SEC Petition Evaluation Report
Petition SEC-00236

Report Rev Number:	0
Report Submittal Date:	April 5, 2017
Subject Expert(s):	Pat McCloskey
Site Expert(s):	None

Petition Administrative Summary

Petition Under Evaluation

Petition Number:	SEC-00236
Petition Type:	83.13
Petition Receipt Date:	September 1, 2016
Qualification Date:	November 14, 2016
DOE/AWE Facility Name:	Metals and Controls Corp.

Petition Class

Petitioner-Requested Class Definition:	All facilities construction and maintenance workers including lubricators/oilers, industrial pipefitters, engineering technicians (mechanical, electrical, structural), maintenance supervisors, electricians, plumbers, millwrights, carpenters, instrumentation technicians, chemical handlers, waste treatment operators, and all production workers, including machine operators/helpers and repair & maintenance (commonly called R&M) workers, who worked in Buildings 4, 5, 10 interior areas, and Buildings 5, 10, 11, 12, 17 exterior areas at Metals and Controls Corp. in Attleboro, Massachusetts, from January 1, 1968 through March 21, 1997.
Class Evaluated by NIOSH:	All atomic weapons employees who worked as facilities construction and maintenance workers, including lubricators/oilers, industrial pipefitters, engineering technicians (mechanical, electrical, structural), maintenance supervisors, electricians, plumbers, millwrights, carpenters, instrumentation technicians, chemical handlers, waste treatment operators, and all production workers, including machine operators/helpers and repair & maintenance (commonly called R&M) workers, who worked in Buildings 4, 5, 10 interior areas, and Buildings 5, 10, 11, 12, 17 exterior areas at Metals and Controls Corp. in Attleboro, Massachusetts, from January 1, 1968 through March 21, 1997.
NIOSH-Proposed Class to be Added to the SEC:	None

Related Petition Summary Information

SEC Petition Tracking Number(s):	SEC-00149
Petition Type:	83.14
DOE/AWE Facility Name:	Metals and Controls Corp.
Petition Status:	Class added to the SEC for January 1, 1952 through December 31, 1967

Related Evaluation Report Information

Report Title:	SEC Petition Evaluation Report for Petition SEC-00149
DOE/AWE Facility Name:	Metals and Controls Corp.

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Evaluation Report Summary: SEC-00236, Metals and Controls Corp.

The National Institute for Occupational Safety and Health (NIOSH) prepared this evaluation report in response to a petition to add a class of workers at Metals and Controls Corp. (often referred to as M&C throughout this report) to the Special Exposure Cohort (SEC). The *Energy Employees Occupational Illness Compensation Program Act of 2000*, as amended, (EEOICPA) and 42 C.F.R. pt. 83, *Procedures for Designating Classes of Employees as Members of the Special Exposure Cohort under the Energy Employees Occupational Illness Compensation Program Act of 2000,* describe the process for adding new classes to the SEC.

Petitioner-Requested Class Definition

NIOSH received petition SEC-00236 on September 1, 2016, and qualified it on November 14, 2016. The petitioner requested that NIOSH consider the following class: *All facilities construction and maintenance workers including lubricators/oilers, industrial pipefitters, engineering technicians (mechanical, electrical, structural), maintenance supervisors, electricians, plumbers, millwrights, carpenters, instrumentation technicians, chemical handlers, waste treatment operators, and all production workers, including machine operators/helpers and repair & maintenance (commonly called R&M) workers, who worked in Buildings 4, 5, 10 interior areas, and Buildings 5, 10, 11, 12, 17 exterior areas at Metals and Controls Corp. in Attleboro, Massachusetts, from January 1, 1968 through March 21, 1997.*

Class Evaluated by NIOSH

Based on its preliminary research, NIOSH accepted the petitioner-requested class. NIOSH evaluated the following class: All atomic weapons employees who worked as facilities construction and maintenance workers, including lubricators/oilers, industrial pipefitters, engineering technicians (mechanical, electrical, structural), maintenance supervisors, electricians, plumbers, millwrights, carpenters, instrumentation technicians, chemical handlers, waste treatment operators, and all production workers, including machine operators/helpers and repair & maintenance (commonly called R&M) workers, who worked in Buildings 4, 5, 10 interior areas, and Buildings 5, 10, 11, 12, 17 exterior areas at Metals and Controls Corp. in Attleboro, Massachusetts, from January 1, 1968 through March 21, 1997.

NIOSH Determination about the Proposed Class to be added to the SEC

NIOSH has obtained personal and area monitoring records from the end of the operational period and prior to the beginning of the residual radiation period being evaluated in this report, and when coupled with radiological data in the residual period, the data can be used by NIOSH to develop bounding dose assessments for the entire residual radiation period. Based on its analysis of these available resources, NIOSH found no part of the class under evaluation for which it cannot estimate radiation doses with sufficient accuracy.

Feasibility of Dose Reconstruction

Per EEOICPA and 42 C.F.R. § 83.13(c) (1), NIOSH has established that it has 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

the maximum dose. Information available from the site profile and additional resources is sufficient to estimate the maximum internal and external potential exposure to members of the evaluated class under plausible circumstances during the specified period.

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

- NIOSH finds that it is not applicable to reconstruct medical X-ray dose for Metals and Controls Corp. during the period under evaluation because medical X-ray is not a covered occupational radiation exposure during a residual radiation period.

- Principal sources of internal and external radiation for members of the evaluated class included exposures to residual uranium and thorium. Metals and Controls Corp. performed operations involving uranium and thorium for nuclear weapons production during the facility's operational period. During the residual radiation period, sources of covered occupational exposures to members of the evaluated class were the residual uranium and thorium materials.

- NIOSH has obtained personal and area monitoring data from the end of the operational period and prior to the beginning of the residual radiation period and intends to use this data, coupled with data obtained during the residual radiation period, to bound internal dose for the residual radiation period. The methodology incorporates resuspension and source depletion assessments to provide inhalation and ingestion sources that are used to bound internal dose.

- NIOSH intends to use the external monitoring data from the end of the operational period, coupled with the external dose reconstruction methodologies from Battelle-TBD-6000, to support bounding external dose for the residual radiation period.

- Based on its analysis of the available data resources for Metals and Controls Corp., NIOSH found no part of the class under evaluation for which it cannot estimate radiation doses with sufficient accuracy.

- Pursuant to 42 C.F.R. § 83.13(c) (1), NIOSH determined that there is sufficient 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.

Health Endangerment Determination

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

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SEC Petition Evaluation Report for SEC-00236

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: Pat McCloskey, Oak Ridge Associated Universities (ORAU). The rationales for all conclusions in this document are explained in the associated text.

1.0 Purpose and Scope

This report evaluates the feasibility of reconstructing radiation doses for all atomic weapons employees who worked as facilities construction and maintenance workers, including lubricators/oilers, industrial pipefitters, engineering technicians (mechanical, electrical, structural), maintenance supervisors, electricians, plumbers, millwrights, carpenters, instrumentation technicians, chemical handlers, waste treatment operators, and all production workers, including machine operators/helpers and repair & maintenance (commonly called R&M) workers, who worked in Buildings 4, 5, 10 interior areas, and Buildings 5, 10, 11, 12, 17 exterior areas at Metals and Controls Corp. in Attleboro, Massachusetts, from January 1, 1968 through March 21, 1997. It 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]

2.0 Introduction

Both EEOICPA and 42 C.F.R. pt. 83 require NIOSH to evaluate qualified petitions requesting that the Department of Health and Human Services (DHHS) add a class of employees to the SEC. The evaluation is intended to provide a fair, science-based determination of whether it is feasible to estimate with sufficient accuracy the radiation doses of the class of employees through NIOSH dose reconstructions.[2]

42 C.F.R. § 83.13(c)(1) states: *Radiation doses can be estimated with sufficient accuracy if NIOSH has established that it has access to sufficient information to 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 if NIOSH has established that it has access to*

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

[2] NIOSH dose reconstructions under EEOICPA are performed using the methods promulgated under 42 C.F.R. pt. 82 and the detailed implementation guidelines available on the NIOSH Radiation Dose Reconstruction Program webpage.

sufficient information to estimate the radiation doses of members of the class more precisely than an estimate of the maximum radiation dose.

Under 42 C.F.R. § 83.13(c)(3), if it is feasible to estimate with sufficient accuracy radiation doses for members of the class, then NIOSH must determine that there is a reasonable likelihood that such radiation doses may have endangered the health of members of the class. The regulation 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 employees who were employed for at least 250 aggregated work days within the parameters established for the class or in combination with work days within the parameters established for one or more other SEC classes.

NIOSH is required to document its evaluation in a report, and to do so, relies upon both its own dose reconstruction expertise as well as technical support from its contractor, Oak Ridge Associated Universities (ORAU). Once completed, NIOSH provides the report to both the petitioner(s) and the Advisory Board on Radiation and Worker Health (Advisory Board). The Advisory Board will consider the NIOSH evaluation report, together with the petition, petitioner(s) comments, and other information the Advisory Board considers appropriate, in order to make recommendations to the Secretary of DHHS on whether or not to add one or more classes of employees to the SEC. Once NIOSH has received and considered the advice of the Advisory Board, the Director of NIOSH will propose a decision on behalf of DHHS. The Secretary of DHHS will make the final decision, taking into account the NIOSH evaluation, the advice of the Advisory Board, and the proposed decision issued by NIOSH. As part of this decision process, petitioners may seek a review of certain types of final decisions issued by the Secretary of DHHS.[3]

3.0 SEC-00236, Metals and Controls Corp. Class Definitions

The following subsections address the evolution of the class definition for SEC-00236, Metals and Controls Corp. When a petition is submitted, the requested-class definition is reviewed as submitted. Based on its review of the available site information and data, NIOSH will make a determination whether to qualify for full evaluation all, some, or no part of the petitioner-requested class. If some portion of the petitioner-requested class is qualified, NIOSH will specify that class along with a justification for any modification of the petitioner's class. After a full evaluation of the qualified class, NIOSH will determine whether to propose a class for addition to the SEC and will specify that proposed class definition.

3.1 Petitioner-Requested Class Definition and Basis

NIOSH received petition SEC-00236 on September 1, 2016, and it qualified on November 14, 2016. The petitioner requested that NIOSH consider the following class: *All facilities construction and*

[3] See 42 C.F.R. pt. 83 for a full description of the procedures summarized here. Additional internal procedures are available on the NIOSH Radiation Dose Reconstruction Program webpage.

maintenance workers including lubricators/oilers, industrial pipefitters, engineering technicians (mechanical, electrical, structural), maintenance supervisors, electricians, plumbers, millwrights, carpenters, instrumentation technicians, chemical handlers, waste treatment operators, and all production workers, including machine operators/helpers and repair & maintenance (commonly called R&M) workers, who worked in Buildings 4, 5, 10 interior areas, and Buildings 5, 10, 11, 12, 17 exterior areas at Metals and Controls Corp. in Attleboro, Massachusetts, from January 1, 1968 through March 21, 1997.

The petitioner provided information and affidavit statements in support of the petitioner's belief that accurate dose reconstruction over time is impossible for the M&C employees in question. NIOSH deemed the following affidavit statements, regarding a lack of radiological monitoring and controls, sufficient to qualify SEC-00236 for evaluation:

- In reference to Affidavit No. 1's attached documents, an affidavit statement indicated that *the residual radioactivity described within the attached documents was not fully identified until the comprehensive characterization surveys, as part of what was called the Nuclear Decommissioning Project (ca. 1992–1997) to terminate SNM License No. 23 and to release the TI-M&C Attleboro site for "Unrestricted Use" as defined under Option 1 of the 1986 USNRC Branch Technical Position* (DSA Ref ID: 127266, PDF p. 2).

- Affidavit No. 1 included a statement that *all the final termination and characterization surveys focused almost entirely on uranium, at the exclusion of any other radionuclides* (DSA Ref ID: 127266, PDF p. 2).

