitioners or from other resources that would establish that the proposed class was exposed to radiation during a discrete incident likely to have involved exceptionally high-level exposures. However, evidence indicates that some workers in the proposed class may have accumulated substantial chronic exposures through episodic intakes of radionuclides, combined with external exposures to gamma and beta radiation. Consequently, NIOSH has determined that health was endangered for those workers covered by this evaluation who were employed for at least 250 aggregated work days either solely under this employment or in combination with work days within the parameters established for one or more other SEC classes.

1.0 Purpose and Scope

The previous (2012) SEC-00195 Evaluation Report (NIOSH, 2012) recommended adding a class to the SEC for October 29, 1958 through December 31, 1979, and NIOSH reserved its full assessment of the then newly-acquired post-1979 data. This Addendum evaluates the feasibility of reconstructing doses for all employees who worked for Nuclear Metals, Inc. at its facility in West Concord, Massachusetts, during the period reserved for further evaluation, January 1, 1980 through December 31, 1990. This report provides information and analyses germane to considering a petition for adding a class of employees to the congressionally-created SEC.

This report does not make any determinations concerning the feasibility of dose reconstruction that necessarily apply to any individual energy employee who might require a dose reconstruction from NIOSH. This report also does not contain the final determination as to whether the proposed class will be added to the SEC (see Section 2.0).

This evaluation was conducted in accordance with the requirements of EEOICPA, 42 C.F.R. pt. 83, and the guidance contained in the Division of Compensation Analysis and Support's (DCAS) *Internal Procedures for the Evaluation of Special Exposure Cohort Petitions*, DCAS-PR-004.[1]

3.2 Class Evaluated by NIOSH (in this Addendum)

In NIOSH's 2012 SEC-00195 Evaluation Report, the feasibility of performing dose reconstructions for the period from January 1, 1980 through December 31, 1983, was reserved for further consideration to allow for full assessment of then-recently-available post-1979 data. During NIOSH's subsequent analysis of the reserved January 1, 1980 through December 31, 1983 period, it was determined that thorium operations continued beyond 1983 based on worker outreach meetings, interviews with senior NMI personnel and workers, and the 25,000 kg of thorium on the NRC license

[1] DCAS was formerly known as the Office of Compensation Analysis and Support (OCAS).

that NMI maintained. This SEC-00195 Addendum details NIOSH's evaluation of all AWE employees who worked for Nuclear Metals, Inc. at their facility in West Concord, Massachusetts, during the period beginning January 1, 1980, and extended through December 31, 1990.

3.3 NIOSH-Proposed Class to be Added to the SEC

NIOSH's 2012 SEC-00195 Evaluation Report recommended a single class of employees who worked at the facility owned by Nuclear Metals Inc. in West Concord, Massachusetts during the period from of October 29, 1958 through December 31, 1979. However, after further research (as detailed in this SEC-00195 Addendum), NIOSH has proposed a second class to include all Atomic Weapons Employees who worked for Nuclear Metals Inc. at its facility in West Concord, Massachusetts during the period from January 1, 1980 through December 31, 1990, for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more other classes of employees included in the Special Exposure Cohort.

4.0 Data Sources Reviewed by NIOSH to Evaluate the Class

As is standard practice, NIOSH completed an extensive database and Internet search for information regarding Nuclear Metals, Inc. The database search included the DOE Legacy Management Considered Sites database, the DOE Office of Scientific and Technical Information (OSTI) database, the Energy Citations database, and the Hanford Declassified Document Retrieval System. In addition to general Internet searches, the NIOSH Internet search included OSTI OpenNet Advanced searches, OSTI Information Bridge Fielded searches, Nuclear Regulatory Commission (NRC) Agency-wide Documents Access and Management (ADAMS) web searches, the DOE Office of Human Radiation Experiments website, and the DOE-National Nuclear Security Administration-Nevada Site Office-search. Attachment 1 contains a summary of Nuclear Metal, Inc. documents. The summary specifically identifies data capture details and general descriptions of the documents retrieved.

In addition to the database and Internet searches listed above, NIOSH identified and reviewed numerous data sources to determine information relevant to determining the feasibility of dose reconstruction for the class of employees under evaluation. This included determining the availability of information on personal monitoring, area monitoring, industrial processes, and radiation source materials. NIOSH also reviewed approximately 250 documents received in February 2014 from the Massachusetts Environmental Protection Agency. The following subsections summarize the data sources identified and reviewed by NIOSH.

4.2 ORAU Technical Information Bulletins (OTIBs) and Procedures

An ORAU Technical Information Bulletin (OTIB) is a general working document that provides guidance for preparing dose reconstructions at particular sites or categories of sites. NIOSH reviewed the following OTIBs as part of its evaluation:

- *OTIB: Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures,* ORAUT-OTIB-0006, Rev. 03 PC-1; December 21, 2005; SRDB Ref ID: 20220

- *OTIB: Internal Coworker Dosimetry Data for Nuclear Metals, Inc.,* ORAUT-OTIB-0084, Rev. 00; November 15, 2013; SRDB Ref ID: 128501

4.3 Facility Employees and Experts

In support of its September 2012 SEC-00195 Evaluation Report, NIOSH interviewed eight former Nuclear Metals, Inc. (NMI) employees. Interviewee selection was based on individual availability and the potential knowledge of NMI working conditions during the 1958-1983 period under evaluation. Information obtained during the interviews contributed to the general knowledge of NMI conditions and monitoring practices. In addition to the eight interviews, three worker outreach meetings were held in Concord, Massachusetts on March 14 and March 15, 2012. The meetings consisted of a presentation and discussion-type format. Approximately 50 former workers and owners of the company attended these meetings. Significant insight into the operations and potential problems were identified and discussed.

In support of this Evaluation Report Addendum for the 1980-1990 period, NIOSH interviewed or re-interviewed seven former NMI employees. Interviewee selection was based on individual availability and the potential knowledge of NMI working conditions during the period under evaluation. Information obtained during these additional interviews contributed to the general knowledge of NMI operations during the 1980-1990 period.

- Personal Communication, 2012a, *Documented Communication with a Manager*; Telephone Interview by ORAU Team; March 8, 2012, 10:00 AM EST; SRDB Ref ID: 111247

- Personal Communication, 2012b, *Documented Communication with a Manager*; Telephone Interview by ORAU Team; November 5, 2012; SRDB Ref ID: 122512

- Personal Communication, 2012c, *Documented Communication with an Engineer*; Telephone Interview by ORAU Team; November 24, 2012; SRDB Ref ID: 122510

- Personal Communication, 2014a, *Documented Communication with a former NMI worker*; Telephone Interview by ORAU Team; March 5, 2014; SRDB Ref ID: 131021

- Personal Communication, 2014b, *Documented Communication with a former NMI worker*; Telephone Interview by ORAU Team; February 24; 2014; SRDB Ref ID: 131017

- Personal Communication, 2014c, *Documented Communication with a former NMI worker*; Telephone Interview by ORAU Team; February 24, 2014; SRDB Ref ID: 131022

- Personal Communication, 2014d, *Documented Communication with a former NMI worker* Telephone Interview by ORAU/NIOSH Team; February 24, 2014; SRDB Ref ID: 131016

- Personal Communication, 2014e, *Documented Communication with a former NMI worker*; Telephone Interview by ORAU Team; February 24, 2014; SRDB Ref ID: 131020

- Personal Communication, 2014f, *Documented Communication with a former NMI worker* Telephone Interview by ORAU Team; February 24, 2014; SRDB Ref ID: 131019

- Personal Communication, 2014g, *Documented Communication with a former NMI worker*; Telephone Interview by ORAU Team; February 27, 2014; SRDB Ref ID: 131018

- Worker Outreach, 2012, *Transcript of NIOSH SEC Outreach Meeting for Nuclear Metals, Inc.*; National Institute for Occupational Safety and Health; meeting held in Concord, Mass. with former NMI workers; March 15, 2012; SRDB Ref ID: 117721

4.4 Previous Dose Reconstructions

NIOSH reviewed its NIOSH DCAS Claims Tracking System (referred to as NOCTS) to locate EEOICPA-related dose reconstructions that might provide information relevant to the petition evaluation. NIOSH reviewed each claim to determine whether internal and/or external personal monitoring records could be obtained for the employee. Table 4-1 summarizes the results of this review. (NOCTS data available as of March 27, 2014)

Table 4-1: No. of Nuclear Metals, Inc. Claims Submitted Under the Dose Reconstruction Rule

Description	Totals
Total number of claims submitted for dose reconstruction	26
Total number of claims submitted for energy employees who worked during the period from January 1, 1980 through December 31, 1990	19
Number of dose reconstructions completed for energy employees who worked during the period from January 1, 1980 through December 31, 1990 (i.e., the number of such claims completed by NIOSH and submitted to the Department of Labor for final approval).	18
Number of claims for which internal dosimetry records were obtained for the period from January 1, 1980 through December 31, 1990	19
Number of claims for which external dosimetry records were obtained for the period from January 1, 1980 through December 31, 1990	19

4.5 NIOSH Site Research Database

NIOSH also examined its Site Research Database (SRDB) to locate documents supporting the assessment of the evaluated class. One thousand six hundred twenty documents in this database were identified as pertaining to Nuclear Metals, Inc. for NIOSH's 2012 SEC-00195 Evaluation Report. An additional 327 NMI-related documents have been added to the database and reviewed in support of the continuing evaluation for this SEC-00195 Addendum. These documents were evaluated for their relevance to this petition. The documents include historical background on locations, licenses, process descriptions, radiological training, hazards associated with uranium, external dosimetry monitoring data, air sample data, urinalysis data, lung counts, medical program, and the radiological control program.

