# SEC Petition Evaluation Report
## Petition SEC-00198

Report Rev.#: 0 Report Submittal Date: June 21, 2012

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| Subject Expert(s): | Jason Davis |
| Site Expert(s): | N/A |

**Petition Administrative Summary**

**Petition Under Evaluation**

| Petition # | Petition Type | Petition Receipt Date | Qualification Date | DOE/AWE Facility Name |
|---|---|---|---|---|
| SEC-00198 | 83.13 | December 5, 2011 | January 20, 2012 | Ventron Corporation |

**Petitioner-Requested Class Definition**

All metallurgical operators and electric furnace operators who worked at Ventron Corporation in Beverly, Massachusetts, from January 1, 1942 to December 31, 1948.

**Class Evaluated by NIOSH**

All Atomic Weapons Employees who worked at the Ventron Corporation site in Beverly, Massachusetts, from August 13, 1942 through December 31, 1948.

**NIOSH-Proposed Class(es) to be Added to the SEC**

All Atomic Weapons Employees who worked in all buildings owned by the Ventron Corporation in Beverly, Massachusetts, from November 1, 1942 through December 31, 1948, for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more classes of employees included in the Special Exposure Cohort.

**Related Petition Summary Information**

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

**Related Evaluation Report Information**

| Report Title | DOE/AWE Facility Name |
|---|---|
| N/A | N/A |

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| **ORAU Lead Technical Evaluator:** Jason Davis | **ORAU Peer Review Completed By:** Michael Kubiak |

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| **Peer Review Completed By:** | [Signature on File]<br>*Samuel Glover* | 6/19/2012<br>*Date* |
| **SEC Petition Evaluation Reviewed By:** | [Signature on File]<br>*J. W. Neton* | 6/19/2012<br>*Date* |
| **SEC Evaluation Approved By:** | [Signature on File]<br>*Stuart L. Hinnefeld* | 6/21/2012<br>*Date* |

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# Evaluation Report Summary: SEC-00198, Ventron Corporation

This evaluation report by the National Institute for Occupational Safety and Health (NIOSH) addresses a class of employees proposed for addition to the Special Exposure Cohort (SEC) per the *Energy Employees Occupational Illness Compensation Program Act of 2000*, as amended, 42 U.S.C. § 7384 *et seq.* (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*.

Petitioner-Requested Class Definition

Petition SEC-00198 was received on December 5, 2011, and qualified on January 20, 2012. The petitioner requested that NIOSH consider the following class: *All metallurgical operators and electric furnace operators who worked at Ventron Corporation in Beverly, Massachusetts, from January 1, 1942 to December 31, 1948.*

Class Evaluated by NIOSH

Based on its preliminary research, NIOSH modified the petitioner-requested class. In the interest of conducting a comprehensive analysis, the categories of workers under evaluation were expanded to include all workers. To conform to EEOICPA rules, the class period start date was changed to August 13, 1942, the official start date of the Manhattan Engineer District (MED). EEOICPA evaluations only cover time periods beginning on or after the MED start date. As a result of these two modifications, NIOSH evaluated the following revised class: All Atomic Weapons Employees who worked at the Ventron Corporation site in Beverly, Massachusetts, from August 13, 1942 through December 31, 1948 (See Section 3.0).

NIOSH-Proposed Class(es) to be Added to the SEC

Based on its full research of the class under evaluation, NIOSH has defined a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. The NIOSH-proposed class includes all Atomic Weapons Employees who worked in all buildings owned by the Ventron Corporation in Beverly, Massachusetts, from November 1, 1942 through December 31, 1948 for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more classes of employees included in the Special Exposure Cohort. The start date for the NIOSH-proposed class was changed to November 1, 1942 because NIOSH obtained documentation showing that the MED took over cognizance of weapons-related metal production at the site on that date. The inclusion of all workers in the class under evaluation was accepted because NIOSH found indications that an observed lack of available personnel and area monitoring data was not limited to Metallurgical Operators and Electric Furnace Operators working in the Foundry (See Section 3.0).