- Regarding concern about thorium dose, one site expert does not ever recall any routine whole-body counting and stated that it would have only been used in an emergency-type situation (DSA Ref ID: 127266, PDF p. 3)

- Two former employees that together were employed from 1980–2006, within the Environmental, Safety and Health Department at the Attleboro site, stated that none of the members of the class of employees evaluated in this SEC petition received any radiological monitoring, either personal monitoring or area monitoring (DSA Ref ID: 127266, PDF p. 14; DSA Ref ID: 127268, PDF p. 2).

- One pipefitter testified that he routinely worked *...on lines that were later classified by health physicists during the Nuclear Decommissioning Project as Priority 1 and Priority 2 drainage lines, and that we now know posed a health risk to untrained and unprotected workers, and should never have been disturbed without proper radiological controls and monitoring* (DSA Ref ID: 127266, PDF p. 5).

- Affidavit No. 2 indicated that during the residual period, the period covered in this report, *neither I, nor any other members of the proposed class, were provided with any knowledge of the hazards to which we were exposed, nor were we provided with any radiological monitoring or controls in the form of personal or area monitoring* (DSA Ref ID: 127267, PDF p. 2).

- Regarding a persistent lack of radiological monitoring, Affidavit No. 2 indicated that, *not once during my entire career at the TI/M&C Attleboro site was I ever monitored, through either personal or area monitoring, for radiological exposure/dose* (DSA Ref ID: 127267, PDF p. 7).

- Affidavit No. 3 indicated that *...there was no active or ongoing radiological monitoring program related to the nuclear operations and materials authorized under SNM License No. 23* (DSA Ref ID: 127268, PDF p. 2) and that *...employees had no radiological protection or controls to measure or minimize their exposures* (DSA Ref ID: 127268, PDF p. 3).

- Affidavits No. 1 and No. 3 indicated that *to the best of my knowledge, the only employees who would have been monitored for radiological exposure at the TI-M&C site during the Residual Period were those employees who worked in certain manufacturing areas where X-ray equipment was used for production quality control. That would not have included any of the members of the class of employees subject to this SEC Petition* (DSA Ref ID: 127268, PDF p. 3; DSA Ref ID: 127266, PDF p. 14).

Based on its Metals and Controls Corp. research and data capture efforts, NIOSH has access to some area and personal monitoring records for M&C employees during the period under evaluation. However, NIOSH also determined that personal monitoring records are not complete for the evaluated time period or for all radionuclides. NIOSH concluded that there is sufficient documentation to support the petition basis that radiation exposures and radiation doses were not adequately monitored at Metals and Controls Corp., either through personal monitoring or area monitoring. The information and statements provided by the petitioner qualified the petition for further consideration by NIOSH, the Advisory Board, and DHHS. The details of the petition basis are addressed in Section 7.4.

3.2 Class Evaluated by NIOSH

Based on its preliminary research, NIOSH accepted the petitioner-requested class. Therefore, NIOSH defined the following class for further evaluation: All atomic weapons employees who worked as facilities construction and maintenance workers, including lubricators/oilers, industrial pipefitters, engineering technicians (mechanical, electrical, structural), maintenance supervisors, electricians, plumbers, millwrights, carpenters, instrumentation technicians, chemical handlers, waste treatment operators, and all production workers, including machine operators/helpers and repair & maintenance (commonly called R&M) workers, who worked in Buildings 4, 5, 10 interior areas, and Buildings 5, 10, 11, 12, 17 exterior areas at Metals and Controls Corp. in Attleboro, Massachusetts, from January 1, 1968 through March 21, 1997.

3.3 NIOSH Determination about the Proposed Class to be Added to the SEC

NIOSH has obtained personal and area monitoring data from the end of the operational period and prior to the beginning of the residual radiation period. These data can be used by NIOSH to develop bounding dose assessments for the entire residual radiation period. NIOSH has also reviewed data from surface contamination surveys, air monitoring, urinalysis, lung scans, personal film badges, and area radiation surveys that were performed during the evaluated period for M&C employees performing commercial work and decontamination and decommissioning (D&D). These data can also be used for developing bounding dose assessments for the evaluated class. Based on its analysis of these available resources, NIOSH found no part of the class under evaluation for which it cannot estimate radiation doses with sufficient accuracy.

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 Metals and Controls Corp. 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 One includes a summary of Metals and Controls Corp. documents. The summary specifically includes 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. The following subsections summarize the data sources identified and reviewed by NIOSH.

4.1 Site Profile Technical Basis Documents (TBDs)

A Site Profile provides specific information concerning the documentation of historical practices documented at the specified site. Dose reconstructors can use the Site Profile to evaluate internal and external dosimetry data for monitored and unmonitored employees, and to supplement, or substitute for, individual monitoring data. A Site Profile consists of an Introduction and five Technical Basis Documents (TBDs) that provide process history information, information on personal and area monitoring, radiation source descriptions, and references to primary documents relevant to the radiological operations at the site. The Site Profile for a small site may consist of a single document. As part of NIOSH's evaluation detailed herein, it examined the following TBD for insights into Metals and Controls Corp. operations or related topics/operations at other sites:

- *Site Profiles for Atomic Weapons Employers that Worked Uranium Metals*, Rev. 01; Battelle-TBD-6000; effective June 17, 2011; SRDB Ref ID: 101251

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. An ORAU Procedure provides specific requirements and guidance regarding EEOICPA project-level activities, including preparation of dose reconstructions at particular sites or categories of sites. NIOSH reviewed the following OTIBs as part of its evaluation:

- *OTIB: Use of Coworker Dosimetry Data for External Dose Assignment*, Rev. 03; ORAUT-OTIB-0020; effective November 14, 2011; SRDB Ref ID: 104029

- *OTIB: Estimation of Neutron Dose Rates from Alpha-Neutron Reactions in Uranium and Thorium Compounds*, Rev. 00; ORAUT-OTIB-0024; effective April 7, 2005; SRDB Ref ID: 19445

- *OTIB: Dose Reconstruction During Residual Radioactivity Periods at Atomic Weapons Employer Facilities*, Rev. 01; ORAUT-OTIB-0070; effective March 5, 2012; SRDB Ref ID: 108851

- *OTIB: Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures*, ORAUT-OTIB-0006, Rev. 04; effective June 20, 2011; SRDB Ref ID: 98147

- *OTIB: Guidance on Assigning Occupational X-Ray Dose Under EEOICPA for X-Rays Administered Off Site*, ORAUT-OTIB-0079, Rev. 01; effective March 18, 2016; SRDB Ref ID: 152173

4.3 Facility Employees and Experts

To obtain additional information in support of its SEC-00236 evaluation, NIOSH reviewed the computer-assisted telephone interviews previously conducted with M&C employees that worked during the period from 1952 through 1997. The information from these interviews did not indicate any additional process information or potential exposure sources that would change NIOSH's feasibility determination. Interviews for the specific purpose of supporting this SEC-00236 evaluation were not considered likely to produce new information or change the feasibility determination for the period under evaluation. Therefore, additional interviews were not conducted.

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. Table 4-1 summarizes the results of this review. (NOCTS data available as of January 17, 2017)

Table 4-1: No. of M&C Claims Submitted Under the Dose Reconstruction Rule

Description	Totals
Total number of claims submitted for dose reconstruction	448
Total number of claims submitted for energy employees who worked during the period under evaluation (January 1, 1968 through March 21, 1997)	397
Total number of claims submitted for energy employees who started their employment during the period under evaluation (January 1, 1968 through March 21, 1997)	314
Number of dose reconstructions completed for energy employees who worked during the period under evaluation (i.e., the number of such claims completed by NIOSH and submitted to the Department of Labor for final approval).	369
Number of claims for which internal dosimetry records were obtained for the time period in the evaluated class definition	1
Number of claims for which external dosimetry records were obtained for the time period in the evaluated class definition	4

NIOSH reviewed each claim to determine whether internal and/or external personal monitoring records could be obtained for the employee. Most claims did not include any monitoring records. However, the records that NIOSH does have available provide a large amount of information that NIOSH can use to characterize the Metals and Controls Corp. site for the purpose of reconstructing dose.

4.5 NIOSH Site Research Database

NIOSH also examined its Site Research Database (SRDB) to locate documents supporting the assessment of the evaluated class. There were 619 documents in this database that were identified as pertaining to Metals and Controls Corp. These documents were evaluated for their relevance to this petition. The documents include historical background on M&C operations including materials and process descriptions, limited personal and area monitoring records (e.g., air monitoring, urinalysis data, film badge results, and medical monitoring), and radiological control program descriptions.

4.6 Documentation and/or Affidavits Provided by Petitioners

In qualifying and evaluating the petition, NIOSH reviewed the following documents submitted by the petitioners, some of which were previously available in NIOSH's SRDB:

- *Special Exposure Cohort Petition—Form B*; September 2016; DSA Ref ID: 127261
- *Three Affidavits Supporting the F1 SEC Petition Basis*; uploaded September 12, 2016; DSA Ref ID: 127266, 127267, 127268
- *Supplementary Information Regarding Proposed Energy Employee Class Definition Covered by Petition*; uploaded September 12, 2016; DSA Ref ID: 127265
- *Building Interiors Remediation Drainage System Characterization*; Weston, Inc.; January 1996; DSA Ref ID: 127269
- *Remediation of Building Interiors Buildings 4, 5, and 10*, includes select attachments; Weston, Inc.; October 1996; DSA Ref ID: 127270, 127271
- *Remediation of Exterior Areas Adjacent to Buildings 11 and 12*; Weston, Inc.; August 1996; DSA Ref ID: 127272
- *Remediation of Exterior Areas Showing Various Area Grid Blocks*; multiple dates throughout December 1995; DSA Ref ID: 127273
- *Remediation of the Metals Recovery Area*; CPS Environmental, Inc.; October 1996; DSA Ref ID: 127274
- *Metals Recovery Area Radiological Survey Results*; author not specified; dates not specified; DSA Ref ID: 127275
- *Remediation of the Former Radioactive Waste Burial Site*; Creative Pollution Solutions, Inc.; September 1993; DSA Ref ID: 127276
- *Removal of Texas Instruments Inc. from Site Decommissioning Management Plan*, internal memo with attached report; L. Joseph Callan; March 13, 1997; DSA Ref ID: 127277
- *Decommissioning a Former Uranium Fuel Manufacturing Facility*, slide presentation regarding M&C Facility; Sensata Technologies, Inc.; date not specified; DSA Ref ID: 127278

- *Supplementary Information Regarding SEC Petition and Lack of Monitoring*, correspondence; [Name Redacted]; August 18, 2016; DSA Ref ID: 127279