5.0 Radiological Operations Relevant to the Class Evaluated by NIOSH

The following subsections summarize both radiological operations at the Nuclear Metals, Inc. site from January 1, 1980 through December 31, 1990, and the information available to NIOSH to characterize particular processes and radioactive source materials. From available sources NIOSH has gathered process and source descriptions, information regarding the identity of each radionuclide of concern, and information describing processes through which radiation exposures may have occurred and the physical environment in which they may have occurred. The information included within this SEC-00195 Addendum is intended only to be a summary of the available information as it relates to the period from January 1, 1980 through December 31, 1990. Information for the period from October 29, 1958 through December 31, 1979 can be found in NIOSH's 2012 SEC-00195 Evaluation Report (NIOSH, 2012).

5.1 Nuclear Metals, Inc. Plant and Process Descriptions

While some of the same basic processes were continued through the entire period that Nuclear Metals, Inc. was designated as an AWE (October 29, 1958-December 31, 1990), NIOSH's 2012 SEC-00195 Evaluation Report was developed to evaluate the period from October 29, 1958 through December 31, 1983. As indicated previously, NIOSH reserved its feasibility determination for the period from January 1, 1980 through 1983 pending full assessment of the then-newly-acquired post-1979 data. This SEC-00195 Addendum covers the period from January 1, 1980 through December 31, 1990. As a result, there may be some information from the 1980-1983 period that was included in the 2012 SEC-00195 Evaluation Report that may be repeated in this Addendum for context and clarity.

Nuclear Metals, Inc. was located at 2229 Main Street, Concord, Massachusetts, on 30 acres of land during the evaluated time period, but later expanded to 46.4 acres of land in 1990 when Nuclear Metals purchased adjacent properties from the Memorial Drive Trust (MDT) (MACTEC, 2004). For the period evaluated by NIOSH, the Nuclear Metals, Inc. workforce, based on various contracts held during different times, varied from approximately 60 to over 650 workers. The number of employees decreased during the period from 1960 through the mid-1970s. The number of employees (obtained from various inspection reports) increased rapidly starting in the latter half of the 1970s, peaking

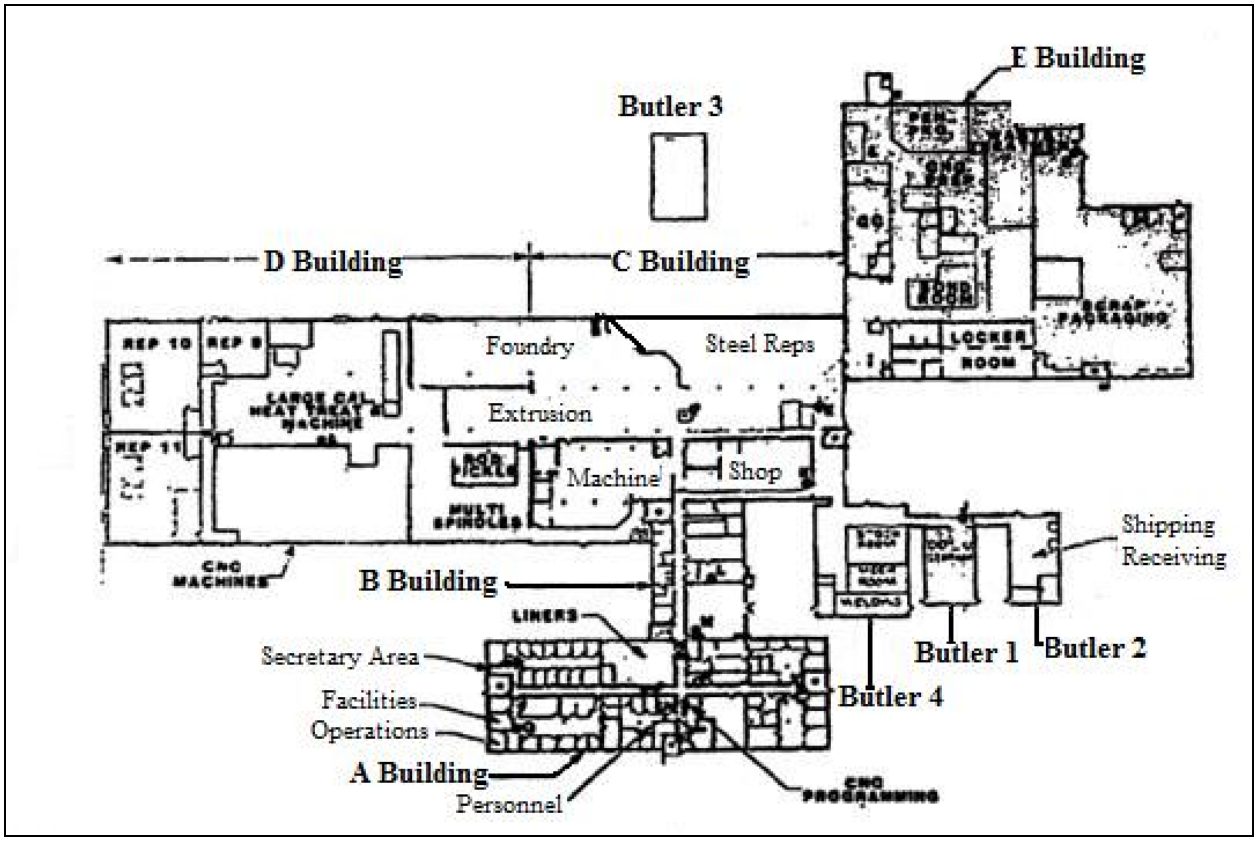
around 1982 through 1983 to over 650. Table 5-1 shows what is known to NIOSH regarding the Nuclear Metals, Inc. workforce population from 1959 through 1990. In the years not represented in the table below, NIOSH has found no information regarding the number of employees per year.

Table 5-1: Nuclear Metals, Inc. 1959-1990 Workforce Population

Month and Year	No. of Employees	SRDB Ref ID
October 1959	275	25090, pdf p. 48
October 1960	350	25090, pdf p. 70
July 1961	250	25090, pdf p. 74
January 1962	165	25090, pdf p. 80
September 1962	167	25090, pdf p. 88
October 1963	156	25090, pdf p. 96
February 1964	154	25090, pdf p. 98
August 1964	167	25090, pdf p. 101
October 1964	163	25090, pdf p. 104
May 1965	143	25090, pdf p. 106
November 1965	135	25090, pdf p. 114
May 1966	128	25090, pdf p. 119
1967	---	---
1968	---	---
1969	---	---
July 1970	100	109544, pdf p. 6
July 1971	80	105866, pdf p. 6
July 1972	50	105867, pdf p. 4
August 1972 to 1982	---	---
1982	555	115400, pdf p 3
August 1983	654	112167, pdf p. 5
1984	615	113402
1985	---	---
1986	---	---
1987	---	---
1988	---	---
1989	574	112189, pdf p 6
1990	401	118650, pdf p 38

Three hyphens (---) means records not identified by NIOSH.

Figure 5-1 shows a diagram of the Nuclear Metals, Inc. facility.



Source: ACI, 1994, pdf p. 26, with enhanced text

Figure 5-1: Diagram of Nuclear Metals, Inc.

The Concord, Massachusetts site was originally a specialty metal research and development facility that was licensed to possess low-level radioactive substances. The original facility consisted of three principal buildings, designated as Buildings A, B, and C. Building A contained office space and research laboratories. Building B contained services (e.g., cafeteria, laboratories, etc.). Building C was initially configured for use as the main production facility and included foundry equipment for melting metals, extrusion presses, metal working equipment, pickling and etching tanks, and electroplating equipment (MACTEC, 2004, pdf p. 21). After 1972, Nuclear Metals, Inc. developed a manufacturing orientation. Building D was constructed in 1978 to expand the production capabilities of the facility. Building E was constructed in 1983 and occupied in January 1984 and was used to house the radioactive waste-processing operations (MACTEC, 2004, pdf p. 22).

In 1990, Nuclear Metals, Inc. acquired adjacent properties designated as Parcels A and B from the Memorial Drive Trust (MDT), which owned land to the west and south of the Nuclear Metals, Inc. property. At the same time, MDT acquired Lots C and D from Nuclear Metals, Inc. The Nuclear Metals, Inc. property then consisted of approximately 46 acres (MACTEC, 2004, pdf p. 22). On October 1, 1997, Nuclear Metals, Inc. changed its name to Starmet Corporation (Quinn, 2001, pdf p. 13).

5.1.3 Operations (1980-1990)

[NOTE TO READER: This is a new Section 5.1.3. The original Section 5.1.3 in the Rev. 0 version of the Nuclear Metals ER, *Health Physics Program Practices and Inspections*, is now renumbered Section 5.1.4.]