Feasibility of Dose Reconstruction

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

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

- Principal sources of internal radiation for members of the proposed class included exposures to uranium contained in uranium oxides, uranium metal powder, uranium tetrafluoride, scrap uranium metal, thorium, and uranium progeny from ore-handling operations. The modes of exposure were inhalation and ingestion of uranium and its progeny during uranium metal fabrication and scrap recovery operations, including spontaneous uranium fires, as well as inhalation of thorium dusts.

- NIOSH has not located documentation giving any indication of a routine internal personnel exposure monitoring program for the period under evaluation. The very limited internal monitoring and air sample data available to NIOSH are sparse and there is no evidence to indicate these data are representative of the most highly-exposed workers at the Ventron facility, or to indicate that the available sample results are representative of all workers. Without additional personnel radiation monitoring data representing the period from 1942 through 1948, NIOSH has insufficient information to appropriately characterize radioactive material intakes during Ventron operations.

- Principal sources of external radiation for members of the proposed class included exposures to uranium during metal-handling operations, uranium progeny derived from naturally-occurring ores exhibiting a natural isotopic abundance, as well as thorium during commercial production of thoriated tungsten.

- NIOSH has not located any indication of external personnel exposure monitoring for the period under evaluation. NIOSH's research indicates personnel monitoring for external exposure to radiological materials was not performed. No records of any program for personnel external dose monitoring, or data that would be associated with such a program have been located.

- NIOSH does not have access to sufficient personnel monitoring, workplace monitoring, or source term data to estimate unmonitored internal exposures for Ventron workers during the periods of refining and smelting operations from November 1, 1942 through December 31, 1948.

- NIOSH has determined that adequate reconstruction of medical dose is feasible by using claimant-favorable assumptions and the technical information bulletin Dose Reconstruction from Occupational Medical X-Ray Procedures (ORAUT-OTIB-0006).

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

- Although NIOSH found that it is not possible to completely reconstruct radiation doses for the proposed class, NIOSH intends to use any internal and external monitoring data that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures). Therefore, dose reconstructions for individuals employed at Ventron Corporation during the period from November 1, 1942 through December 31, 1948, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

Health Endangerment Determination

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

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

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# SEC Petition Evaluation Report for SEC-00198

*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: Jason Davis, Oak Ridge Associated Universities. 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 doses for all Atomic Weapons Employees who worked at the Ventron Corporation site in Beverly, Massachusetts, from August 13, 1942 through December 31, 1948. 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 (HHS) 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 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 not 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

[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 at http://www.cdc.gov/niosh/ocas.

NIOSH to assume that any duration of unprotected exposure may have endangered the health of members of a class when it has been established that the class may have been exposed to radiation during a discrete incident likely to have involved levels of exposure similarly high to those occurring during nuclear criticality incidents. If the occurrence of such an exceptionally high-level exposure has not been established, then NIOSH is required to specify that health was endangered for those workers who were employed for 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 (Board). The Board will consider the NIOSH evaluation report, together with the petition, petitioner(s) comments, and other information the Board considers appropriate, in order to make recommendations to the Secretary of HHS 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 Board, the Director of NIOSH will propose a decision on behalf of HHS. The Secretary of HHS will make the final decision, taking into account the NIOSH evaluation, the advice of the 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 HHS.[3]

# 3.0 SEC-00198, Ventron Corporation Class Definitions

The following subsections address the evolution of the class definition for SEC-00198, Ventron Corporation. 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

Petition SEC-00198 was received on December 5, 2011, and qualified on January 20, 2012. The petitioner requested that NIOSH consider the following class: *All metallurgical operators and electric furnace operators who worked at Ventron Corporation in Beverly, Massachusetts, from January 1, 1942 to December 31, 1948.*

The petitioner provided information and affidavit statements in support of the petitioner's belief that accurate dose reconstruction over time is impossible for the Ventron workers in question. NIOSH deemed the following information and affidavit statements sufficient to qualify SEC-00198 for evaluation:

[3] See 42 C.F.R. pt. 83 for a full description of the procedures summarized here. Additional internal procedures are available at http://www.cdc.gov/niosh/ocas.