5.0 Radiological Operations Relevant to the Class Evaluated by NIOSH

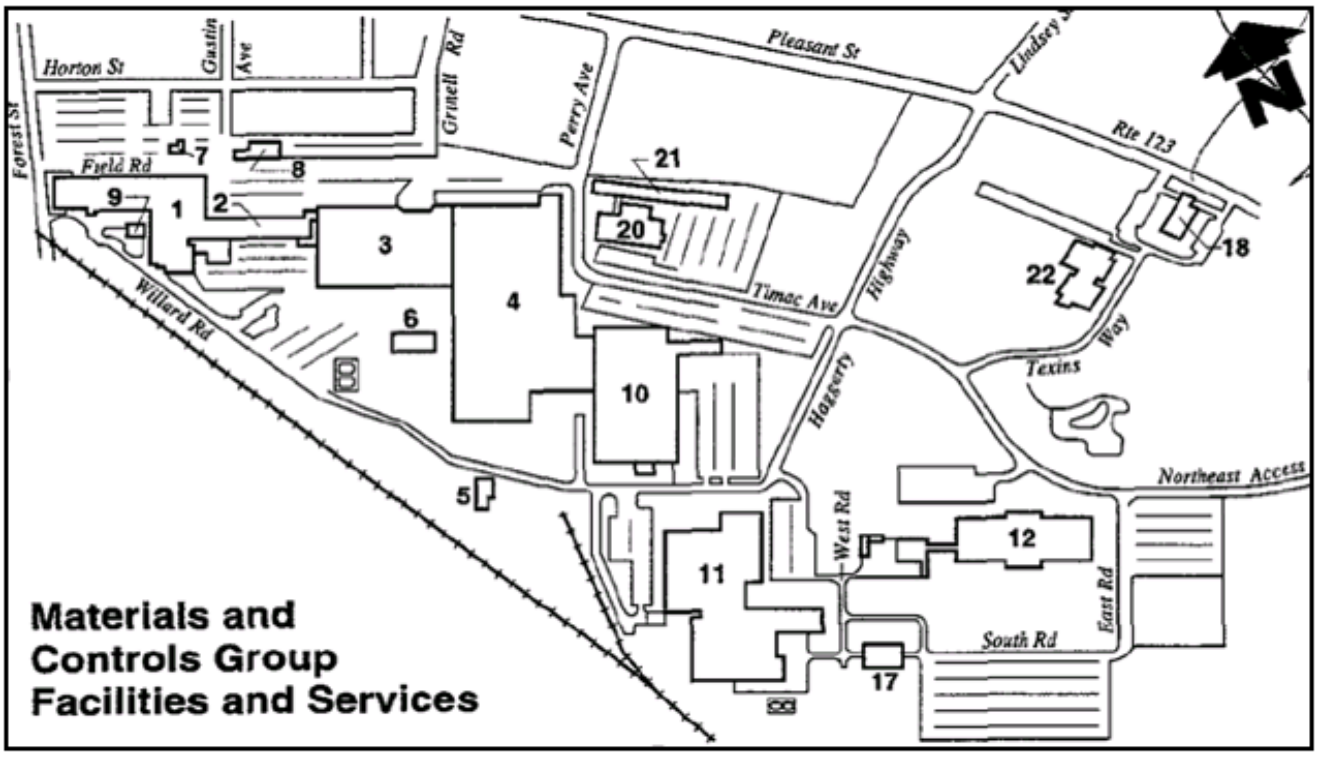
The following subsections summarize both AWE Facility nuclear weapons operations at Metals and Controls Corp. and the information available to NIOSH to characterize particular processes and radioactive source materials that impact this evaluation of the residual radiation period from January 1, 1968 through March 21, 1997. From available sources NIOSH has gathered process and source descriptions, sufficient information regarding the identity and quantities 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 evaluation report is intended only to be a summary of the available information.

5.1 Metals and Controls Corp. Plant and Process Descriptions Impacting the Residual Radiation Period

Please note that Metals and Controls Corp. became a division of Texas Instruments in 1959. For the purposes of the plant and process discussion in Section 5.1, both Texas Instruments and Metals and Controls Corp. (sometimes referred to as M&C) describe the same facility, albeit at different points in time.

This report evaluates M&C employee exposures during the residual radiation period from January 1, 1968 through March 21, 1997, resulting from radioactive materials leftover from AWE Facility nuclear weapons operations that were performed during the covered AWE period at the site. However, for purposes of completeness, there will be some discussion of non-weapons related work, as well as decontamination and decommissioning (D&D) efforts that were performed by non-covered contractors, which took place during the evaluated years. From 1965 through 1981, Texas Instruments performed fuel fabrication for the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory and other government-owned research reactors. While this information is necessary for the site description and related topics, this HFIR work is considered non-weapons related work and therefore the radiological exposures associated with this work are not covered under the Energy Employee Occupational Illness Compensation Program Act (EEOICPA) radiological dose reconstruction process during the AWE Facility residual radiation period (DOE, 2001).

Metals and Controls Corp. is located on 100 acres in Attleboro, Massachusetts, approximately 10 miles north of Providence, Rhode Island, and 30 miles south of Boston, Massachusetts. For the period evaluated by NIOSH, the M&C workforce consisted of approximately several thousand employees. By the 1960s, M&C had become Attleboro's largest employer, with roughly 6,000 employees in 23 buildings. However, by the time non-weapons related radiological operations ended in 1981, there were 1,100 employees. At the end of the evaluated period in 1997, the site was comprised of 18 buildings (Callan, 1997). By 2006, there were fewer than 200 employees involved in manufacturing (Adams, 2016, PDF p. 4). Figure 5-1 is a 1996 diagram showing 22 buildings and their relative locations on the M&C site.



Source: Weston, May1996, PDF p. 8

Figure 5-1: Metals and Controls Corp. Diagram Showing 22 Buildings

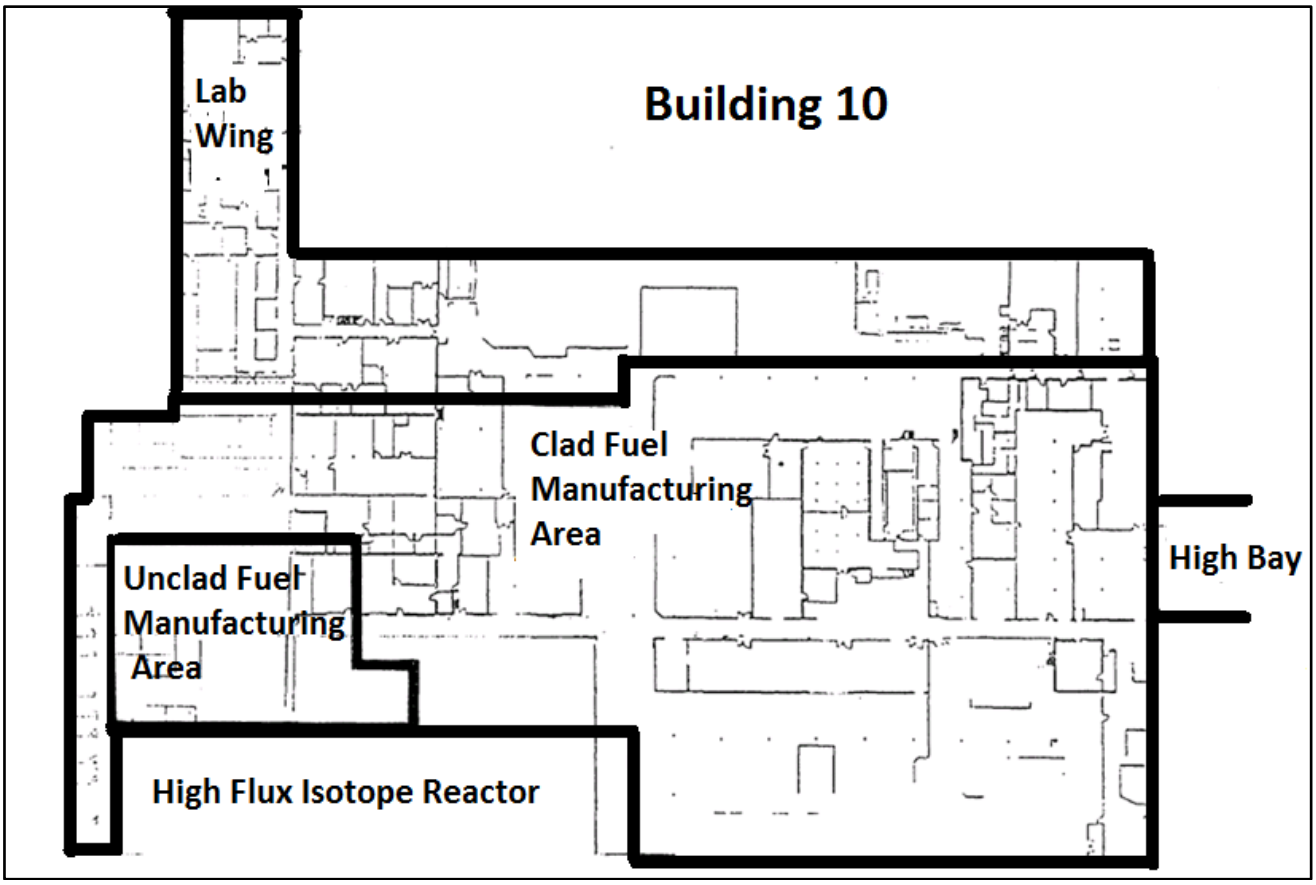
Buildings 3, 4, and 10

Operations using radioactive materials during the covered AWE Facility period (1952–1967) were initially conducted in portions of Building 4, with very limited operations conducted in Building 3. In 1956, M&C constructed Building 10 to house all manufacturing work that used radioactive materials. By 1957, all manufacturing operations involving radioactive material were moved to Building 10 (Callan, 1997, PDF p. 4) and normally occurred during the day shift, Monday through Friday (TI, 1979, PDF p. 12). NIOSH is aware of instances where former employees indicated that some members of the evaluated class routinely worked overtime.

Building 10 was constructed of fabricated metal, bricks, and concrete blocks. The roof was made of crushed stone on corrugated steel and insulation panels. An 8-foot fence with one monitored employee entrance protected the area. The inside of Building 10 included a Fuel Manufacturing Area (FMA) and the non-weapons related High Flux Isotope Reactor (HFIR) fuel-fabrication project (DOE, 2001).

The FMA was separated into two areas by floor-to-ceiling partitions: (1) the Unclad Fuel Manufacturing Area (UFMA), which was dedicated to fabricating bare uranium materials and was considered a contaminated area, and (2) the Clad Fuel Manufacturing Area (CFMA), which handled only clad material and was maintained as a clean area. Figure 5-2 shows a diagram of the Unclad and Clad fuel-manufacturing areas. The UFMA, approximately 1,200 ft^2 in size, was surrounded by the CFMA, approximately 14,000 ft^2 in size, and was maintained at a negative pressure relative to the surrounding CFMA. No exposed or unclad special nuclear material (SNM) was processed in the CFMA (NRC, 1982, PDF p. 15; TI, May1982, PDF p. 53; Ketzlach, 1978). All unclad SNM processing in the UFMA was performed in dry boxes or hoods with ventilation conforming to Nuclear

Regulatory Commission (NRC) requirements (NRC, 1982, PDF p. 15; TI, May1982). Two exhaust fans ventilated and removed air from the UFMA. One ventilation stack equipped with a high-efficiency filter exhausted air from the press room in the UFMA at a rate of 616 ft^3 per minute (cfm), and another stack exhausted air from the furnace area at a rate of 500 cfm (TI, 1979, PDF p. 17).



Source: Modified version of figure in CPS, 1997, PDF p. 13

Figure 5-2: Diagram of Clad and Unclad Fuel-Manufacturing Areas

A combination change room and counting room, under the supervision of health physics employees, served as the only point of entry between the UFMA and CFMA. Everyone entering the UFMA from the CFMA were required to wear shoe covers and protective clothing, all of which were removed upon returning to the CFMA. In addition, contamination surveys were performed on all material, equipment, or tools transferred from the UFMA to the CFMA (TI, May1978, PDF p. 5).

Building 5 Waste Handling and On-site Burial

Waste handling, scrap metal and residue processing, and waste acids and water treatment were conducted in Building 5 and outside of Building 5 in areas known as the Metals Recovery Area and the Stockade. A waste evaporator and an incinerator operated in Building 5 and the adjacent Metals Recovery Area. Scrap and waste generated in the manufacturing processes were returned to the U.S. government. However, some materials contaminated with low levels of radioactivity were disposed in an on-site burial adjacent to Building 11 (Callan, 1997, PDF p. 4).

A 1964 Texas Instruments health and safety manual states that uranium- and thorium-contaminated noncombustible scrap material and machinery were collected in 55-gallon steel drums and were

disposed of through authorized agencies, or were buried on-site in compliance with 10 C.F.R. 20.304. Available records indicate two known burials of radioactive material: (1) contaminated ductwork in 1958, and (2) 28.4 mCi of enriched uranium noncombustible scrap in 1961. The burial site was closed in 1967 (Ansari, 1994, PDF p. 12).

Decontamination and Decommissioning (D&D) Operations

In 1978, the NRC approved Texas Instruments' general D&D plan for Building 10's HFIR area. The plan was filed to comply with NRC requirements in existence at the time, specifically, *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source or Special Nuclear Material* (NRC, 1976). The plan included the following: (1) equipment, furniture, tools, and light fixture disposal, (2) hydraulic press decontamination, (3) partition wall removal and disposal, (4) concrete floor scabbling, and (5) ceiling cleaning and painting. The plan also provided assurance that the health and safety of employees and the environment would be protected. It also specified that the Union Carbide Corporation, a prime contractor to DOE at Oak Ridge National Laboratory, would pay for the D&D operations (Ketzlach, 1978; Read, 1978; TI, Jul1978).