With the exception of enriched uranium (production discontinued in 1974), NMI continued the same operations and processes during the period from 1980 through 1983 as were performed during the period covered by NIOSH's 2012 evaluation of the October 29, 1958 through December 31, 1979 period. This included melting and casting of depleted uranium and UF_4, billet assembly, extrusion, copper removal/pickling, straightening, etc. In 1983, NMI ceased processing UF_4 and transferred that operation to Carolina Metals in South Carolina. During the period from 1984 through 1990, NMI continued manufacturing operations such as: depleted uranium (DU) shields, counterweights to balance control surface movements on commercial and military aircraft, armor penetrators, the manufacture of metal powders, and other commercial and medical applications. NMI also provided both DU and natural uranium for the Atomic Vapor Laser Isotope Separation Project (AVLIS) for Lawrence Livermore National Laboratory (LLNL). One former employee stated that they produced tonnage quantities of that material over a period of approximately fifteen years (Worker Outreach, 2012, pdf p. 5).

NMI worked with large quantities of thorium beginning with their move from the Hood Building to the Concord facility in 1958. Possibly due to the compartmentalized work assignments and work protocols, NIOSH has been unable to find a consolidated information source regarding thorium operations during the period from 1980 through 1990. Former worker interviewees appear to have greatly differing levels of knowledge regarding thorium operations through the AWE period at NMI. Worker outreach meetings, interviews with senior NMI personnel and workers, and the 25,000 kg of thorium maintained on the site's NRC license indicate that thorium operations were performed through varying periods of the 1980 and 1990s.

During its document reviews, NIOSH found indications of possible thorium-related activities carrying over into or beyond the 1980 -1990 period, such as:

- Indication in a Helgeson *in vivo* program weekly report for July 1982 that they performed one lung count specifically for natural thorium during the week, in addition to the 96 DU lung counts performed that week (Helgeson, 1982, pdf p. 38).

  - The information available to NIOSH does not indicate the purpose of the thorium bioassay, but NIOSH concludes that it is indication that the site health physics staff was investigating a possible intake of non-uranium-related thorium.

- NIOSH found one urinalysis sample performed for Th-232 in July 1983 (Thorium Urinalysis, 1983, pdf. p. 65).

  - The worker's Th-232 result was reported as <0.2 dpm/liter, as was the single control sample submitted by the site.

- The information available to NIOSH does not indicate the purpose of the thorium bioassay. The analysis was performed for NMI by a consulting radiochemist and does not appear to be part of the NMI routine bioassay program. NIOSH concludes that it is indication that the site health physics staff was investigating a possible intake of Th-232, presumably sampling for a known or expected NMI thorium source term.

- NMI held various NRC licenses for production operations and for waste processing and repackaging activities, allowing for varying amounts of thorium inventory. In September 1974, NMI submitted an amendment to their license SMB-179 in which they requested thorium in the form of natural thorium metal, alloy or oxide in the amount of 20,000 lbs (License, 1977). In a subsequent 1981 application for an amendment to the same license, NMI requested thorium in the form of natural thorium or thorium oxide in the amount of 25,000 kg (~55,100 lbs) (License, 1981b).

  - Based on the 1981 site-requested increase (175% increase) in the licensed thorium quantity, NIOSH concludes that NMI was planning for increased operations with thorium in the early to mid 1980s.

- In response to a previous request for License Amendment 2 to NMI License SMB-179, the NRC requested (in 1975) that NMI describe the survey procedures designed to evaluate the hazards when thorium concentrations exceeding 2% are handled since NMI requested use of materials containing up to 90% thorium (NRC Comments, 1975). At that time (1976), the NMI response was: "To correct an apparent misunderstanding relative to thorium-containing materials, the license request was for 90% thorium minimum. We plan to operate under the same philosophy of control when working with thorium as for depleted uranium."

  - The information available to NIOSH does not indicate the specific processes involving the concentrated thorium materials. NIOSH concludes that NMI was working with materials containing >90% thorium during the licensing period associated with the late 1970s.

- In their license application dated November 16, 1981, NMI requested natural thorium and thorium oxide in the form of solids either 2% ThO_2 or 90% Th minimum (License, 1981). Attachment Supplement 2, Item B in the application states: "Natural or depleted metallic uranium, natural thorium, or alloys based on these metals for use both as manufactured products and for development purposes." However, it does not give specific details of the 90% thorium (License, 1981).

  - NIOSH concludes from this 1981 correspondence that NMI intended to continue their work with natural thorium (>90%) at least into the licensing period associated with the first half of the 1980s.

- The NRC web site description of the NMI/Starmet facility (http://www.nrc.gov/info-finder/decommissioning/complex/starmet-corporation.html) states that in 1999, Starmet ceased making munitions with DU, but other subsidiaries continued work onsite with beryllium-aluminum alloys, thorium, thorium oxide, and DU (SRDB Starmet, 2014).

    - Although the above does not apply directly to the 1980-1990 AWE period, and does not state when the subsidiaries' on-site work began, it is an indication that operations with thorium continued during the 1990s.

During communications with former NMI workers, NIOSH found indications of thorium-related activities, such as:

- The use of thorium powder was discussed in a group setting at the March 2012 Worker Outreach meeting where a worker indicated that thorium in powder form was blended with other constituents, pressed into a form, and put through a heated extrusion process. The consolidated material was then further processed by machining and grinding, and then shipped to the end customer to be reprocessed. The worker indicated that this process was taking place while the worker was an engineer on site (between 1980 and 1990). The worker further indicated that they typically worked in 25-pound lots, two to three times a year, but it was not unusual for NMI to get feed materials that contained thorium for processing in smaller quantities. The worker indicated that when NMI did an order for Army Research and other areas, NMI did not always know the exact concentration of thorium in the material that was being processed (Worker Outreach, 2012)

    - A subsequent November 2012 interview with the same senior-level worker indicated that workers on this process did not wear protective clothing or respirators, and relied on the ventilation on the press equipment (Personal Communication, 2012b).

- An individual in the [group name redacted] Group during [time period redacted] was aware of thorium on site in the mid-1980s and stated there may have been a couple of bins of thorium, but he was not aware of any significant quantities (Personal Communication, 2012c).

- Another individual stated: "*We had constant contact with thorium and thoriated tungsten.*" (Worker Outreach, 2012, pdf p. 6). NIOSH believes NMI was producing small welding rods containing this material. It is unknown whether the feed material arrived already thoriated from another site, or whether the material was thoriated at NMI.

NIOSH has not identified the quantity of thorium used in the processes listed above during the 1980 through 1990 period of evaluation; however, indications are that various thorium activities were conducted during the period, or were carried over into the period, or possibly continued beyond 1990.

5.1.4 Health Physics Program Practices and Inspections

[NOTE TO READER: This was Section 5.1.3 in the Rev. 0 version of the Nuclear Metals ER. With the addition of a new Section 5.1.3, *Operations (1908-1990)*, this section now becomes Section 5.1.4.]

During the 1980-1990 period, radiation protection practices at NMI improved considerably through hiring of additional radiation protection personnel, the development of procedures for radiation protection and dosimetry for each major operation, and the development of a Radiation Work Permit (RWP) Program. The RWP Program consisted of identifying hazards, prescribing protective clothing and dosimetry, instituting a surveillance program, increasing the training program, and implementing an audit program. NIOSH has been unable to locate any RWP documentation specifically describing the work processes or radiological controls associated with the handling of the concentrated thorium contained in the site's NRC license(s) during the 1980s.

Although the radiation safety program was improved, there were many violations of standard procedures and RWPs that were identified in self-inspections by NMI personnel (as noted in the Radiation Protection Observations weekly summary reports). Some of the violations noted included scrap material left in processing areas at the end of a shift, increases in surface contamination at change areas, leaving the work site while still dressed in company-issued protective clothing, and missing or improperly worn badges (Survey Observations, 1984).

In addition to the in-house observations, the NRC inspections identified a variety of issues in the 1980-1990 period, such as failure to evaluate an apparent 110 rem extremity exposure during the period from December 1, 1982 through February 28, 1983 (exact date unknown), failure to provide adequate extremity dosimeters, and failure to notify the NRC of that potential exposure (Inspection Report, Aug1983). During another inspection in 1981, the violations included a quarterly overexposure to the hands of an employee, exclusive-use vehicle contamination in excess of regulatory limits, and failure to self-monitor upon exiting a restricted area (Inspection Report, 1981).

5.2 Radiological Exposure Sources from Nuclear Metals, Inc. Operations

The following subsections provide an overview of the internal and external exposure sources for Nuclear Metals, Inc. as it applies to the January 1, 1980 through December 31, 1990 class under evaluation in this SEC-00195 Addendum. A detailed description of available source term information for the pre-1980 period is found in NIOSH's 2012 SEC-00195 Evaluation Report (NIOSH, 2012).

5.2.1 Internal Radiological Exposure Sources from Nuclear Metals, Inc. Operations

Consistent with the findings presented in NIOSH's 2012 evaluation of the period from 1958 through 1983 (NIOSH, 2012), inhalation of airborne contamination during the various processes, inhalation of re-suspended contamination, and associated ingestion continued to also be the primary sources of internal exposure to Nuclear Metals, Inc. workers during the remainder of the AWE operations period ending December 31, 1990. Various processes presented in Section 5.1 of NIOSH's 2012 SEC-00195 evaluation continued through the AWE operations period and were capable of producing airborne contamination, thereby subjecting the workers to an internal exposure hazard during the period from 1980 through 1990. There were nearly 70 documented fire, smoke, and spill incidences that occurred

from 1981 through 1984 (Unusual Occurrences, 1981-1984; Survey Observations, 1984). NIOSH has not identified documented incidents in 1980 or during 1985 through 1990.