In support of the claim, the SEC-00198 petitioner asserted that radiation exposures and radiation doses potentially incurred by members of the proposed class were not monitored, either through personal monitoring or through area monitoring. In the original petition, the petitioner provided the following statements:

- *To the best of my knowledge, there was no monitoring at Ventron Corp.*
- *To the best of my knowledge there was no internal monitoring at Ventron Corporation.*
- *To the best of my knowledge there was no internal monitoring at Ventron Corporation and no records could be found.*

Based on its Ventron Corporation research and data capture efforts, NIOSH determined that it has access to limited process information, air sampling, area surveys, and internal dosimetry data for Ventron workers during the time period under evaluation. However, NIOSH also determined that internal and external monitoring, as well as air sampling and area survey records are not complete for all time periods or for all radionuclides. NIOSH concluded that there is sufficient documentation to support, for at least part of the requested time period, the petition basis that both internal and external radiation exposures and radiation doses were not adequately monitored at Ventron, either through personal monitoring or area monitoring. The information and statements provided by the petitioner qualified the petition for further consideration by NIOSH, the Board, and HHS. The details of the petition basis are addressed in Section 7.4.

## 3.2 Class Evaluated by NIOSH

Based on its preliminary research, NIOSH modified the petitioner-requested class. In the interest of conducting a comprehensive analysis, the categories of workers under evaluation were expanded to include all workers. To conform to EEOICPA rules, the class period start date was changed to August 13, 1942, the official start date of the Manhattan Engineer District (MED). EEOICPA evaluations only cover time periods beginning on or after the MED start date. As a result of these two modifications, NIOSH evaluated the following revised class: All Atomic Weapons Employees who worked at the Ventron Corporation site in Beverly, Massachusetts, from August 13, 1942 through December 31, 1948.

## 3.3 NIOSH-Proposed Class(es) to be Added to the SEC

Based on its research of the class under evaluation, NIOSH has defined a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. The NIOSH-proposed class to be added to the SEC includes all Atomic Weapons Employees who worked in all buildings owned by the Ventron Corporation in Beverly, Massachusetts, from November 1, 1942 through December 31, 1948 for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more classes of employees included in the Special Exposure Cohort. The start date for the NIOSH-proposed class was changed to November 1, 1942 because NIOSH obtained documentation showing that the MED took over cognizance of weapons-related metal production at the site on that date (Authority Review, 1985, pdf pp. 3-7). The inclusion of all workers in the class under evaluation was accepted because NIOSH found indications that an observed lack of available personnel and area monitoring data was not limited to Metallurgical Operators and Electric Furnace Operators working in the Foundry.

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

In addition to the database and Internet searches listed above, NIOSH identified and reviewed numerous data sources to determine information relevant to determining the feasibility of dose reconstruction for the class of employees under evaluation. This included determining the availability of information on personal monitoring, area monitoring, industrial processes, and radiation source materials. 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 at the specified site. Dose reconstructors can use the Site Profile to evaluate internal and external dosimetry data for monitored and unmonitored workers, 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 TBDs for insights into Ventron operations or related topics/operations at other sites:

- *Site Profiles for Atomic Weapons Employers that Worked Uranium and Thorium Metals,* Battelle-TBD-6000; Rev. 1; June 17, 2011; SRDB Ref ID: 30671

## 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:

- *Estimation of Ingestion Intakes*, OCAS-TIB-009, Rev. 0, NIOSH Office of Compensation Analysis and Support; April 13, 2004; SRDB Ref ID: 22397

- *Dose Reconstruction from Occupational Medical X-Ray Procedures*, ORAUT-OTIB-0006, Rev. 4; Oak Ridge Associated Universities; June 20, 2011; SRDB Ref ID: 98147

- *Guidance on Assigning Occupational X-Ray Dose Under EEOICPA for X-rays Administered Off Site*, ORAUT-OTIB-0079, Rev. 00; Oak Ridge Associated Universities; January 3, 2011; SRDB Ref ID: 89563

## 4.3 Facility Employees and Experts

To obtain additional information, NIOSH attempted to locate and interview former Ventron employees who worked during the 1942 through 1948 timeframe. No living employees meeting this criterion could be located.