At the end of non-weapons related fuel fabrication operations for HFIR in 1981, Texas Instruments submitted a technical proposal to Oak Ridge National Laboratory for D&D of the HFIR area and initiated D&D of the HFIR area in Building 10 (TI, May1982, PDF p. 56). The proposal included disposition instructions for equipment, tools, and waste, and included a flow-chart D&D plan that specified necessary cleaning, painting, and final release surveys (Sherman, 1981).

In May 1982, Texas Instruments requested the termination of their NRC license and release of their facility for unconditional use. The request was filed to comply with NRC requirements in existence at the time, specifically, *Disposal or Onsite Storage of Residual Thorium and Uranium (Either as Natural Ores or Without Daughters Present) from Past Operations* (NRC, 1981). In their request, the decontamination techniques were described to include wire brushing, chipping, cleaning remaining building surfaces with a steam jet and decontaminating solution (Turco #4324), and scarifying concrete floors (TI, May1982, PDF pp. 52-57). All of the equipment, tools, etc., used for fuel processing were disposed at an NRC-licensed facility or removed and sent to Babcock & Wilcox in Lynchburg, Virginia (TI, May1982, PDF p. 53).

Texas Instruments reported to the NRC that the three areas used for AWE Facility operations (Buildings 3, 4, and 10) were decontaminated and decommissioned and that all radioactive materials were removed at the completion of D&D operations (occurring from 1955 to 1968). The largest Building 10 cleanup effort occurred at the end of 1958 (ASTRA, 1962, PDF p. 71). Texas Instruments also reported that all three areas were surveyed after each area's respective D&D efforts were completed (TI, Nov1982, PDF pp. 12–13; NRC, 1983, PDF p. 7). No other AWE-related radiological work was performed in Buildings 3, 4, or 10 again after 1968. From 1968 to 1981, the only radiological work that was performed at the Texas Instruments site was the non-weapons related fuel fabrication operations for HFIR and other government-owned research reactors. Although the three areas were previously surveyed, Texas Instruments could not locate the survey documentation from 1968 for Buildings 3, 4, and 10, so in 1982, Texas Instruments resurveyed the areas used for AWE Facility operations and documented that the three areas had remained decontaminated during the time since the end of AWE Facility operations (TI, Nov1982, PDF pp. 12–13; NRC, 1983, PDF p. 7). In 1983, the NRC was satisfied that the interiors of Buildings 3, 4, and 10 were sufficiently decontaminated and they released Buildings 3, 4, and 10 for unrestricted use, but the NRC withheld

license termination pending further investigations into the former radioactive waste burial site between Buildings 11 and 12 (Ansari, 1994, PDF p. 12; TI, 1994, PDF p. 8).

In April and May 1984, at the request of the NRC, the Oak Ridge Institute for Science and Education (ORISE) conducted a radiological survey of portions of M&C's outdoor areas. The results of that survey indicated several outdoor areas with surface and/or subsurface uranium concentrations in excess of the NRC's release guidelines. Based on the results of the ORISE surveys, in the summer of 1992, Texas Instruments contracted Creative Pollution Solutions, Inc. to initiate remediation activities.

During the remediation of the former burial site, 63,000 ft^3 of soil and debris were removed for disposal (CPS, 1993). The D&D contractors, including Creative Pollution Solutions, Inc., and later Weston, Inc., followed health and safety procedures that required radiological and decontamination training, personal dosimetry, area and breathing-zone air monitoring, urinalysis, action limits, and employee contamination monitoring. Remediation was performed to comply with NRC requirements in existence at the time, specifically in accordance with *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source or Special Nuclear Material* (CPS, 1992; CPS, 1993; Weston, 1996; TI, 1994, PDF pp. 67-75). Texas Instruments submitted a post-excavation radiological survey report for the burial area to the NRC in November 1992 (CPS, no date).

A confirmatory survey conducted by ORISE in December 1992 identified some remaining contamination on the walls of the west side of the excavation, adjacent to the Building 11 parking lot (the former burial site). In July 1993, further remediation of the former burial site was performed by Creative Pollution Solutions, Inc. Following this last remediation effort, Texas Instruments completed the final survey activities and backfilling operations. After this outdoor remediation, the NRC requested that ORISE perform a final confirmatory survey. ORISE's December 1993 confirmatory survey (conducted on December 14–15, 1993) did not identify burial area residual contamination in excess of the NRC criteria for release for unrestricted use (Ansari, 1994, PDF p. 13).

In March 1994, Texas Instruments notified the NRC of its intent to remediate the Metals Recovery Area (located near Building 5 and to the northwest of Building 11) and received NRC approval to proceed with the remediation. Remediation activities began on April 28, 1994, were completed November 14, 1994, and generated 115,000 ft^3 of contaminated soil for disposal (TI, 1994, PDF p. 10).

In May 1994, the NRC provided Texas Instruments with the 1993 *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted use or Termination of Licenses for Byproduct, Source or Special Nuclear Materials*. Upon receiving these Guidelines, Texas Instruments incorporated the new criteria and used them to complete the D&D work (NRC, 1993; TI, 1994, PDF p. 15).

In July 1994, Texas Instruments began performing radiological-characterization surveys of the open land areas at the facility. After identifying additional contamination in the Metals Recovery Area, NRC Region I staff requested that Texas Instruments perform a comprehensive radiological survey of all potentially affected areas on the site. These comprehensive radiological surveys, performed in 1994 and 1995, and discussions with long-term employees led to the identification of additional areas of contaminated soil, primarily in the Stockade and Building 12 south lawn areas. Residual contamination was also identified in Buildings 4, 5, and 10, primarily where unclad uranium operations had been conducted, including areas that were previously decommissioned. This

contamination was generally limited to cracks and joints in the concrete floor, areas around equipment installed in the concrete floor, drain lines buried in or beneath the concrete floor, or was covered with carpet, flooring, machinery, and other items that limited potential exposures to manufacturing workers (Callan, 1997, PDF p. 3; Price, no date, PDF p. 4).

Prior to the full-scale remediation, a comprehensive characterization of the subsurface drainage system was performed. Characterization results were used to designate and prioritize three levels of drain line decontamination with respect to the volume and concentration of radioactive material. Priority 1 lines exhibited residue blockage greater than or equal to 10% and/or total uranium concentrations in excess of 1,000 picocuries per gram (pCi/g), and were identified for complete removal and disposal as radioactive waste. Priority 2 lines exhibited residue blockage of less than 10% and/or total uranium concentrations of 500 to 1 ,000 pCi/g, and were subject to in-situ decontamination using hydrolasing techniques. Drain lines that contained less than 5% blockage and/or a total uranium concentration in residue of less than 500 pCi/g, were designated as Priority 3 and required no remediation (Weston, Oct1996, PDF pp. 169, 171).

Further remediation activities in Buildings 4 and 5 primarily involved scabbling concrete floor surfaces. In a few cases, portions of the concrete slab and some underlying soil were removed. Building 10 required more extensive remediation work to remove contamination because unclad uranium operations had been conducted in portions of this building. Remediation activities included scabbling approximately 75 m^2 (800 ft^2) of the floor and lower wall surfaces. Approximately 1,400 m^2 (15,000 ft^2) of the concrete slab were removed to provide access to contaminated drain lines and soil. In most cases, the concrete was not contaminated or was only contaminated on the surface. Approximately 460 m (1,500 ft) of contaminated drain lines were removed from Building 10, and another 180 m (600 ft) were decontaminated using a high-pressure wash. Approximately 6 m^3 (200 ft^3) of sludge were collected and disposed (Callan, 1997, PDF p. 6). Approximately 10,000 ft^2 of Building 10's roof was subject to decontamination techniques including vacuuming gravel and dust, scraping roof tar layers, and removing section of the roof. Roofing material was transferred directly to shipping containers using a sealed hopper/chute system. Scraping and roof section removal were performed with roof cutters and hand tools. Decontamination and removal operations resulted in approximately 1,000 ft^3 of radioactive waste to be transported for disposal (Weston, Oct1996, PDF p. 17).

During 1995 and 1996, 65,000 ft^2 of combined floor and roof area in Buildings 4, 5 and 10 were decontaminated, and 34,600 ft^3 of radioactive waste containing 278 mCi was shipped to a disposal facility. Texas Instruments took steps to reduce exposure to non-D&D employees by temporary relocating employees to unaffected areas and by performing D&D activities during second and third shifts. From the beginning of all intrusive activities, decontamination work areas were thoroughly isolated through the use of portable containments under negative-pressure with high-efficiency particulate air (HEPA), water-retaining walls, and vacuum collection systems. Portable HEPA units were frequently moved and used at the immediate point of dust generation. Routine air monitoring and contamination control surveys were performed to confirm containment. These contamination control techniques enabled Texas Instruments to maintain all work area contamination levels to less than 20% of the removable contamination unrestricted-release criterion throughout the D&D work (Price, no date, PDF pp. 2-6; Weston, Oct1996, PDF p. 6). Remediation was performed to comply with NRC requirements in existence at the time, specifically NRC's *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted use or Termination of Licenses for Byproduct, Source or Special Nuclear Materials* (NRC, 1993; TI, 1994, PDF p. 84). NIOSH has

documentation indicating that Texas Instruments also performed final release surveys in accordance with NUREG/CR-5849, *Manual for Conducting Radiological Surveys in Support of License Termination* and the Atomic Energy Commission (AEC)'s Regulatory Guide 1.86, *Termination of Operating Licenses for Nuclear Reactors* (TI, 1995, PDF pp. 4, 6; Weston, Oct1996, PDF p. 6).

In February 1997, after these additional areas were decontaminated, NRC representatives from Region I, accompanied and assisted by a representative from the Commonwealth of Massachusetts, conducted confirmatory radiological measurements. These measurements included the inaccessible areas of Buildings 4, 5, and 10 (cracks and joints in the concrete floor, etc.) where AWE Facility operations were performed and that were previously released in 1983. These measurements confirmed the licensee's surveys that the site was acceptable by NRC standards and guidelines to be released for unrestricted use (Callan, 1997; NRC, 1997, CPS, 1997). On March 21, 1997, at the time of release for unrestricted use by the NRC, the M&C facility was still operational in a variety of non-radiological metallurgical production activities (NRC, 1997). In April 2006, Texas Instruments sold the business to Bain Capital and it became a stand-alone entity named Sensata Technologies (ORAUT, 2007; Sensata, 2016).

5.2 Radiological Exposure Sources at Metals and Controls Corp. During the Residual Radiation Period

The following subsections provide an overview of the internal and external exposure sources for the Metals and Controls Corp. class under evaluation. During the residual radiation period from January 1, 1968 through March 21, 1997, the primary source of covered exposure that M&C employees may have been exposed to was from the previous AWE Facility weapons-related work that generated residual uranium residues. Smaller amounts of residual thorium residues were also present.

5.2.1 Internal Radiological Exposure Sources at Metals and Controls Corp. During the Residual Radiation Period

This section addresses exposures to alpha-emitting radionuclides at M&C. The primary potential sources of internally deposited radioactivity for M&C employees during the residual radiation period were inhalation and ingestion of uranium and thorium residual activity remaining at the end of, and as a result of, AWE Facility operations.

5.2.1.1 Uranium

The uranium work activities that M&C performed during AWE Facility operations that generated residual radioactivity that the evaluated class was potentially exposed to included:

- Melting and shearing fuel foils for R&D experiments;
- Pickling, polishing, cropping, and assembling fuel plates into elements; and
- Cladding with zircalloy, aluminum, or stainless steel.

Natural uranium consists of four isotopes, U-234, U-235, and U-238. The term enriched refers to uranium where the amount of U-235 has been increased relative to naturally-occurring uranium, and likewise, depleted refers to uranium where the amount of U-235 has been decreased relative to naturally-occurring uranium.

During the evaluated period, exposure to residual uranium may have occurred while performing work in the areas where former AWE Facility uranium-bearing component fabrication occurred (including reactor fuel, metallic alloys, and metallic foils). The former work occurring during the AWE Facility operational period is discussed in this section to promote an understanding of the origin of the residues remaining during the evaluated period.