5.2.1.2 Thorium

NMI worked with thorium from the beginning of their move to the Concord facility in 1958. During the AWE period, thorium rods were converted to powder. The thorium powder was compacted, pressed into cylindrical shapes, placed in steel canisters, welded in an evacuation chamber, extruded, and made into 1.2 inch-diameter 10-foot rods (Personal Communication, 2012b, pdf p. 7). What is known by NIOSH regarding potential for thorium exposures at NMI during the period 1980 through 1990 is presented above in Section 5.1.3. Possibly due to the compartmentalized work assignments and work protocols at NMI, NIOSH has been unable to find a consolidated information source regarding thorium operations during the period from 1980 through 1990. Former worker interviewees appear to have greatly differing levels of knowledge regarding thorium operations through the AWE period. Based on worker outreach meetings, interviews with senior NMI personnel and workers, and the 25,000 kg of thorium on the site's NRC license(s), the evidence examined by NIOSH indicates that there was a potential for thorium exposures during operations at the Concord facility during the period January 1, 1980 through December 31, 1990.

5.2.1.3 Radon/Thoron

As indicated in NIOSH's 2012 evaluation of the 1958 through 1983 period, thorium work continued after the move from the Hood Building to the Concord site. There are indications that thoron generation could have been a concern; however, NIOSH did not identify any monitoring data for thoron in its 2012 evaluation of the 1958-1979 period, or in the research for this Addendum evaluating the 1980-1990 period.

5.2.2 External Radiological Exposure Sources from Nuclear Metals, Inc. Operations

Consistent with NIOSH's 2012 evaluation of the period from 1958 through 1983, the potential for external radiation doses from thorium, uranium, and their decay products continued to exist at the Nuclear Metals, Inc. site during the period from January 1, 1980 through December 31, 1990, being evaluated in this SEC-00195 Addendum. The detailed external exposure information for the period from October 29, 1958 through December 31, 1979 presented in NIOSH's 2012 SEC-00195 Evaluation Report (NIOSH, 2012) also applies to the external exposure scenarios likely encountered by NMI workers during the period from 1980 through 1990 being evaluated in this Addendum.

6.0 Summary of Available Monitoring Data for the Class Evaluated by NIOSH

The following subsections provide an overview of the state of the available internal and external monitoring data for the Nuclear Metals, Inc. as it applies to the January 1, 1980 through December 31, 1990 class under evaluation in this SEC-00195 Addendum. A detailed description of available monitoring data for the pre-1980 period is found in NIOSH's 2012 SEC-00195 Evaluation Report (NIOSH, 2012).

6.1 Available Nuclear Metals, Inc. Internal Monitoring Data

Discussed below are the available 1980-1990 bioassay, air monitoring, lung count, and surface contamination data that have been identified by NIOSH. The NMI routine bioassay program consisted of urine sampling and lung counts for uranium supplemented by the air sampling and contamination monitoring programs. Most of the urinalysis sample datasheets indicate that the samples were analyzed for total uranium by fluorometric methods.

6.1.1 Urine Bioassay Data

The urine bioassay program was well established in the 1980s with a total of approximately 44,000 legible samples from 1980-1990, and an average of over 4,400 urine samples per year during the evaluation period. During 1983 and 1984, the samples were analyzed by a contractor (Bioassay Data, 1983). However, there is evidence that Carolina Metals, Inc. (CMI, which was part of NMI) performed some of the analyses. One of the NMI employees prepared the CMI Fluorometric Laboratory Procedures Manual in 1985 (Carolina Metals, 1985), which was the method used for urine analysis. The NMI urinalysis program is also described in detail in the Radiation Safety Reference (NMI Urinalysis, 1982, pdf p. 6).

Nearly all urine samples were analyzed for total uranium using fluorometry. NIOSH has found five urinalyses performed for tritium in February 1985 (Tritium Urinalysis, 1985, pdf p. 173) with four results shown as <0.005 µCi/liter, and one reported as 0.013 µCi/liter. NIOSH has found one urinalysis sample performed for Th-232 in July 1983 (Thorium Urinalysis, pdf p. 65). The worker's Th-232 result was reported as <0.2 dpm/liter, as was the single control sample submitted by the site. The analysis was performed for NMI by a consulting radiochemist and does not appear to be part of the NMI routine bioassay program. NIOSH concludes that it is an indication that the site health physics staff was investigating a possible Th-232 intake, presumably sampling for a known or expected NMI thorium source term.

6.1.2 Air Monitoring Data

NIOSH has found general area and breathing zone air sample data, including high-volume, isokinetic, and stack air sample data for the 1980 through 1990 period. The total number of air sample results found in the database for this period is approximately 34,400. But, as noted in ORAUT-OTIB-0084 for urinalysis data, there were instances of air sample results being reported more than once, leaving approximately 33,000 useful air sample data.

Nearly all air samples appear to have been analyzed for gross alpha and for gross beta activity. Some datasheets from 1984, 1988, and 1990 indicate analysis for depleted uranium, U-238, and/or Th-234 (as an indicator of uranium intakes).

NIOSH has found no indication that isotopic studies on air samples were performed. A thorough review of available air monitoring data performed by NIOSH in support of its November 2013 internal coworker analysis, ORAUT-OTIB-0084, found no air monitoring results attributed to thorium during the period 1980 through 1990.

6.1.3 *In Vivo* Counting Bioassay Data

In vivo analyses were not performed at NMI until April 1981 following a discovery of a probable overexposure of an individual to airborne concentration of DU. A whole body count on the individual was performed in October 1981 (Incident, 1981, pdf p. 3). The whole body count results indicated the presence of 8 mg of DU in the subject. The document does not reveal where the whole body count was performed.

Starting in the summer of 1982, NMI brought in a Helgeson Scientific mobile whole body counter trailer for uranium lung counting of selected workers. Approximately 800 uranium lung counts were performed from 1982 through 1990 by Helgeson Scientific Services (Helgeson, 1981; Lung Counting, 1982; *In Vivo* Counting, 1982; Lung Counting, 1982-1986). Some workers were given multiple lung counts. One employee was subjected to three consecutive counts in 1982.

NIOSH has identified one Helgeson lung count for natural thorium performed during the week of July 19-23, 1982 (Helgeson, 1982, pdf p. 38; Lung Counting, 1982, pdf p. 25). The information available to NIOSH does not indicate the purpose of the thorium bioassay, but NIOSH concludes that it is an indication that the site health physics staff was investigating a possible intake of non-uranium-related thorium in 1982.

7.0 Feasibility of Dose Reconstruction for the Class Evaluated by NIOSH

The feasibility determination for the class of employees under evaluation in this report is governed by both EEOICPA and 42 C.F.R. § 83.13(c)(1). Under that Act and rule, NIOSH must establish whether or not it has access to sufficient information either to estimate the maximum radiation dose for every type of cancer for which radiation doses are reconstructed that could have been incurred under plausible circumstances by any member of the class, or to estimate the radiation doses to members of the class more precisely than a maximum dose estimate. If NIOSH has access to sufficient information for either case, NIOSH would then determine that it would be feasible to conduct dose reconstructions.

In determining feasibility, NIOSH begins by evaluating whether current or completed NIOSH dose reconstructions demonstrate the feasibility of estimating with sufficient accuracy the potential radiation exposures of the class. If the conclusion is one of infeasibility, NIOSH systematically

evaluates the sufficiency of different types of monitoring data, process and source or source term data, which together or individually might assure that NIOSH can estimate either the maximum doses that members of the class might have incurred, or more precise quantities that reflect the variability of exposures experienced by groups or individual members of the class as summarized in Section 7.5. This approach is discussed in DCAS's SEC Petition Evaluation Internal Procedures which are available at http://www.cdc.gov/niosh/ocas. The next four major subsections of this Evaluation Report examine:

- The sufficiency and reliability of the available data. (Section 7.1)
- The feasibility of reconstructing internal radiation doses. (Section 7.2)
- The feasibility of reconstructing external radiation doses. (Section 7.3)
- The bases for petition SEC-00195 as submitted by the petitioner. (Section 7.4)

7.1 Pedigree of Nuclear Metals, Inc. Data

This subsection answers questions that need to be asked before performing a feasibility evaluation. Data Pedigree addresses the background, history, and origin of the data. It requires looking at site methodologies that may have changed over time; primary versus secondary data sources and whether they match; and whether data are internally consistent. All these issues form the bedrock of the researcher's confidence and later conclusions about the data's quality, credibility, reliability, representativeness, and sufficiency for determining the feasibility of dose reconstruction. The feasibility evaluation presupposes that data pedigree issues have been settled.

7.1.1 Internal Monitoring Data Pedigree Review

With the exception of thorium and its progeny, the internal monitoring data located by NIOSH are of sufficient quality and quantity to adequately represent potential exposures for the class under evaluation.

During the period from January 1980 through December 1990, NIOSH has available an average of over 4,000 uranium urinalysis results per year, and approximately 100 uranium-related lung count results per year (beginning in 1982). As stated above, NIOSH has found only one thorium urine bioassay, and a single *in vivo* analysis performed for thorium.

The available urinalysis data from NMI are original reports and are, therefore, primary data sources. They are mostly legible and use appropriate reporting units. Therefore, no additional pedigree review was performed for those data.