## 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 June 4, 2012).

**Table 4-1: No. of Ventron Claims Submitted Under the Dose Reconstruction Rule**

| Description | Totals |
|---|---|
| Total number of claims submitted for dose reconstruction | 19 |
| Total number of claims submitted for energy employees who worked during the period under evaluation (August 13, 1942 through December 31, 1948). | 9 |
| 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). | 9 |
| Number of claims for which internal dosimetry records were obtained for the identified years in the evaluated class definition | 0 |
| Number of claims for which external dosimetry records were obtained for the identified years in the evaluated class definition | 0 |

NIOSH reviewed each claim to determine whether internal and/or external personal monitoring records could be obtained for the employee. As noted in Table 4-1, NIOSH has not received external or internal monitoring data from Ventron Corporation for any claimants.

## 4.5 NIOSH Site Research Database

NIOSH also examined its Site Research Database (SRDB) to locate documents supporting the assessment of the evaluated class. Three-hundred and eighty three (383) documents in this database were identified as pertaining to Ventron. These documents were evaluated for their relevance to this petition. The documents include historical background on facility operations and medical surveillance as well as limited results of air and surface contamination sampling.

## 4.6 Documentation and/or Affidavits Provided by Petitioners

In qualifying and evaluating the petition, NIOSH reviewed the following document submitted by the petitioners:

- *Affidavit from [Survivor name redacted]*; December 5, 2011; DSA Ref ID: 115418

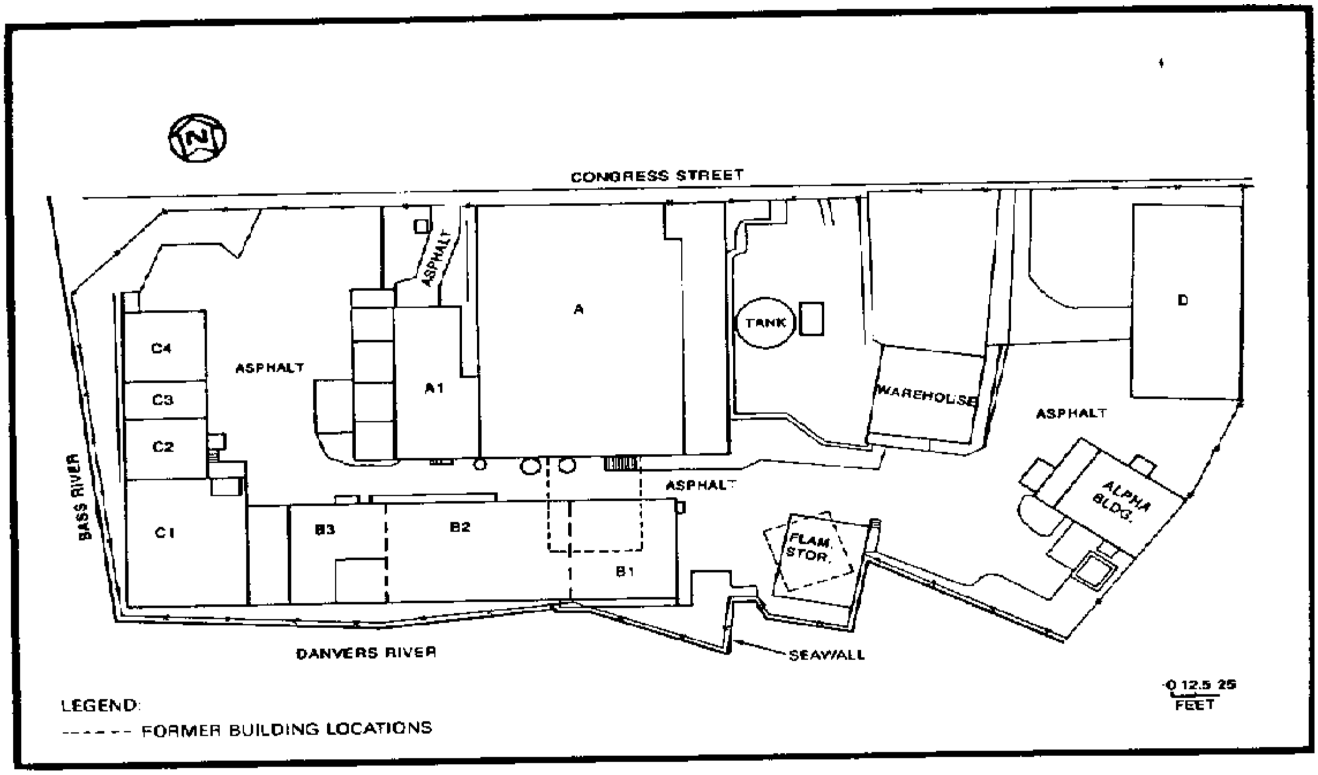
# 5.0 Radiological Operations Relevant to the Class Evaluated by NIOSH