Most of the fuel fabrication activities that occurred during the AWE Facility operational period involved uranium enriched to more than 93%. However, some of the projects involved lower enrichments and depleted uranium. It was accepted practice to fabricate small orders requiring intermediate enrichment by combining the on-hand 93% enriched uranium with natural or depleted uranium so that a special enrichment order would not be necessary.

During AWE Facility operations, M&C received enriched uranium in the form of metal, $U0_2$, and U_30_8, depending on the specifications for the reactor core. The U_3O_8 work involved alloying, pressing, annealing, and cladding the powder for the fuel plate manufacturing process (TI, no date-b, PDF p. 9). The early operations used uranium metal; the later operations used U_30_8 in powder metallurgy, and only a few cores required $U0_2$ (TI, no date-b, PDF pp. 9–11).

The amount of enriched uranium present in the former AWE Facility can be described by the limited inventory information available. In January 1962, M&C possessed 1,282 kg of uranium at a 93% enrichment; 71 kg at a 20% enrichment; 1,449 kg at 3.2%; 3,932 kg at 2.2%; and 363 kg at 1.8% (ASTRA, 1962, PDF p. 47).

Operations prior to 1963 used natural uranium as a metal, and after 1963 it was used in its oxide form (TI, no date-b, PDF pp. 9–11). The amount of natural uranium present at M&C can be described by the limited inventory information available. Inventory indicates that in January 1962, M&C possessed 253 kg of natural uranium (ASTRA, 1962, PDF p. 47).

M&C also worked with natural uranium in a powder form as UO_2. This work involved mixing the powdered form with stainless steel powder and rolling it to make fuel plates; however, very few cores required UO_2 fuel (ASTRA, 1962; M&C, Apr1957; M&C, 1957).

From 1957 to 1963, M&C supplied Argonne with 39,000 metal pieces fabricated from 68,000 kg of depleted uranium metal derbies. Records indicate that depleted uranium was shipped between Rocky Flats and M&C from 1955 through 1958 (ASTRA, 1962; McKinley, 1960; M&C, no date; Williams, 1959; Callan, 1997).

5.2.1.2 Thorium

During the evaluated period, exposure to residual thorium may have occurred during work in the areas where previous AWE Facility thorium-bearing component fabrication occurred (including reactor fuel, metallic alloys, and metallic foils) (Callan, 1997). NIOSH has limited information about thorium operations at M&C, and will assume that any residual thorium present during the evaluated period would have been generated during the previous AWE Facility operations period. Therefore, any potential thorium exposures during the evaluated period will be considered covered exposures.

M&C's use of thorium is indicated in undated product literature (M&C, no date, PDF p. 45; M&C, 1956, PDF p. 60; M&C, 1962, PDF p. 65) and in a 1960 brochure (TI, 1960). Based on these references, M&C supplied thorium foil strips for criticality experiments, source tests, and reactivity

tests. Thorium was vacuum-melted and cast into flat ingots. These ingots were subsequently rolled into the desired thickness. A 1964 Standard Procedures Manual references thorium use (M&C, Jan1964a; M&C, Jan1964b; M&C, Oct1964a; M&C, Oct1964b; M&C, Oct1964c; M&C, Oct1964d), while the 1968 and 1973 versions of this same document (Weiss, 1968; Barletta, 1973) do not mention thorium. No other versions, for the intervening years or prior to the 1964 version, are available.

A comprehensive listing of thorium shipments from the Fernald site (Thorium Shipments, 1952–85, PDF p. 108) documents three shipments of small quantities of thorium metal (less than 15 kg each) to M&C. One of these shipments occurred in June 1955, the second in February 1957, and the third in October 1957. NIOSH also has documentation of a fourth thorium shipment containing one 3 ft x 5 ft piece of thorium foil being shipped to the Brookhaven National Laboratory in June 1954 (Huke, 1954). A 1957 uranium exposure assessment, conducted by the Environmental Measurement Laboratory, lists the production of thorium foils as one of the processes at M&C (M&C, Apr1957). The only definitive information regarding the amount of thorium at M&C is from a 1962 nuclear safety analysis that lists the total quantity of natural thorium as 244 kg (ASTRA, 1962, PDF p. 47).

5.2.1.3 Radium

From 1965 to 1967, Texas Instruments performed commercial work that produced 5,000 electrical breakers containing radium-bearing luminescent markers for the U.S. Navy. This work involved placing a luminous glass bead with Ra-226 coating onto each toggle switch so that the switch would glow in the dark. Activity was estimated at 0.12 μCi for each bead (TI, 1997; ORAUT, 2008; ORAU, 2008).

This Ra-226 commercial work was limited to a single process in Building 1 and was kept separate from M&C's AWE Facility weapons-related work (Email, 2006, PDF p. 4). M&C's Ra-226 work is not considered an EEOICPA-covered exposure during the subsequent residual radiation period. Therefore, Ra-226 and any associated exposures will not be addressed further in this report.

5.2.2 External Radiological Exposure Sources at Metals and Controls Corp. During the Residual Radiation Period

The primary potential sources of external exposure for M&C employees during the residual radiation period include small amounts of surface contamination present after AWE Facility operations with uranium and thorium ended.

5.2.2.1 Photon

During the residual period, M&C employees conducted work in areas where previous AWE Facility operations occurred with enriched, natural, and depleted uranium. Uranium emits both beta particles (electrons) and photons (gamma and X-rays). The two primordial components of natural uranium are U-238 and U-235, but some of their decay products grow into equilibrium fast enough to contribute to worker exposures. External exposures to photon radiation would have resulted from the immediate daughter radionuclides in the uranium decay chain. The uranium progeny that result in the most significant photon exposures include Th-234 and Pa 234m (Rad Handbook, 1998), but these isotopes have relatively short half-lives and can be assumed to be in equilibrium with the parent U-238. Because of their short half-lives, the exposure potential from these isotopes would follow the parent and will not be considered separately in this document.

The beta and photon emissions of the radionuclides of major external exposure concern can be found in most standard health physics reference documents. Exposure to these emissions was possible for the period under evaluation during inadvertent contact with contaminated surfaces during normal work activities and from submersion in contaminated air.

Thorium has a significant number of higher-energy photons in the Th-232 decay chain. Based on the half-lives of the progeny, only a partial equilibrium is possible. Therefore, it is conservative to state that equilibrium would be reached in this decay chain. It has been assumed that Ra-228 and Th-228 progeny were in equilibrium with Th-232. Under this assumption, the progeny are the major source of both penetrating and non-penetrating external exposure during the residual radiation period.

5.2.2.2 Beta

Beta particle radiation was the dominant source of external radiation exposure associated with work in areas with residual uranium contamination at M&C, primarily from U-238 decay products. For example, nearly the entire beta radiation field from uranium comes from the daughter radionuclide Pa-234m, and to a lesser extent from Th-234.

Beta doses to the skin, extremities, and (sometimes) the lens of the eye may occur in facilities that processed uranium. Potential skin exposure from uranium occurs primarily from the Pa-234m beta particles at tissue depths of 4 mg/cm^2 and greater. At 2.29-MeV (Emax), beta particles from Pa-234m are the most energetic contributors to the beta exposure.

5.2.2.3 Neutron

Neutron exposures were not evaluated because they are negligible for facilities with residual quantities of uranium and thorium present, such as in the case of M&C during the evaluated period (Battelle-TBD-6000; ORAUT-OTIB-0024).

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

Monitoring data, which may be available for some M&C employees during the residual period, are associated with commercial or D&D work and not with EEOICPA-covered operations. Therefore, using these data provides an overestimate of the exposure to residual radioactivity from covered operations alone. A bounding estimate of radiation exposure during the period from January 1, 1968 through March 21, 1997, can be based on monitoring data at the end of the AWE Facility operations period. Monitoring data from the end of the AWE Facility operations period include doses from residual radioactive material and, as such, would be bounding for exposures to residual surface contamination during the January 1, 1968 through March 21, 1997 period. The following subsections provide an overview of the state of the available internal and external monitoring data for the M&C class under evaluation.

6.1 Available Metals and Controls Corp. Internal Monitoring Data

Throughout the AWE Facility operational period, M&C's health protection equipment and procedures enabled M&C to maintain levels of uranium air concentration at a factor of fifty lower than those permitted by the applicable Code of Federal Regulations. To ensure that these low levels were

maintained, constant air monitoring was performed in the specially segregated area where bare uranium and thorium were handled, as well as throughout the inside of the plant and outside Building 10. M&C engineers were considered to be pioneers in low-level alpha counting and quantitative gamma spectrometry. Beginning in the 1950s, M&C's Instrument Engineering Section developed nondestructive testing methods for process control and to ensure in-process quality including radiography and radiation monitoring (TI, 1960, PDF p. 24). M&C's intensive cleaning program during the AWE Facility operational period required daily surface surveys to check for nuclear materials (TI, 1960, PDF p. 27).

M&C performed routine contamination monitoring of employees and areas. Area surface-contamination survey data[4] (analyzed for gross-alpha content) from the end of the AWE Facility operational period indicate that removable alpha contamination was generally below 100 dpm/100 cm^2.

NIOSH is aware of surface contamination surveys, air monitoring, and urinalysis that were performed in 1981 and 1982, and from 1992 until the end of the covered period (March 21, 1997) for personnel performing D&D work as described in Section 5.1 of this report. However, this D&D work was performed in either the HFIR area or by contractors (TI, 1994, PDF pp. 8, 22, 70; CPS, 1992, PDF p. 6; Weston, Oct1996, PDF pp. 15, 16) and therefore, the D&D of M&C is not an EEOICPA-covered operation and will not be further assessed in this report.

The areas where AWE Facility weapons-related operations occurred (Buildings 3, 4 and 10) were cleaned as those operations ended from 1955 through 1968 (TI, Nov1982, PDF p. 12; ASTRA, 1962, PDF p. 71). However, the first available survey of these areas was performed on November 1, 1982 (TI, Nov1982, PDF p. 12). The NRC performed an over check survey of these same areas from January 31 to February 2, 1983. The NRC documented that direct alpha measurements were all below 175 dpm/100 cm^2 except for one location in Building 4 that was 350 dpm/100 cm^2, and that 92% were below 50 dpm/100 cm^2 (NRC, 1983, PDF pp. 6–8). Using the data from the end of AWE Facility operations and D&D, NIOSH can model exposures to the evaluated class.

NIOSH is aware of data from surface contamination surveys, air monitoring, urinalysis, and lung scans that were performed during the evaluated period for M&C employees performing commercial work (TI, 1973-82, PDF p. 34; Barletta, 1973, PDF p. 50; CPS, no date, PDF p. 11; Hopper, 1979 PDF p. 43). Since these data are representative of conditions that existed during commercial operations, NIOSH will not rely on them to bound doses during the evaluated period. However, NIOSH can consider these data as supporting evidence to validate the bounding method used in Section 7 of this report.

6.2 Available Metals and Controls Corp. External Monitoring Data

Data from film-badge monitoring (Monitoring, Oct1965–Sep1974) performed at the end of AWE Facility operations in 1967, document exposure for 162 M&C employees. M&C required employees and visitors whom health physics staff deemed likely to receive a dose in excess of 125 mrem in any

[4] The Health and Safety Contamination and Radiation surveys that were analyzed are located in the following SRDB Ref ID numbers: 69181, 69314, 69231, 69239, 69289, 69283, 69210, 69228, 69233, 69287, 69295, 69300, 69305, 69269, 69271, 69276, 69293, 69185, and 69167.

calendar quarter, to wear a Kodak Type 2 film-badge dosimeter. These dosimeters contained differentially shielded beta-, X-, and gamma-sensitive film and neutron-monitoring resonance threshold foils. M&C processed dosimeters quarterly, or more frequently in some cases (M&C, Oct1964b). Using the data from the end of AWE Facility operations, NIOSH can model exposures to the evaluated class.

NIOSH is aware of data from personal film badges, as well as surveys of areas and items handled frequently (e.g., fuel elements) that were performed during the evaluated period for M&C employees performing commercial work (TI, 1973–82, PDF p. 34; Barletta, 1973, PDF p. 50; Hopper, 1979, PDF p. 43). Since the data are representative of conditions that existed during commercial operations, NIOSH will not rely on the data to bound doses during the evaluated period. However, NIOSH can consider the data as supporting evidence to validate the bounding method used in Section 7 of this report.