NMI initiated annual uranium lung counts for approximately 100 select employees per year starting in the summer of 1982 through 1990. The total number of lung counts performed from 1982 through 1990 was 802. Helgeson Scientific analyzed the lung count spectrum for U-235, depleted uranium, and Th-234. The lung count results are available in the original Helgeson computer printouts; therefore, they are the original data. As a result, no additional pedigree review was performed for those data.

A large number (~ 33,000) of air sample results from 1980 through 1990 were located. Most air samples from 1980 through 1990 were analyzed for gross alpha and gross beta. NIOSH has found no indication that isotopic studies were performed on air samples. A thorough review of available air monitoring data performed by NIOSH in support of its November 2013 internal coworker analysis, ORAUT-OTIB-0084, found no air monitoring results attributed to thorium during the period 1980 through 1990.

The air sample data from 1980 through 1990 are contained in original handwritten data sheets or computer printouts and are, therefore, primary data sources. Therefore, no additional pedigree review was performed for those data.

In summary, a large amount of internal monitoring data is available to NIOSH, but NIOSH is unable to verify if all pertinent data have been located. With the exception of thorium and its progeny, for which NIOSH has identified only two worker bioassay results, and no thorium-specific air data, the quality and quantity of the data available to NIOSH are sufficient to adequately represent the possible internal dose contributors for the Nuclear Metals, Inc. class under evaluation over the entire evaluation period.

7.1.2 External Monitoring Data Pedigree Review

The external monitoring data, based on film badge dosimetry results, are available in sufficient quantity and quality to adequately represent the class under evaluation. The available external dosimetry data are primary source documents that contain the personnel monitoring (film badge) results for individual workers across the site. The data are legible with the exception of the monthly reports for March-May, September-October, and December 1987. For all available documentation, appropriate reporting units were used.

7.2 Evaluation of Bounding Internal Radiation Doses at Nuclear Metals, Inc.

The principal source of internal radiation doses for members of the class under evaluation was the potential inhalation and ingestion of natural and depleted uranium, thorium oxides and metals, and uranium and thorium progeny during foundry, machining, extrusion, welding, grinding, and reduction operations. Intake of radioactive material was also possible through wounds that may have occurred during the processing of these metals. Other employees were potentially exposed to the re-suspension of contamination on surfaces during the course of their work with non-radioactive materials, and inhalation of smoke and fumes from fires and explosions (Incident, 1982a; Incident, 1982b; Incident, 1996).

The following subsections address the ability to bound internal doses, methods for bounding doses, and the feasibility of internal dose reconstruction.

7.2.1 Evaluation of Bounding Process-Related Internal Doses

The NMI bioassay program consisted of urine sampling and lung counts for uranium, supplemented by the air sampling and contamination monitoring programs. NIOSH has obtained urinalysis and air sampling data for all years evaluated by this Addendum. NIOSH has found uranium lung count data

during the period from 1982 through 1990. Most urinalysis sample datasheets indicate that the samples were analyzed for total uranium by fluorometric methods; the lung counts were performed by Helgeson Scientific.

The following subsections summarize the extent and limitations of information available for reconstructing the process-related internal doses of members of the class under evaluation.

7.2.1.1 Urinalysis Information and Available Data

As indicated in Section 6.1.1, the uranium bioassay program was well established in the 1980s. NIOSH has obtained over 40,000 uranium urinalysis results for all years under evaluation in this Addendum (1980-1990). The number of urinalyses averaged over 4,000 per year during the period. The samples were analyzed by various contractors during this period (Uranium Urinalysis, 1982; Bioassay Data, 1983). There were only two samples analyzed for Th-232, both of which were personnel with one person's sample acting as a control sample. The results were reported as <0.2 dpm/liter (Thorium Urinalysis, 1983, pdf p. 65). In addition, five samples were analyzed for tritium with four results shown as < 0.005 pCi/liter and one reported as 0.013 μCi/liter (Tritium Urinalysis, 1985, pdf p. 173). The routine urine samples were usually analyzed for uranium or DU by outside contractors, with indications that, for some years, the analyses were conducted either in-house or by NMI's subsidiary, Carolina Metals, Inc.

There are sufficient urinalysis data to support dose reconstruction for natural and depleted uranium during the recommended SEC period from January 1, 1980 through December 31, 1990, using available claimant data, site monitoring data, and information in ORAUT-OTIB-0084, *Internal Coworker Dosimetry Data for Nuclear Metals, Inc.*

However, NIOSH has found only one worker urinalysis sample performed for Th-232, performed in [month and year redacted]. The information available to NIOSH does not indicate the purpose of the thorium bioassay or the existence of a routine monitoring program for thorium intakes. NIOSH concludes that it is an indication that the site health physics staff was investigating a possible Th-232 intake, presumably sampling for a known or expected NMI thorium source term. Although a substantial urine bioassay monitoring program is evident for uranium during the 1980s at NMI, NIOSH has found no indication of a urine bioassay program appropriate for detection of routine or incident-related intakes of thorium in the NMI workplace.

There are insufficient thorium urine bioassay data available to NIOSH to support efforts to bound the internal dose from thorium and thorium progeny during the period from January 1, 1980 through December 31, 1990.

7.2.1.2 Lung Counting Information and Available Data

The production rate for DU ammunition was at or near its maximum when NMI started performing annual lung counts on its production employees in 1982. NIOSH has uranium lung count data for the period from 1982 through 1990. The results of the lung counts are found in Helgeson Scientific reports.

The measured maximum lung burden reported was 154.3 mg of depleted uranium and 83.0 µg of U-235 in 1982. The highest average lung burden was 7.5 mg of DU, and 16.1 µg of U-235, again in 1982. The lung burdens measured after 1982 were substantially lower.

A Helgeson *in vivo* program weekly report for July 1982 documents that they performed one lung count specifically for natural thorium during the week, in addition to the 96 DU lung counts performed that week (Helgeson, 1982, pdf p. 38). The information available to NIOSH does not indicate the purpose of the lone thorium bioassay, but NIOSH concludes that it is an indication that the site health physics staff was investigating a possible thorium intake. Although a substantial lung counting program is evident for uranium beginning in 1982 at NMI, NIOSH has found no indication of a thorium-specific *in vivo* bioassay program appropriate for detection of routine or incident-related intakes of thorium in the NMI workplace.

There are insufficient *in vivo* bioassay data available to NIOSH to support efforts to bound the internal dose from thorium and thorium progeny for the period from January 1, 1980 through December 31, 1990.

7.2.1.3 Airborne Levels

There were over 33,000 air samples taken during the period under evaluation (1980-1990). Most of the samples were analyzed for gross alpha and gross beta. NIOSH has found no indication that isotopic studies were performed on air samples. A thorough review of available air monitoring data performed by NIOSH in support of its November 2013 internal coworker analysis, ORAUT-OTIB-0084, found no air monitoring results attributed to thorium during the period 1980 through 1990.

NIOSH has not found indication that the site's routine air sampling program was directed at assessing potential thorium exposures, and cannot show that sampling locations were chosen to include thorium-handling work areas. In the absence of a complementary thorium-specific bioassay program, the gross-alpha air results available to NIOSH for the period from 1980-1990 are insufficient to support efforts to bound the internal dose from thorium and thorium progeny for the period from January 1, 1980 through December 31, 1990.

7.2.2 Methods for Bounding Internal Dose at Nuclear Metals, Inc.

Based on the evaluations presented above, NIOSH has been unable to locate sufficient thorium-specific urine bioassay data, lung count data, or air monitoring data adequate to support sufficiently accurate dose reconstruction of internal dose from thorium and thorium progeny for the period from January 1, 1980 through January 31, 1990.

NIOSH found that it is feasible to reconstruct internal doses from natural and depleted uranium for employees during the recommended evaluation period from January 1, 1980 through December 31, 1990 using available claimant data, site monitoring data, and information in ORAUT-OTIB-0084, *Internal Coworker Dosimetry Data for Nuclear Metals, Inc.*

7.2.3 Internal Dose Reconstruction Feasibility Conclusion

NIOSH has concluded that it did not locate sufficient data, including thorium-specific bioassay results and air monitoring data to estimate with sufficient accuracy the total internal dose from exposures to thorium and thorium progeny during the period from January 1, 1980 through December 31, 1990. NIOSH found that it is feasible to reconstruct internal doses from natural and depleted uranium for employees during the recommended SEC evaluation period from January 1, 1980 through December 31, 1990 using available claimant data, site monitoring data, and information in ORAUT-OTIB-0084, *Internal Coworker Dosimetry Data for Nuclear Metals, Inc.*

Although NIOSH found that it is not possible to completely reconstruct internal radiation doses for the period from January 1, 1980 through December 31, 1990, NIOSH intends to use any internal monitoring data that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures). Dose reconstructions for individuals employed at Nuclear Metals, Inc. during the period from January 1, 1980 through December 31, 1990, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

7.3 Evaluation of Bounding External Radiation Doses at Nuclear Metals, Inc.

The principal source of external radiation doses for members of the evaluated class was photon and beta (electron) radiation associated with AEC operational activities, including handling of radioactive materials in production or research activities. Thorium, uranium metal and uranium compounds from depleted and enriched uranium constituted the principal external radiation dose-producing material sources for members of the class.