The following subsections summarize both radiological operations at the Ventron Corporation site from August 13, 1942 through December 1948 and the information available to NIOSH to characterize particular processes and radioactive source materials. From available sources NIOSH has gathered process and source descriptions, information regarding the identity of each radionuclide of concern, and information describing processes through which radiation exposures may have occurred and the physical environment in which they may have occurred. The information included within this evaluation report is intended only to be a summary of the available information.

## 5.1 Ventron Corporation Plant and Process Descriptions

Plant History and Description

The Ventron Corporation site is located in Beverly, Massachusetts. The site occupies three acres on Massachusetts Bay at the confluence of the Bass and Danvers rivers. The property is bordered by Congress Street on the north, the Boston and Maine Railroad on the east, the Bass River on the west, and the Danvers River on the south. A seawall composed primarily of granite boulders surrounds the property along the Danvers and Bass River boundaries. The western and southern boundaries of the property extend beyond the seawall to the low tide mark of the adjacent harbor. Figure 5-1 shows the buildings on the Ventron site.




Source: Noey, 1987

**Figure 5-1: Buildings on the Ventron Corporation Site**

Metal Hydrides, Inc. (predecessor of the Ventron Corporation), was incorporated on June 16, 1933, and began research and development operations to develop the process of reducing uranium oxide to metal using calcium hydride in space rented from General Electric, Thomson Research Laboratory, Lynn, Massachusetts. In 1965, Metal Hydrides Corporation became the Ventron Corporation. In 1976, the Ventron Corporation was acquired by the Thiokol Corporation, which became a division of Morton Thiokol, Inc., in 1980, and was subsequently renamed Morton International in 1990. In 1994, Morton production activity at the Ventron site ceased.

Although NIOSH does not have access to a concise employee roster for the time period under evaluation, workforce data can be distilled from personnel medical records and chest radiographs compiled during that time. NIOSH has access to employee medical records files for 254 individuals (Monitoring Results, 1942-1947; Monitoring Results, 1942-1945; Monitoring Results, 1943-1945). These records span 1942-1947 and contain worker names and job descriptions. In most cases, hire and termination dates are also recorded. A log of pre-employment and follow-up chest X-rays performed between November 1942 and November 1943 suggests that the workforce was around 107 individuals for that one-year span (Monitoring Results, 1943-1945, pdf p. 1430). NIOSH believes this presents a reasonable estimate of the workforce during this time period because the MED requirement for all workers at Metal Hydrides to have a pre-employment chest X-ray was communicated in May 1943 along with direction that any individuals who had not received a chest X-ray prior to that time should receive one at the earliest possible date (Friedell, 1943). The scrap re-casting operations were observed to have employed 16 individuals in 1947 (Randall, 1947).