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. This approach is discussed in NIOSH's SEC Petition Evaluation Internal Procedures which are available on the NIOSH Radiation Dose Reconstruction Program webpage. 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-00236 as submitted by the petitioner. (Section 7.4)

7.1 Pedigree of Metals and Controls Corp. 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

As presented in Section 6.1.1 above, M&C engineers were considered to be pioneers in low-level alpha counting, and site procedures required routine work-area contamination monitoring. The data NIOSH relies on (presented in Section 6.1.1) to estimate airborne concentration during the evaluated period were obtained at the end of AWE Facility operations and consist of 7,765 survey data entries. The data sources are copies of original reports and are therefore considered primary data sources. The locations chosen by M&C for these surveys provide information that is representative of the conditions that employees experienced in the areas where AWE Facility weapons-related work was performed.

M&C followed monitoring procedures that were appropriate for control and assessment of their operations and NIOSH has determined that the data obtained from M&C's monitoring effort are adequate for estimating exposures to the evaluated class.

7.1.2 External Monitoring Data Pedigree Review

The external monitoring data that NIOSH will use to estimate exposures for the evaluated class are taken from Landauer film badge dosimetry reports (Monitoring, Oct1965–Sep1974). These reports document exposure monitoring for 162 M&C employees performed at the end of AWE Facility operations in 1967. The data sources are copies of original reports and are therefore considered primary data sources. During this period at the end of AWE Facility operations, M&C required all employees and visitors whom health physics staff deemed likely to receive a dose in excess of 125 mrem in any calendar quarter, to wear a film-badge dosimeter (M&C, Oct1964b, PDF p. 48).

M&C followed AEC requirements and monitoring procedures that were appropriate for assessing external exposures to M&C employees. NIOSH has determined that the data obtained from that effort are adequate for estimating exposures to the evaluated class.

7.2 Evaluation of Bounding Internal Radiation Doses at Metals and Controls Corp.

The principal source of covered internal radiation doses for members of the class under evaluation was the inhalation and ingestion of resuspended surface contamination created from previous AWE Facility weapons-related operations with uranium and thorium (See Section 5.2.1 of this report).

NIOSH has reviewed M&C radiological controls manuals to understand the protective measures in place during the AWE Facility operations that generated the radioactivity, and those measures in place during the residual period. M&C's manual in place at the end of AWE Facility operations included

requirements for training and qualification, personal and area monitoring, internal and external radiation protection, personal protective equipment (PPE), medical surveillance, and contamination and waste control (TI, no date-a, PDF pp. 31, 42; Weiss, 1968). NIOSH is aware of documents that indicate that M&C utilized engineering controls and PPE such as ventilated hoods, gloveboxes, and respirators (M&C, no date, PDF pp. 44, 51; Weiss, 1968).

D&D activities at M&C were controlled so that all employees, including those not participating in the particular effort, were made aware of the work with daily briefings. Non-D&D employees were required to remain at a safe distance from the work (TI, 1995, PDF p. 9). Access to D&D work areas was restricted by a conspicuously posted control point and only those enrolled in the contractor's monitoring program were permitted to enter. The control point was the access location through which all workers entered the area and included a frisking station to assess and prevent contamination transferring from the work area. Control points were supervised by a health physics technician during high traffic periods (TI, 1994, PDF pp. 73, 74, 84; CPS, 1992, PDF p. 10).

The following subsections address the ability to bound internal doses for the residual period, methods for bounding doses, and the feasibility of internal dose reconstruction. Process-related doses will not be discussed in detail because this report is evaluating the residual period (January 1, 1968 through March 21, 1997) and not the operational period.

7.2.1 Evaluation of Bounding Residual Period Internal Doses

NIOSH can bound residual radiation period internal doses from uranium and thorium to M&C workers using surface contamination monitoring data from the areas where AWE Facility weapons-related operations were performed, and applying methodology as described in Battelle-TBD-6000, ORAUT-OTIB-0070, and NUREG/CR-5512 (*Residual Radioactive Contamination from Decommissioning*), for the evaluated class.

7.2.2 Methods for Bounding Residual Internal Dose at Metals and Controls Corp.

All of the surface contamination surveys used to create these bounding methods were initially analyzed for gross alpha content; therefore, NIOSH will choose the most claimant-favorable isotope of thorium or uranium when estimating worker doses. For thorium, both natural and triple-separated mixtures will be considered. For uranium, the recycled uranium ratios in Battelle-TBD-6000 will be considered. NIOSH will determine the amount of activity ingested with methodologies presented in NUREG/CR-5512.

Inhalation Dose Methodology for Production Employees

M&C performed routine employee and area contamination monitoring. Area surface-contamination survey data from the end of the AWE Facility operational period (described in Section 6.1 of this report), indicate that removable alpha contamination was generally below 100 dpm/100 cm^2. The contamination data, consisting of 7,765 survey data entries, were compiled and then a 95^{th} percentile value was calculated as 54.8 dpm/100 cm^2.

A resuspension factor of 10^{-6} m^{-1} was applied to the 95^{th} percentile contamination levels (54.8 dpm/100 cm^2) to estimate an air concentration (2.47×10^{-15} µCi/mL or 0.00548 dpm/m^3) that would have been present at the start of the residual period (per guidance in ORAUT-OTIB-0070).

The areas where AWE Facility weapons-related operations occurred (Buildings 3, 4 and 10) were cleaned as those operations ended from 1955 through 1968. However, the first documented survey of these areas is dated November 1, 1982 (TI, Nov1982, PDF p. 12). NIOSH used the 207 direct alpha average results from this survey (TI, Nov1982, PDF pp. 23–31) and calculated the 95th percentile as 144.85 dpm/100 cm^2. As these are direct alpha results, NIOSH then assumed that 10% of the activity measured in this direct survey was associated with removable activity (per guidance in ORAUT-OTIB-0070), which results in a removable surface contamination level of 14.5 dpm/100 cm^2.

A resuspension factor of 10^{-6} m^{-1} was applied to the 95th percentile contamination levels (14.5 dpm/100 cm^2) to estimate an air concentration (6.53 x 10^{-16} µCi/mL or 0.00145 dpm/m^3) that would have been present on November 1, 1982.

NIOSH used the air concentration of 0.00548 dpm/m^3 present at the start of the residual period (January 1, 1968), and the air concentration of 0.00145 dpm/m^3 present on November 1, 1982, to calculate a source term depletion rate of 2.45 x 10^{-4} day^{-1}. The air concentration available for inhalation by production employees during each year from January 1, 1968 through March 21, 1997, can be calculated using the starting concentration (0.00548 dpm/m^3) and the source term depletion rate (2.45 x 10^{-4} day^{-1}). Table 7-1 shows the calculated air concentration and intake rates for production employees.

Table 7-1: Intake Rates for Production Employees

Year	Air Concentration (dpm/m^3)	Inhalation (dpm/yr.)	Ingestion (dpm/yr.)
1968	5.48E-03	13.15	1,096
1969	5.01E-03	12.03	1,002
1970	4.58E-03	10.99	916
1971	4.19E-03	10.05	838
1972	3.83E-03	9.19	766
1973	3.50E-03	8.40	700
1974	3.20E-03	7.68	640
1975	2.93E-03	7.03	585
1976	2.68E-03	6.42	535
1977	2.45E-03	5.87	489
1978	2.24E-03	5.37	448
1979	2.05E-03	4.91	409
1980	1.87E-03	4.49	374
1981	1.71E-03	4.10	342
1982	1.56E-03	3.75	313
1983	1.43E-03	3.43	286
1984	1.31E-03	3.14	261
1985	1.20E-03	2.87	239
1986	1.09E-03	2.62	219
1987	9.99E-04	2.40	200
1988	9.14E-04	2.19	183
1989	8.35E-04	2.00	167

Year	Air Concentration (dpm/m^3)	Inhalation (dpm/yr.)	Ingestion (dpm/yr.)
1990	7.64E-04	1.83	153
1991	6.98E-04	1.68	140
1992	6.39E-04	1.53	128
1993	5.84E-04	1.40	117
1994	5.34E-04	1.28	107
1995	4.88E-04	1.17	98
1996	4.46E-04	1.07	89
1997	4.08E-04	0.98	82

Ingestion Methodology for Production Employees

NUREG/CR-5512 will be used to determine the amount of activity ingested. A factor of 10^{-4} m^2/hour will be applied to the surface contamination levels as they are depleted over time, as shown in Tables 7-1 and 7-2.

Internal Dose Bounding Methodology for Non-production or Administrative Employees

For unmonitored administrative, office, or non-production area employees, NIOSH will assume that their inhalation and ingestion rates are 10% of the rates associated with the production workers described above (per guidance in Battelle-TBD-6000). Table 7-2 shows intake rates for non-production employees.

Table 7-2: Intake Rates for Non-production/Administrative Employees

Year	Air Concentration (dpm/m^3)	Inhalation (dpm/yr.)	Ingestion (dpm/yr.)
1968	5.48E-04	1.32	110
1969	5.01E-04	1.20	100
1970	4.58E-04	1.10	92
1971	4.19E-04	1.01	84
1972	3.83E-04	0.92	77
1973	3.50E-04	0.84	70
1974	3.20E-04	0.77	64
1975	2.93E-04	0.70	59
1976	2.68E-04	0.64	54
1977	2.45E-04	0.59	49
1978	2.24E-04	0.54	45
1979	2.05E-04	0.49	41
1980	1.87E-04	0.45	37
1981	1.71E-04	0.41	34
1982	1.56E-04	0.38	31
1983	1.43E-04	0.34	29
1984	1.31E-04	0.31	26
1985	1.20E-04	0.29	24
1986	1.09E-04	0.26	22

Year	Air Concentration (dpm/m^3)	Inhalation (dpm/yr.)	Ingestion (dpm/yr.)
1987	9.99E-05	0.24	20
1988	9.14E-05	0.22	18
1989	8.35E-05	0.20	17
1990	7.64E-05	0.18	15
1991	6.98E-05	0.17	14
1992	6.39E-05	0.15	13
1993	5.84E-05	0.14	12
1994	5.34E-05	0.13	11
1995	4.88E-05	0.12	10
1996	4.46E-05	0.11	9
1997	4.08E-05	0.10	8

7.2.3 Internal Dose Reconstruction Feasibility Conclusion

NIOSH concludes that there are methods available in Battelle-TBD-6000, NUREG/CR-5512, and ORAUT-OTIB-0070, as well as available surface-contamination data, air-monitoring data, and operational descriptions, so that internal radiation doses can be reconstructed with sufficient accuracy for all employees during the period under evaluation.

7.3 Evaluation of Bounding External Radiation Doses at Metals and Controls Corp.

The principal source of external radiation doses for members of the evaluated class was the small amounts of surface contamination created from previous uranium and thorium operations, including radiation from uranium- and thorium-contaminated surfaces and the floor as described in Section 5.2.2 of this report.

The following subsections address the ability to bound external doses for the residual period, methods for bounding doses, and the feasibility of external radiation dose reconstruction. Process-related doses will not be discussed in detail because this report is evaluating the residual period (January 1, 1968 through March 21, 1997) and not the operational period.

7.3.1 Evaluation of Bounding Residual Period External Doses

NIOSH can bound M&C workers' external doses from uranium and thorium during the residual radiation period by using the data as described in Section 6.2 of this report.

7.3.2 Metals and Controls Corp. Occupational X-ray Examinations

Medical X-ray dose is not a covered occupational exposure during residual radiation periods for AWE Facilities (ORAUT-OTIB-0006; ORAUT-OTIB-0079). Therefore, NIOSH is not reconstructing occupational medical dose for Metals and Controls Corp. employees from January 1, 1968 through March 21, 1997.

7.3.3 Methods for Bounding Residual External Dose at Metals and Controls Corp.

NIOSH can use personal dosimetry data and methods available in Battelle-TBD-6000 to bound external doses.