Consistent with the findings presented in NIOSH's 2012 evaluation of the period from October 29, 1958 through December 31, 1979, NIOSH has located individual external monitoring records for NMI employees associated with material processing during the operational period under evaluation in this Addendum. Documentation retrieved from the site verifies that a robust personnel external monitoring program existed for photon and beta radiation exposures, as reflected in the individual external monitoring records. Neutron personnel exposures were not tracked as a component of the routine external dosimetry program.

Employment at NMI involved routine medical X-ray examinations required as a condition of employment; therefore, occupational X-rays are also a source of external radiation dose.

The following subsections address the ability to bound external doses, methods for bounding doses, and the feasibility of external dose reconstruction.

7.3.1 Evaluation of Bounding Process-Related External Doses

Consistent with the findings presented in NIOSH's 2012 evaluation of the period from October 29, 1958 through December 31, 1979, NIOSH has located external monitoring records for beta and gamma radiation for NMI workers associated with uranium processing during the class period under evaluation. Individual dosimetry data for the operational period is the preferred data source for evaluating the external radiation doses for members of the NMI class.

NIOSH will use the appropriate methodology and external uranium dose reconstruction assumptions and approach described in Battelle-TBD-6000. NIOSH will also use individual dosimetry data in conjunction with this methodology and to validate or adjust any assumptions, as appropriate. The monitoring data and methodologies available to NIOSH support its ability to reconstruct monitored external doses associated with NMI operations during the period from January 1, 1980 through December 31, 1990.

7.3.2 Nuclear Metals, Inc. Occupational X-Ray Examinations

NIOSH has indications that NMI employees received on-site annual physical exams that included a chest X-ray (Monitoring, 1955-1966, pdf p. 57). These radiographs were taken using a Picker X-ray machine and consisted of two views (presumably a lateral view and an anterior-posterior view) acquired with exposure times of one-tenth and one-twentieth of a second (Monitoring, 1955-1966, pdf pp. 60-62). Information presented to NIOSH during worker outreach meetings with former site employees indicated that medical X-ray examinations were also performed at local medical facilities. NIOSH has no further data regarding when medical X-ray examinations may have been performed on-site versus off-site. Due to the known performance of on-site medical X-ray examinations, per ORAUT-OTIB-0079, *Guidance on Assigning Occupational X-ray Dose Under EEOICPA for X-rays Administered Off Site*, NIOSH has determined that it is applicable to reconstruct occupational medical X-ray exposures for NMI workers during the period from October 29, 1958 through December 31, 1990.

Consistent with the findings presented in NIOSH's 2012 evaluation of the period from October 29, 1958 through December 31, 1979, NIOSH has determined that sufficiently accurate reconstruction of occupational medical doses is feasible for the period from January 1, 1980 through December 1990 using information and methods available in ORAUT-OTIB-0006, *Dose Reconstruction from Occupationally Related X-Ray Procedures*.

7.3.4 External Dose Reconstruction Feasibility Conclusion

Due to the availability of external personal monitoring data throughout the period under evaluation, NIOSH considers reconstruction of monitored external radiation dose to be feasible for the NMI worker class for the period from January 1, 1980 through December 31, 1990. Such reconstruction can be accomplished using the bounding assumptions and applicable protocols specified in various complex-wide Technical Information Bulletins. NIOSH also considers reconstruction of medical X-ray dose to be feasible for the period from January 1, 1980 through December 31, 1990.

7.4 Evaluation of Petition Basis for SEC-00195

The following evaluates the assertions made on behalf of petition SEC-00195 for Nuclear Metals, Inc. relevant to the period from January 1, 1980 through December 31, 1990 under evaluation in this Addendum.

Lack of Monitoring

Issue: The petitioner provided affidavits and supporting documents describing unmonitored uranium airborne and external exposures.

Response: In support of its 2012 evaluation of the period from October 29, 1958 through December 31, 1979, NIOSH reviewed the affidavits and supporting documents. NIOSH noted that there were many fires and explosions that subjected the workers to airborne uranium and that were not monitored. NIOSH further noted that it had not identified any monitoring data for thorium during the period (NIOSH, 2012). Consistent with its 2012 findings, NIOSH has found in this current evaluation that the potential for internal exposure to thorium continued during the period from January 1, 1980 through December 31, 1990. NIOSH has identified only two thorium-232 bioassay results during the period. Therefore, as discussed in Section 7.2 above, NIOSH has concluded that the available data are insufficient to bound the total internal dose for the period from January 1, 1980 through December 31, 1990.

7.5 Summary of Feasibility Findings for Petition SEC-00195

This Addendum completes the feasibility evaluations for completing dose reconstructions for employees at Nuclear Metals, Inc. from January 1, 1980 through December 31, 1990. NIOSH found that the available monitoring records, process descriptions and source term data available are not sufficient to complete dose reconstructions for the evaluated class of employees for the period from January 1, 1980 through December 31, 1990.

Table 7-1 summarizes the results of the feasibility findings at Nuclear Metals, Inc. for each exposure source during the evaluated AWE time period from January 1, 1980 through December 31, 1990.

Table 7-1: Summary of Feasibility Findings for SEC-00195 Addendum, 2014
Jan. 1, 1980 through Dec. 31, 1990

Source of Exposure	Reconstruction Feasible	Reconstruction Not Feasible
Internal[1]		**X**
- Natural and Depleted Uranium	X[2]	
- Uranium Progeny	X	
- Thorium		X
- Thorium Progeny		X
External	**X**[3]	
- Gamma	X	
- Beta	X	
- Neutron	X	
- Occupational Medical X-ray	X	

Notes:
[1] Internal dosimetry data are insufficient to determine the internal doses for the recommended SEC period from January 1, 1980 through December 31, 1990.

[2] NIOSH found that it is feasible to reconstruct internal doses from natural and depleted uranium for employees during the evaluated period from January 1, 1980 through December 31, 1990 using available claimant and site monitoring data, and information in *Internal Coworker Dosimetry Data for Nuclear Metals, Inc.*, ORAU-OTIB-0084.

[3] External monitoring data available to NIOSH consist of film badge and thermoluminescent dosimeter results covering the operational period under evaluation. NIOSH has determined that reconstruction of monitored external doses, including occupational medical doses, is feasible for the period from January 1, 1980 through December 31, 1990.

As of March 27, 2014, a total of 26 claims have been submitted to NIOSH for individuals who worked at Nuclear Metals, Inc. during either: (1) the period evaluated in NIOSH's 2012 evaluation (October 29, 1958 through December 31, 1979); or (2) the period evaluated in this Addendum (January 1, 1980 through December 31, 1990). Dose reconstructions have been completed for 24 individuals (~ 92%).

Although NIOSH found that it is not possible to completely reconstruct radiation doses for the proposed class, NIOSH intends to use any internal and external monitoring data that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures). Therefore, dose reconstructions for individuals employed at Nuclear Metals, Inc. during the period from January 1, 1980 through December 1990, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

8.0 Evaluation of Health Endangerment for Petition SEC-00195

The health endangerment determination for the class of employees covered by this evaluation report is governed by both EEOICPA and 42 C.F.R. § 83.13(c)(3). Under these requirements, if it is not feasible to estimate with sufficient accuracy radiation doses for members of the class, NIOSH must also determine that there is a reasonable likelihood that such radiation doses may have endangered the health of members of the class. Section 83.13 requires NIOSH to assume that any duration of unprotected exposure may have endangered the health of members of a class when it has been established that the class may have been exposed to radiation during a discrete incident likely to have involved levels of exposure similarly high to those occurring during nuclear criticality incidents. If the occurrence of such an exceptionally high-level exposure has not been established, then NIOSH is required to specify that health was endangered for those workers who were employed for a number of work days aggregating at least 250 work days within the parameters established for the class or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

Consistent with NIOSH's 2012 findings in its evaluation of the 1958 through 1979 period at Nuclear Metals, Inc., NIOSH has found that the potential for internal exposure to thorium continued during the period from January 1, 1980 through December 31, 1990. NIOSH has identified only two thorium-232 bioassay results during the period.

NIOSH's evaluation determined that it is not feasible to estimate radiation dose for members of the NIOSH-evaluated class with sufficient accuracy based on the sum of information available from available resources. Therefore, the resulting NIOSH-proposed SEC class must include a minimum required employment period as a basis for specifying that health was endangered.

9.0 Class Conclusion for Petition SEC-00195

Based on its full research of the class under evaluation, NIOSH has defined a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. The NIOSH-proposed class to be added to the SEC includes all Atomic Weapons Employees who worked for Nuclear Metals Inc. at its facility in West Concord, Massachusetts during the period from January 1, 1980 through December 31, 1990, for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more other classes of employees included in the Special Exposure Cohort.

NIOSH has carefully reviewed all material sent in by the petitioner, including the specific assertions stated in the petition, and has responded herein (see Section 7.4). NIOSH has also reviewed available technical resources and many other references, including the Site Research Database (SRDB), for information relevant to SEC-00195. In addition, NIOSH reviewed its NOCTS dose reconstruction database to identify EEOICPA-related dose reconstructions that might provide information relevant to the petition evaluation.