External Dose Methodology for Production Employees

Film-badge data (Monitoring, Oct1965–Sep1974) from the end of the AWE Facility operations period (1967) was used to determine the 95th percentile penetrating dose. The data used was from the cumulative totals column of the Landauer dosimetry reports for "X" or "Gamma" exposure for the 162 monitored M&C employees. From this data, the 95th percentile value for the measured doses was determined to be 150 mrem/year.

Landauer documents their minimum quantity measurable, also referred to as limit of detection (LOD), for these exposures as 10 mrem/quarter (Monitoring, Oct1965–Sep1974, PDF p. 16). To account for missed doses, NIOSH will assume that the entire annual dose for each employee was delivered in the final quarter of 1967, and that the dose for the previous three quarters was below the LOD (10 mrem). NIOSH will then add in a missed dose component equivalent to the LOD/2 (5 mrem) for the other three previous quarters. This results in a missed dose component equivalent to 3 x LOD/2 (15 mrem). Adding this to the measured dose, results in a 95th percentile total dose (missed and measures) value of 165 mrem/year. A corroborating review of the quarterly film-badge data from a 5-quarter span in the 1970s (during the residual period) indicated that the mean dose rate for that population of workers was 48.3 mrem/quarter (Hopper, 1979, PDF p. 43). This would equate to an annual dose of approximately 193 mrem/year. Considering this and the 1967 data, NIOSH will apply a constant distribution of 200 mrem/year, with no source term depletion, for penetrating dose over the entire residual radiation period (January 1, 1968 through March 21, 1997).

The same film-badge data from the end of the AWE Facility operational period (Monitoring, Oct1965–Sep1974) was also used to determine a shallow dose. The data used was from the "Beta" column of the Landauer dosimetry reports for 1967. Of the 162 monitored M&C employees in 1967, 12 were monitored for beta radiation. From this data, a 95th percentile value of 112.5 mrem/year was calculated. To account for missed dose, NIOSH assumed that there were also three additional quarterly doses that were below LOD (40 mrem). This results in a missed dose component equivalent to 3 x LOD/2 (60 mrem). Adding this to the measured dose, results in a 95th percentile total shallow dose (missed and measures) value of 172.5 mrem/year. A corroborating review of the quarterly film-badge data from a 5-quarter span in the 1970s (during the residual period) indicated that the mean dose rate for that population of workers was 48.3 mrem/quarter (Hopper, 1979, PDF p. 43). This results in an annual dose of about 193 mrem/year. Considering this and the 1967 data, NIOSH will apply a constant distribution of 200 mrem/year, with no source term depletion, for shallow dose over the entire residual period (January 1, 1968 through March 21, 1997).

External Dose Bounding Methodology for Non-production or Administrative Employees

For unmonitored administrative, office, or non-production area employees, NIOSH will assume that their doses are 10% of the doses associated with the production workers described above (per guidance in Battelle-TBD-6000).

7.3.4 External Dose Reconstruction Feasibility Conclusion

NIOSH concludes that there are methods available in Battelle-TBD-6000, as well as available film-badge data and operational descriptions, so that external radiation doses can be reconstructed with sufficient accuracy for all Atomic Weapons Employees during the period under evaluation.

7.4 Evaluation of Petition Basis for SEC-00236

The following subsections evaluate the assertions made on behalf of petition SEC-00236 for Metals and Controls Corp.

7.4.1 Unmonitored Exposures

Issue: Employees with some job titles were not monitored for radiation exposure while working in certain areas of the site.

Response: NIOSH has researched and compiled available monitoring data (such as contamination surveys, air monitoring, and film-badge data) and has developed methods for bounding exposures for all covered M&C employees, as described in Section 7 of this report.

7.4.2 Thorium Exposures

Issue: D&D at the M&C site did not address the presence of thorium for the post-operational period.

Response: NIOSH has reviewed documents that indicate that samples were analyzed for the presence of thorium. Furthermore, NIOSH has developed methods for bounding thorium exposures for all covered M&C employees, as described in Section 7 of this report.

7.5 Other Potential SEC Petition Issues Identified During the Evaluation

During the SEC-00236 evaluation, some issues were identified that needed further analysis and resolution. The issues and their current status are identified in the subsections below.

7.5.1 Thorium Internal Monitoring Data

Issue: A previous evaluation performed in 2009 for SEC-00149 (NIOSH, 2009) determined that there was a lack of sufficient thorium internal monitoring or air sampling data to allow dose reconstruction.

Response: All of the contamination surveys used to create bounding methods (described in Section 7 of this report) were initially analyzed for gross alpha content. Therefore, NIOSH can choose the most claimant-favorable isotope of thorium or uranium when estimating worker doses.

7.5.2 D&D Activities

Issue: D&D activities at M&C were protracted and involved several contractors. An understanding of processes and D&D activities is necessary to determine the extent of potential radiation exposures.

Response: Based on its reviews of relevant records, NIOSH has outlined the D&D activities that took place at M&C during the residual radiation period. Based on this knowledge, NIOSH has determined

that D&D work was performed in the HFIR area or by contractors; therefore, the D&D work at M&C is not EEOICPA-covered work.

7.6 Summary of Feasibility Findings for Petition SEC-00236

This report evaluates the feasibility for completing dose reconstructions for employees at Metals and Controls Corp. from January 1, 1968 through March 21, 1997. NIOSH found that the available monitoring records, process descriptions, and source term data available are sufficient to complete dose reconstructions for the evaluated class of employees.

Table 7-3 summarizes the results of the feasibility findings at Metals and Controls Corp. for each exposure source during the period from January 1, 1968 through March 21, 1997.

Table 7-3: Summary of Feasibility Findings for SEC-00236
January 1, 1968 through March 21, 1997

Source of Exposure	Reconstruction-Feasible (Yes or No)
Internal[1]	**Yes**
Uranium	Yes
Thorium	Yes
External	**Yes**
Gamma	Yes
Beta	Yes
Neutron	N/A
Occupational Medical X-ray	N/A

[1] Internal includes an evaluation of airborne dust.

As of January 17, 2017, a total of 448 claims have been submitted to NIOSH for individuals who worked at Metals and Controls Corp. during the period under evaluation in this report. Dose reconstructions have been completed for 369 individuals (~82%). In addition, 314 claims have been submitted for energy employees who started their employment during the period under evaluation (January 1, 1968 through March 21, 1997).

8.0 Evaluation of Health Endangerment for Petition SEC-00236

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 employees 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.

NIOSH's evaluation determined that it is 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, a health endangerment determination is not required.

9.0 Class Conclusion for Petition SEC-00236

Based on its full research of the class under evaluation, NIOSH found no part of the class for which it cannot estimate radiation doses with sufficient-accuracy. This class includes all atomic weapons employees who worked as facilities construction and maintenance workers, including lubricators/oilers, industrial pipefitters, engineering technicians (mechanical, electrical, structural), maintenance supervisors, electricians, plumbers, millwrights, carpenters, instrumentation technicians, chemical handlers, waste treatment operators, and all production workers, including machine operators/helpers and repair & maintenance (commonly called R&M) workers, who worked in Buildings 4, 5, 10 interior areas, and Buildings 5, 10, 11, 12, 17 exterior areas at Metals and Controls Corp. in Attleboro, Massachusetts, from January 1, 1968 through March 21, 1997.

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 SRDB, for information relevant to SEC-00236. 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 radiation dose for the class under evaluation.

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TI, no date-b, *Report on Texas Instruments, Inc. (Metals and Controls Corporation)*, draft; Texas Instruments, Inc. (TI); date is not specified; SRDB Ref ID: 7092, PDF pp. 9–14

TI, 1960, *Fuels of the Future*; Texas Instruments Incorporated (TI); March 1960; SRDB 13634, PDF pp. 21–37

TI, 1973–82, *Correspondence and Amendments Related to SNM-23 License*; Texas Instruments (TI) and limited Nuclear Regulatory Commission (NRC) correspondence; various dates ranging from August 1973 through May 1982; SRDB Ref ID: 24654

TI, May1978, *Renewal Application for SNM-23*; Texas Instruments Incorporated (TI); May 5, 1978; SRDB Ref ID: 24653, PDF pp. 3–5

TI, Jul1978, *Decommissioning Plan for Inclusion in License SNM-23*; Texas Instruments Incorporated (TI); July 20, 1978; SRDB Ref ID: 24658, PDF pp. 5-12

TI, 1979, *Environmental Information Report for 1979 HFIR Facility License Renewal by NRC*, Rev. 0; Texas Instruments Incorporated (TI); February 15, 1979; SRDB Ref ID: 13633

TI, May1982, *Request for Termination of Nuclear Regulatory Commission License SNM-23*; Texas Instruments Incorporated (TI); May 17, 1982; SRDB Ref ID: 24651, PDF pp. 52–166

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TI, 1994, *Supplement to the 1992 Remediation Plan, Special Nuclear Material License No. 23, Docket No. 70-33*, Rev. 0.0, includes previously dated documents as attachments; Texas Instruments Incorporated (TI); December 1994; SRDB Ref ID: 114177

TI, 1995, *Response to NRC Letter Dated April 13, 1995 Requesting Additional Information Regarding the December 1994 Supplement to the 1992 Remediation Plan for the Attleboro Site*, correspondence to the NRC; Texas Instruments (TI); June 6, 1995; SRDB Ref ID: 114176

TI, 1997, *Risk-Based Criteria for Addressing Radium within Flooring in Building 1*; Texas Instruments, Inc. (TI); April 21, 1997; SRDB Ref ID: 26726

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Attachment One: Data Capture Synopsis

Table A1-1: Summary of Holdings in the SRDB for Metals and Controls Corp.

Data Capture Information	Data Capture Description	Date Completed	No. Uploaded into SRDB
Primary Site / Company Name: Metals and Controls Corp. AWE 1952–1967; Residual Radiation 1968–July 2006 Alternate Site Names: M & C M & C Nuclear Metals and Controls Nuclear Corp. Texas Instruments (Successor Company): [Name Redacted], Attorney, 03/04/2009 Sensata Technologies (Successor Company): [Name Redacted], General Counsel, 04/02/2007 Physical Size of the Site: The site comprises 18 buildings on 100 acres. Radioactive materials operations were conducted initially in Buildings 3 and 4, until Building 10 was constructed and radioactive material operations were consolidated there. Waste handling was conducted in and adjacent to Building 5. Radium work was conducted in Building 1. Site Population: In 1964, 650 employees were monitored for radiation exposure and 97 employees were not monitored.	Report of urinalysis, personnel monitoring surveys, contamination/radiation survey records of acid room #1, personnel external exposure report, personnel monitoring roster, film badge procedures, reactor fuel information, Atomic Energy Commission (AEC) and Nuclear Regulatory Commission (NRC) licenses, applications, and amendments, health and safety manual for the High Flux Isotope Reactor (HFIR) Project, environmental surveys, and reports.	09/18/2006	47
State Contacted: [Name Redacted], [Title Redacted], Massachusetts Radiation Control Program	No relevant documents identified.	01/23/2007	0
State Contacted: Massachusetts Department of Public Health	Licensing documents, site health and safety plan, site health physics plan, High Flux Isotope Reactor emergency plan, site safeguards plan, site inspections, and remediation reports.	04/23/2012	18
Brookhaven National Laboratory (BNL)	BNL reports which mention fuel orders placed with Metals and Controls.	02/18/2009	2
Dade Moeller & Associates	A film badge summary for 1956.	02/08/2006	1