These actions are based on existing, approved NIOSH processes used in dose reconstruction for claims under EEOICPA. NIOSH's guiding principle in conducting these dose reconstructions is to ensure that the assumptions used are fair, consistent, and well-grounded in the best available science. Simultaneously, uncertainties in the science and data must be handled to the advantage, rather than to the detriment, of the petitioners. When adequate personal dose monitoring information is not available, or is very limited, NIOSH may use the highest reasonably possible radiation dose, based on reliable science, documented experience, and relevant data to determine the feasibility of reconstructing the dose of an SEC petition class. NIOSH contends that it has complied with these standards of performance in determining the feasibility or infeasibility of reconstructing dose for the class under evaluation.

10.0 References

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Attachment 1: Data Capture Synopsis

Table A1-1: Data Capture Synopsis for Nuclear Metals, Inc.			
Data Capture Information	**General Description of Documents Captured**	**Date Completed**	**Uploaded to SRDB**
Primary Site / Company Name: Nuclear Metals, Inc.; BE 1954-1986; AWE 1958-1990; Residual Radiation 1991-October 2009 Alternate Site Names: Starmet, Inc. Whittaker Corp. Nuclear Metals Division NMI Physical Size of the Site: 46.4 Acres Site Population: Apparent peak of 650 (1984/85)	Aerial radiological survey, air sample data, ALARA control information, personnel radiological exposure, area dosimetry, area radiation surveys, urinalyses sample results, bioassay and air sampling program procedure, breathing zone and area air sample records, fluorometry laboratory procedures, company history, depleted uranium processing, dissolution rates of uranium from air samples, chest x-rays, environmental survey, GAU-8 program, in vivo counting for Nuclear Metals, Inc, incident reports, license documentation, NMI Views volumes, NRC inspection reports, proposed action levels for uranium urinalysis, radiological work permit system, safety precautions for depleted uranium powder production, site visit reports, summary of air emissions, summary of perimeter and off-site uranium air concentrations and calculated lung doses, thorium work in Concord, and TLD badge program information.	02/14/2014	305
State Contacted: MA Department of Public Health, Radiation Control Program [telephone number redacted]	Airborne emissions report, ambient air monitoring data, personnel radiological exposure information, calculation of uranium inventory, drum excavation work plan, depleted uranium inventory, environmental survey, floor plans and site map showing location of drains and utilities, holding basin decommissioning project site specific health and safety plan, incident notifications, inspection reports, radiation dosimetry report, license amendments and other documentation, Massachusetts Environmental Radiation Laboratory sample procedure and radiation control program inspection report, site photographs, update to holding basin release abatement measure project, radioactive materials inventory, radiological survey data, registration of ionizing radiation sources, health and safety plan, disposal of industrial wastes, routing of radioactive waste shipments, time line of events, town of Concord air monitoring data, USEPA National Air and Radiation Environmental Laboratory thorium analyses, uranium emissions summary, ventilation information and air data at plant boundary, and waste disposal practices and shipments.	04/12/2012	84

Table A1-1: Data Capture Synopsis for Nuclear Metals, Inc.			
Data Capture Information	**General Description of Documents Captured**	**Date Completed**	**Uploaded to SRDB**
Albany Research Center	Metallurgy of thorium.	03/19/2013	1
Battelle Memorial Institute, King Avenue	Report on explosion of extruded thorium.	04/14/2011	1
Claimant Provided	Licensing and product information and employee work history.	07/05/2012	2
Concord, MA Public Library	Description of bioassay program, use of asbestos, survey frequency, air sample data, and uranium inventory.	10/06/2008	7
Concord, MA Town Hall	Beryllium monitoring, exposure investigation, personnel intake evaluations, personnel dosimetry reports, and personnel rosters and photographs.	10/07/2008	35
Department of Labor / Paragon	Uranium requests and thorium slugs from extruded rod.	01/23/2012	3
DOE Germantown	Site description and beryllium related material.	09/11/2002	4
DOE Legacy Management - Grand Junction Office	Report to Congress excerpt, research in support of Savannah River, material receipts, waste classification, thorium procurement, and uranium shipment documentation.	08/25/2011	28
DOE Legacy Management - Morgantown	Special Nuclear Material accountability station symbols, Fernald agreements, production orders, ALARA program development and division highlight reports.	03/02/2011	7
DOE Legacy Management - MoundView (Fernald Holdings, includes Fernald Legal Database)	Weekly progress report, thorium receipts and campaigns, actinium inventory, tritium release, and a report on normal uranium scrap materials.	09/08/2008	7
DOE ORO Records Holding Task Group (RHTG)	Activities resumption and a thorium technical review.	04/08/2011	3
DOE Office of Scientific and Technical Information (OSTI)	Thorium receipts, zirconium cladding of uranium, trip report, explosion of extruded thorium, fabrication and properties of extruded uranium tubes.	06/06/2012	12
Environmental Management File Room	Radiological history.	09/11/2002	1
Federal Record Center (FRC) - Boston	Urine sample collection data, breathing zone air samples, radiation dosimetry reports, general area air sample results, personnel termination exposure records, and quality control information.	05/30/2012	388
Hagley Museum and Library	Trip reports and research programs in support of Savannah River and fabrication of uranium tubes.	10/28/2010	4
Hanford	Monthly processing and operations reports. **NOTE:** Cannot submit requested documents from search results until funding issues at Hanford are resolved.	03/14/2013	20
HASL - EML	Thorium sampling and storage.	03/08/2005	1

Table A1-1: Data Capture Synopsis for Nuclear Metals, Inc.			
Data Capture Information	**General Description of Documents Captured**	**Date Completed**	**Uploaded to SRDB**
Idaho National Laboratory	Nuclear Metals urine and soil data.	06/14/2012	1
Interlibrary Loan	M.I.T. beginnings, "The Legacy of Nuclear Metals, Inc."	05/15/2008	1
Internet - Defense Technical Information Center (DTIC)	Nuclear Metals site history, feasibility of recycling penetrators, filtration of molten depleted uranium, depleted uranium reclamation report, machining depleted uranium, techniques for cleaning depleted uranium derbys, dies for extrusion of complex shapes of steel and refractory alloys, disposal of depleted uranium, compatibility studies of molten uranium and thorium alloys, and development of high strength columbium and tantalum alloy tubing progress report.	03/05/2014	38
Internet - DOE Comprehensive Epidemiologic Data Resource (CEDR)	No relevant documents identified.	07/09/2012	0
Internet - DOE Hanford Declassified Document Retrieval System (DDRS)	Monthly processing and operations reports.	10/24/2008	11
Internet - DOE Legacy Management Considered Sites	Considered sites listing.	03/15/2012	1
Internet - DOE National Nuclear Security Administration (NNSA) - Nevada Site Office	No relevant documents identified.	03/20/2012	0
Internet - DOE OpenNet	No relevant documents identified.	03/20/2012	0
Internet - DOE OSTI Energy Citations	Progress reports, report on low exposure irradiation of enriched seven-rod cluster in KER loop, extrusion program summary report, and thorium 1.4 wt percent uranium-235 metal fuel tubes fabrication.	01/26/2013	9
Internet - DOE OSTI Information Bridge	Departmental monthly reports, decommissioning management plan, grain refinement of case uranium by heat, trip reports, evaluation of thorium - uranium alloys, irradiation of uranium 2% zirconium fuel tube, effects of irradiation, Mound Laboratory monthly report, stockpile management quarterly report, and heavy water moderated power reactors progress reports.	07/02/2012	59
Internet - DOE OSTI Information Bridge / SC&A	Preparation and characterization of uranium oxides.	03/15/2012	1
Internet - Environmental Protection Agency	Waste site cleanup and reuse and removal of contaminated buildings.	03/24/2012	2

Table A1-1: Data Capture Synopsis for Nuclear Metals, Inc.			
Data Capture Information	**General Description of Documents Captured**	**Date Completed**	**Uploaded to SRDB**
Internet - Google	Criticality safety inspections, depleted uranium technical brief, drum excavation, engineering evaluation and cost analysis for disposition of structures and contents, enriched uranium liquid sludge transfer, environmental assessments, evaluation of zircaloy clad tubes, evaluation of tantalum bimetallic tubing fabrication, groundwater and surface water sampling and analysis, holding basin characterization, licensing documentation, monthly and bi-annual monitoring data, decommissioning plan for the holding basin, process for removing uranium and other metals from wastes, processing and applications of depleted uranium alloy products, production of high-value fluoride gas from uranium tetrafluoride, radiation exposure information, radiological incidents, radiological surveys, safeguards inspection, scope of work Nuclear Metals, Inc. Superfund site, site characterization report, uranium contamination at Nuclear Metals plant, and whole body counts contamination monitoring.	11/25/2013	269
Internet - Health Physics Journal	No relevant documents identified.	07/09/2012	0
Internet - Journal of Occupational and Environmental Hygiene	No relevant documents identified.	07/09/2012	0
Internet - National Academies Press (NAP)	No relevant documents identified.	03/20/2012	0
Internet - NIOSH	Report on residual radioactive beryllium contamination.	03/07/2014	4