Data Capture Information	Data Capture Description	Date Completed	No. Uploaded into SRDB
Department of Labor/Paragon	Request for thorium foil.	12/29/2008	1
DOE Germantown	AEC reports mentioning Metals and Controls, the hazards of the Shpack Landfill, and confirmation that DOE Oak Ridge Operations Records Holding Area has Metals and Controls records.	03/07/2011	3
DOE Legacy Management - Grand Junction Office	Clean-up of residual radioactive contamination information, survey of the Texas Instruments Inc. former burial site, contracts between AEC and Metals and Controls, early history information, license SNM-23 documents and inspection reports, requests for AEC to allocate U-235, uranium production figures for Texas Instruments, inspection reports, production figures, Shpack Landfill documents, material transfers, procedures, timeline of activities, Formerly Utilized Sites Remedial Action Program (FUSRAP) documents and surveys, and fuel development.	08/23/2011	204
DOE Legacy Management - Grand Junction Office/ Massachusetts Department of Public Health	Nuclear Regulatory Commission investigation of the Shpack Landfill.	10/04/2009	2
DOE Legacy Management - Grand Junction Office/NRC Public Document Room	Surveys and an environmental report.	10/01/2009	2
DOE Legacy Management - Morgantown	A 1954 notice of changes to accountability stations, an accountability statement, documentation of a Metals and Controls shipment of recycled uranium to Portsmouth, and the Shpack Landfill remedial action plan.	01/12/2016	4
DOE Legacy Management - MoundView (Fernald Holdings, includes Fernald Legal Database)	Fernald thorium metal production orders for Metals and Controls, thorium campaign data, and a spill at a truck terminal.	01/17/2008	11
DOE Legacy Management - MoundView/Albany Research Center	The 1958 symposium on occupational health experiences and practices in the uranium industry.	09/30/2003	1
DOE Oak Ridge Operations Records Holding Task Group (RHTG)	A supplement to an AEC 1952 Production Division monthly activity report.	04/05/2011	1
DOE Office of Scientific and Technical Information (OSTI)	A report including Metals and Controls fuel elements used in the ORNL High Flux Isotope Reactor and a report on electro deposited nickel coatings on thorium and uranium.	02/22/2013	2
Federal Records Center - Kansas City (Lenexa)	Exposure records and bioassay sample results.	03/06/2009	2
Federal Records Center - San Bruno	Sample Nuclear Materials Management and Safeguards System notes.	08/01/2012	1
Hagley Museum & Library	Mention of rolling at Metals and Controls, DuPont relations with laboratories, and uranium slug production.	09/29/2010	3

Data Capture Information	Data Capture Description	Date Completed	No. Uploaded into SRDB
Idaho National Laboratory	Record of a shipment to the Materials Test Reactor.	12/10/2014	1
Interlibrary Loan	Proceedings of a 1973 nuclear criticality safety short course.	11/30/2006	1
Internet - Defense Technical Information Center (DTIC)	A listing of metallurgical articles.	12/04/2011	1
Internet - DOE Comprehensive Epidemiologic Data Resource (CEDR)	No relevant documents identified.	03/26/2008	0
Internet - DOE Legacy Management Considered Sites	A FUSRAP stakeholder report and a FUSRAP site elimination report.	05/13/2014	2
Internet - DOE OpenNet	Hanford reports with references to Metals and Controls fuel work, reports to Congress, material balance reports, and a trip report.	09/19/2016	16
Internet - DOE OSTI Energy Citations	A fuel report and a 1980 nuclear accident dosimetry study.	05/07/2013	2
Internet - DOE OSTI Information Bridge	Site decommissioning management plan, fuels and materials reports, reactor project reports, and a nuclear waste incineration report.	03/29/2013	11
Internet - DOE OSTI SciTech Connect	A trip report, fuels and materials development reports, High Flux Isotope Reactor fuel reports, Pathfinder Atomic Power Plant reports, criticality safety, and a Massachusetts state low-level waste briefing book.	09/22/2014	22
Internet - Energy Employees Claimant Assistance Project (EECAP)	No relevant documents identified.	10/18/2016	0
Internet - Google	Removal of Metals and Controls from site decontamination management plan, radium buttons on toggle switches, Bureau of Mines metals yearbook, an NRC list of contaminated sites, effluents from fuel processing facilities, Advisory Board on Radiation and Worker Health (ABRWH) meeting minutes, High Flux Isotope Reactor fuel fabrication, decommissioning reports, and a brief company history.	12/05/2016	45
Internet - Hanford Declassified Document Retrieval System (DDRS)	Hanford monthly reports with references to Metals and Controls fuel work.	08/04/2015	13
Internet - Health Physics Journal	No relevant documents identified.	10/18/2016	0
Internet - Journal of Occupational and Environmental Hygiene	No relevant documents identified.	10/18/2016	0
Internet - National Academies Press (NAP)	No relevant documents identified.	09/21/2016	0
Internet - National Nuclear Security Administration (NNSA) - Nevada Site Office	No relevant documents identified.	10/18/2016	0

Data Capture Information	Data Capture Description	Date Completed	No. Uploaded into SRDB
Internet - National Service Center for Environmental Publications (NEPIS), US EPA	No relevant documents identified.	09/21/2016	0
Internet - NIOSH	Reports on residual contamination at atomic weapons employer sites and the petition evaluation report for SEC-00149 Metals and Controls Corp.	08/31/2011	4
Internet - Nuclear Regulatory Commission (NRC) ADAMS	Flat fuel element documentation, site decontamination management requirements, inspection reports, NRC responses to FOIAs, weekly information reports, decommissioning program status reports, license transfers to agreement states, fuel requirements, and the 1952 justification for entering a contract with Metals and Controls.	09/21/2016	48
Internet - Oak Ridge National Laboratory (ORNL)	ORNL reports mentioning Metals and Controls fuel development and isotope distribution.	02/21/2014	6
Internet - US Army Corps of Engineers (USACE)	No relevant documents identified.	09/21/2016	0
Internet - US Transuranium and Uranium Registries	No relevant documents identified.	09/21/2016	0
MJW Corporation	Proceedings of a short criticality safety course.	10/16/2003	1
National Archives and Records Administration - Atlanta	Excess uranium inventory at Metals and Controls.	03/20/2007	1
National Archives and Records Administration - Atlanta/SC&A	A mention of Metals and Controls doing research on SL-1 core fuel elements.	09/26/2003	1
National Archives and Records Administration - Chicago	Metals and Controls quotations for Argonne National Laboratory-West's ZPR-III reactor fuel.	06/12/2015	1
National Archives and Records Administration - College Park	A recommendation for Metals and Controls to roll thorium sheets.	03/13/2014	1
National Archives and Records Administration - Kansas City	A material transfer from Bridgeport Brass to Metals and Controls.	11/16/2004	1
National Institute for Occupational Safety and Health (NIOSH)	Reports of the Atomic Energy Commission, the 1956 report on radiation safety in atomic energy programs, a 1958 report on research in atomic energy programs, a site radiological survey, and the NIOSH review of Special Exposure Cohort class definitions.	08/27/2014	10
National Technical Information Service (NTIS)	Documentation that Metals and Controls fabricated uranium plate for Battelle.	07/11/2006	1

Data Capture Information	Data Capture Description	Date Completed	No. Uploaded into SRDB
Nuclear Regulatory Commission (NRC) - Public Document Room	The investigation of the Shpack Landfill, an NRC request for decommissioning and emergency plans, a chronology of timely license renewal actions, a trip report, license inspections, requests for uranium, environmental sample analyses, and a site radiological characterization.	11/03/2016	14
Oak Ridge National Laboratory (ORNL)	Fuels supplied by Metals and Controls and material accountability and transfer reports.	03/20/2014	26
ORAU Team	Project spreadsheet, data completion verification, documented communications, a data capture trip report, and several revisions of ORAUT-OTIB-0004 "Estimating the Maximum Plausible Dose to Workers at Atomic Weapons Employer Facilities".	10/08/2008	9
S. Cohen & Associates (SC&A)	Hematite licensing documents mentioning Metals and Controls fuel fabrication.	04/07/2011	3
SC&A / INL	Mention of Metals and Controls as a potential source for Materials Test Reactor fuel.	06/24/2010	1
Savannah River Site (SRS)	A Hagley Museum finding aid, an SRS keyword search, and 300 Area radiation survey sheets.	07/31/2009	4
Science Applications International Corp (SAIC)	The 1964 external exposure summary.	09/02/2004	1
Southern Illinois University	An excerpt from the 1964 Minerals Yearbook identifying Metals and Controls as a thorium processor.	10/29/2008	1
Texas Instruments	Exposure reports, urinalysis reports, contamination/radiation surveys, and Texas Instruments response to a claimant specific dosimetry request.	07/14/2009	44
University of Rochester Radiation Safety Office	Material accountability reports	08/20/2008	2
Unknown	Airborne radioactivity survey, site history, surveys, material transfers with Fernald, thorium reports, AEC reports to Congress, FUSRAP documents, and Shpack Landfill investigations.	02/24/2005	17
US Army Corps of Engineers (USACE) Buffalo District Office	USA Today listing of Metals and Controls as a uranium processing facility.	06/24/2010	1
Westinghouse (Hematite, Missouri)	The shipping route from Hematite to Metals and Controls.	03/13/2009	1
TOTAL	Not Applicable	Not Applicable	**618**

Table A1-2: Database Searches for Metals and Controls Corp.

Database/Source	Keywords	No. of Hits	No. Uploaded into SRDB
Defense Technical Information Center (DTIC) COMPLETED 10/18/2016	Database search terms and Internet URL are available in the Excel file called Metals and Controls Rev 01, (83.13) 01-06-17.	8,639	0
DOE Comprehensive Epidemiologic Data Resource (CEDR) COMPLETED 03/26/2008	Database search terms and Internet URL are available in the Excel file called Metals and Controls Rev 01, (83.13) 01-06-17.	0	0
DOE Hanford Declassified Document Retrieval System (DDRS) COMPLETED 09/20/2016	Database search terms and Internet URL are available in the Excel file called Metals and Controls Rev 01, (83.13) 01-06-17.	0	0
DOE Legacy Management Considered Sites COMPLETED 09/21/2016	Database search terms and Internet URL are available in the Excel file called Metals and Controls Rev 01, (83.13) 01-06-17.	1	0
DOE NNSA - Nevada Site Office COMPLETED 10/18/2016	Database search terms and Internet URL are available in the Excel file called Metals and Controls Rev 01, (83.13) 01-06-17.	0	0
DOE OpenNet COMPLETED 09/20/2016	Database search terms and Internet URL are available in the Excel file called Metals and Controls Rev 01, (83.13) 01-06-17.	270	12
DOE OSTI Energy Citations COMPLETED 03/28/2008	Database search terms and Internet URL are available in the Excel file called Metals and Controls Rev 01, (83.13) 01-06-17.	97	0
DOE OSTI Information Bridge COMPLETED 03/27/2008	Database search terms and Internet URL are available in the Excel file called Metals and Controls Rev 01, (83.13) 01-06-17.	640	1
DOE OSTI SciTech Connect COMPLETED 09/19/2016	Database search terms and Internet URL are available in the Excel file called Metals and Controls Rev 01, (83.13) 01-06-17.	2,209	0
Energy Employees Claimant Assistance Project (EECAP) COMPLETED 10/18/2016	Database search terms and Internet URL are available in the Excel file called Metals and Controls Rev 01, (83.13) 01-06-17.	8	0
Google COMPLETED: 10/17/2016	Database search terms and Internet URL are available in the Excel file called Metals and Controls Rev 01, (83.13) 01-06-17.	9,632,586	8
Health Physics Journal COMPLETED 10/18/2016	Database search terms and Internet URL are available in the Excel file called Metals and Controls Rev 01, (83.13) 01-06-17.	0	0

Database/Source	Keywords	No. of Hits	No. Uploaded into SRDB
Journal of Occupational and Environmental Health COMPLETED 10/18/2016	Database search terms and Internet URL are available in the Excel file called Metals and Controls Rev 01, (83.13) 01-06-17.	0	0
National Academies Press COMPLETED 09/21/2016	Database search terms and Internet URL are available in the Excel file called Metals and Controls Rev 01, (83.13) 01-06-17.	7,276	0
National Service Center for Environmental Publications (NEPIS) COMPLETED 09/21/2016	Database search terms and Internet URL are available in the Excel file called Metals and Controls Rev 01, (83.13) 01-06-17.	326	0
NRC ADAMS Reading Room COMPLETED 09/21/2016	Database search terms and Internet URL are available in the Excel file called Metals and Controls Rev 01, (83.13) 01-06-17.	752	15
United States Army Corps of Engineers (USACE) COMPLETED 09/21/2016	Database search terms and Internet URL are available in the Excel file called Metals and Controls Rev 01, (83.13) 01-06-17.	0	0
U.S. Transuranium & Uranium Registries COMPLETED 09/21/2016	Database search terms and Internet URL are available in the Excel file called Metals and Controls Rev 01, (83.13) 01-06-17.	0	0