Table A1-1: Data Capture Synopsis for Nuclear Metals, Inc.			
Data Capture Information	**General Description of Documents Captured**	**Date Completed**	**Uploaded to SRDB**
Internet - NRC Agencywide Document Access and Management (ADAMS)	Amendments to vendor reported dosimetry, decommissioning cost estimate, evaluation of bioassay data, examination and analysis of three fired depleted uranium penetrators, exclusion boundaries fissile material storage, feasibility reports, guidelines for transferring solid depleted uranium product, holding basin remediation plan, incident reports including notification and corrective actions, inspection reports, notifications and violations, license amendment and termination documentation, material status report, ORNL site summary, placarding of shipment violation, notification of banning radioactive waste shipments, radiological safety inspection, record of shipment forms, requirements for uranium conversion and deconversion facilities, holding basin characterization report, site decommissioning management plan, skin dose report, Starmet Corporation fact sheet, decommissioning program annual report, urinalysis data, and zero power experiments with U-235 enriched thoria and thorium metal lattices.	03/28/2013	162
Internet - Nuclear Metals Inc	Addendum 1 to site Management and Security plan, delineation of groundwater contamination, baseline ecological risk assessment, semiannual groundwater sampling results, site chronological information, maps, progress photos, and a tank house and wastewater treatment area work plan.	03/05/2014	17
Internet - Oak Ridge National Laboratory Library	Status and progress reports.	12/18/2012	19
Internet - USACE/FUSRAP	No relevant documents identified.	03/20/2012	0
Internet - US Transuranium and Uranium Registries	No relevant documents identified.	03/20/2012	0
Iron Mountain Cranberry PA	Survey of control over source and special nuclear materials.	09/11/2006	1
Kansas City Plant	Thorium metal manufacturing.	10/18/2013	1
Massachusetts Department of Environmental Protection	Remediation photographs, documented communication, extrusion, groundwater contamination investigation, and consequences of using depleted uranium.	06/14/2012	10
National Archives and Records Administration (NARA) - Atlanta	Thorium explosion and a proposal for work on solid duel liquid metal cooled aircraft propulsion reactor.	05/20/2008	2
National Institute for Occupational Safety and Health (NIOSH)	History of USAEC and the establishment of EEOICPA.	12/11/2012	13
New South Associates	The 300/M area fuel and target fabrication.	08/08/2009	1
Nuclear Regulatory Commission Region 1	License material, evaluation of urinalysis data, and inspection reports.	03/29/2013	9

Table A1-1: Data Capture Synopsis for Nuclear Metals, Inc.			
Data Capture Information	**General Description of Documents Captured**	**Date Completed**	**Uploaded to SRDB**
Nuclear Regulatory Commission Public Document Room	Soil monitoring program and soil analyses, potential airborne releases, certificate of disposition of materials, disposal of low level waste at Envirocare of Utah, dose rate evaluations for exposure to copper metal contaminated with depleted uranium, environmental summary report, extrapolation chamber measurements, groundwater report, site historical information brochure, license application, renewal and termination documentation, minimum requirements for entrance into restricted areas, air sampling program documentation, annual lung counting program, notice of violation and proposed imposition of civil penalties, pre-construction radiological assessment and decontamination of a depleted uranium waste handling site, regulatory operations routine inspection, request for approval to use the Clive, Utah repository, transportation violations, and a trip report.	10/26/2012	135
Oak Ridge National Laboratory	Status and progress reports.	01/23/2013	1
ORAU Team	Documented communications and co-worker data.	03/14/2014	35
R. S. Landauer	No relevant documents identified (Landauer did not respond to NIOSH request, closed per DCAS).	03/12/2014	0
Sandia National Laboratories, New Mexico / SC&A	Radiological surveys.	09/15/2010	3
Savannah River Site	Classified reports received for 1957, dosimetry visitors' cards, extrusion of electrolytic thorium, monthly progress report, radiation survey log sheets, symposium on high temperature fuel processing, and thorium metal requirements.	06/06/2011	26
SC&A	Discussion of Hematite plant and license.	04/07/2011	1
Science Applications International Corp (SAIC)	Radiation exposure summary.	09/02/2004	3
Southern Illinois University	Nuclear fuels and materials development and an off-site extrusion program summary.	11/08/2008	2
Unknown	Air, stack, water, and urine samples, building contamination, employee radiological summary, occupational exposure record, breathing zone air samples, and occupational exposure to airborne beryllium and uranium.	06/08/2009	22

Table A1-1: Data Capture Synopsis for Nuclear Metals, Inc.			
Data Capture Information	**General Description of Documents Captured**	**Date Completed**	**Uploaded to SRDB**
US Environmental Protection Agency	Environmental survey and remediation, material data input sheet for uranium and thorium, incident reports, maximum contamination levels, site inspection, air monitoring, holding basin meeting, decontamination and decommissioning actions, license information, indoor particulate exposures, status reports, holding basin sludge sampling, material inventory, inspection reports, organizational chart, health and safety plan, isotope transport studies, depleted uranium lung burden, airborne concentrations, trip summary, and well tests.	02/14/2014	175
TOTAL			**1947**

Table A1-2: Databases Searched for Nuclear Metals, Inc.			
Database/Source	**Keywords / Phrases**	**Hits**	**Selected**
NOTE: Database search terms employed for each of the databases listed below are available in the Excel file called "Nuclear Metals Rev 01, (83.13) 03-20-14.xls"			
Defense Technical Information Center (DTIC) https://www.dtic.mil/ COMPLETED 11/08/2012	See Note above	1,479	23
DOE CEDR http://cedr.lbl.gov/ COMPLETED 07/09/2012	See Note above	0	0
DOE Hanford DDRS http://www2.hanford.gov/declass/ COMPLETED 03/20/2012	See Note above	0	0
DOE Legacy Management Considered Sites http://csd.lm.doe.gov/ COMPLETED 03/20/2012	See Note above	6	2
DOE NNSA - Nevada Site Office www.nv.doe.gov/main/search.htm COMPLETED 03/20/2012	See Note above	18	0
DOE OpenNet http://www.osti.gov/opennet/advancedsearch.jsp COMPLETED 03/20/2012	See Note above	224	11
DOE OSTI Energy Citations http://www.osti.gov/energycitations/ COMPLETED 03/20/2012	See Note above	2,385	7
DOE OSTI Information Bridge http://www.osti.gov/bridge/advancedsearch.jsp COMPLETED 03/20/2012	See Note above	1,644	18
Google http://www.google.com COMPLETED 03/31/2012	See Note above	22,494,928	497
HP Journal http://journals.lww.com/health-physics/pages/default.aspx COMPLETED 07/09/2012	See Note above	4	0

Table A1-2: Databases Searched for Nuclear Metals, Inc.			
Database/Source	**Keywords / Phrases**	**Hits**	**Selected**
Journal of Occupational and Environmental Health http://www.ijoeh.com/index.php/ijoeh COMPLETED 07/09/2012	See Note above	0	0
National Academies Press http://www.nap.edu/ COMPLETED 03/20/2012	See Note above	5,879	0
NRC ADAMS Reading Room http://www.nrc.gov/reading-rm/adams/web-based.html COMPLETED 03/20/2012	See Note above	807	107
USACE/FUSRAP http://www.lrb.usace.army.mil/fusrap/ COMPLETED 03/20/2012	See Note above	4	4
U.S. Transuranium & Uranium Registries http://www.ustur.wsu.edu/ COMPLETED 03/20/2012	See Note above	0	0

Table A1-3: DTIC Documents Requested for Nuclear Metals, Inc.			
Document Number	**Document Title**	**Requested Date**	**Received Date**
NA	Extrusion of DU Penetrator Alloys Using the Canned Billet Technique	11/14/2011	
NA	Investment Casting of Uranium Alloy Penetrators	11/14/2011	
NA	An Investigation of (1) Stabilizing the Carbon Content of Investment Cast Performs for Phalanx Penetrators (2) Dual-Hardness Phalanx Penetrators	11/11/2011	NA - Request denied
NA	Fundamental and Applied Research and Development in Metallurgy	11/11/2011	11/22/2011 - Not relevant
NA REF ID: 105845	Reclamation/Recycle of Depleted Uranium and Heavy Metal Alloy Residue for Soils	11/11/2011	12/19/2011
NMI-9709.13 REF ID: 105847	Development of Processing Techniques for the Extrusion of Metal Powders dated December 1967	11/08/2011	12/16/2011

Table A1-3: DTIC Documents Requested for Nuclear Metals, Inc.			
Document Number	**Document Title**	**Requested Date**	**Received Date**
ARCCD-CR-87006 REF ID: 104924	Filtration of Molten Depleted Uranium dated June 24, 1987	11/08/2011	11/28/2011
ARLCD-CR-83018 REF ID: 104927	M774 Machine Chip Recycling	11/08/2011	11/28/2011
AFATL-TR-82-49 REF ID: 104926	Depleted Uranium Test Range Fragment Reclamation dated July 1982	11/08/2011	11/28/2011
ARCCD-CR-86010 REF ID: 104929	Recycle Process for Depleted Uranium Machining Chips by Vacuum Induction Remelt dated May 1987	11/08/2011	11/28/2011
ARCCD-CR-86008 REF ID: 104930	Atmosphere Assisted Machining of Depleted Uranium (DU) Penetration dated May 1987	11/08/2011	11/28/2011
ARCCD-CR-87004 REF ID: 104932	Established Techniques for Cleaning Depleted Uranium Derby in Lieu of Nitric Acid Pickling dated May 1987	11/08/2011	11/28/2011

Table A1-4: Interlibrary Loan Documents Requested for Nuclear Metals, Inc.			
Document Number	**Document Title**	**Requested Date**	**Received Date**
NA	Proceedings of the High Density Alloy Penetrator Materials Conference, April 1977 NOTE: Document was in too poor of condition to make copies and therefore not provided by Library.	11/28/2011	12/31/2011