Metal Hydrides is one of only two companies known to have produced developmental (gram) quantities of uranium metal under two contracts for the National Bureau of Standards. Some of these gram quantities of metal were provided to Columbia University which later, in an OSRD subcontract dated December 31, 1941, agreed to supply Metal Hydrides with five furnaces at the Beverly, Massachusetts location in return for metal produced. In total, approximately two pounds of material were produced under these contracts (Adams, 1994). On April 20, 1942, OSRD contracted directly with Metal Hydrides to install government-owned equipment and to begin large-scale production of uranium metal (Authority Review, 1985, pdf p. 211). Under this contract (OEMsr-333), 7,460 pounds of uranium metal were produced.

The MED was officially established on August 13, 1942 and on November 1, 1942, the MED took over cognizance of OSRD metal production at Metal Hydrides with a direct contract W-7405-Eng-8 (Authority Review, 1985, pdf pp. 3-7). From 1942 to 1948, the Metal Hydrides Corporation conducted uranium-processing operations under contract to the MED and its successor agency, the Atomic Energy Commission (AEC). MED/AEC contract operations at the Ventron site involved conversion of uranium oxide to uranium metal powder using calcium hydride (Ventron, 1979). In a process used later at the facility, uranium oxide was reacted with hydrogen fluoride to produce uranium tetrafluoride, which was mixed with magnesium and heated to produce uranium metal (Cottrell, 1988). Other operations at the site from 1943 to December 31, 1947 included recovery of uranium from scrap and turnings resulting from operations at a fuel fabrication plant in Hanford, Washington. MED/AEC contract work at Ventron involved only natural uranium; no depleted or enriched uranium was processed.

The contract was modified and extended to June 1947 with 19 supplemental agreements. Supplemental Agreement No. 3 did not extend metal production past August 31, 1943. The company maintained the metal production portion of the plant on standby and focused its efforts on recasting scrap uranium metal.

The MED sampled the uranium content of the Metal Hydrides facility grounds in 1943 and found that it contained 0.1 percent to 79 percent uranium oxide. A January 1, 1944 accountability report indicates that the MED advised Metal Hydrides management on environmental matters and maintained its rights to the uranium-contaminated soil on the Metal Hydrides property. Most of this soil (120,000 pounds) was removed from the yard after the company signed a release on portions of the contract dealing with metal production (Cottrell, 1988). This material was subsequently shipped to DuPont Chemical Company Recovery Plant for recovery of the uranium (Adams, 1994).

In addition, a 1946 memo indicates that Ventron had been manufacturing thorium powder at the rate of pounds per month for use in thoriated tungsten filaments for radio tubes produced by Sylvania, Raytheon, and RCA (Morse, 1946).

A lump-sum research and development contract (AT-30-1-GEN-143) to produce a controllable source of neutrons for the AEC was awarded to the company on June 1, 1947. The contract was limited to 100 pounds of high-grade pitchblende ore (Authority Review, 1985, pdf p. 6). Other documentation indicates that an AEC contract to produce 2,000 pounds of uranium powder was put into place as late as 1948 (Authority Review, 1985, pdf p. 6). This contract would have been to produce metal powder using brown oxide and calcium hydride similar to other earlier contracts (Hayden, 1948).

During MED/AEC operations, three buildings were used for uranium work. Building A was used for uranium-processing activities and contains one main floor and a basement. On the first floor, there were offices and laboratories on the east side of the building, and shipping and receiving areas in the northwest quadrant. Crushing, leaching, and retorting processes were carried out in Room 20 of Building A (Cottrell, 1988).

Building A-1 was an addition to Building A and contained facilities for the production of distilled calcium (Room 6) and the drying of uranium oxide powder (Room 4), a machine shop, and electric furnaces and kilns. Two wooden buildings just south of Building A contained the machine shop and foundry. These buildings were demolished sometime between 1948 and 1950 (Ventron, 1979).

Buildings C-1, C-2, C-3, and C-4 were built in 1945 and consist of analytical laboratories. Buildings B-1, B-2, and B-3 were built in 1950, partially on top of the footprint of the former machine shop. Building D, built in 1967, was used for research and development of biocides. The Alfa Building, built in 1953, was used for thorium crystal-growing and other research-related activities. None of these facilities were used for MED/AEC processing of uranium (Cottrell, 1988).

Following the MED/AEC activities, the site was decontaminated to clean-up standards applicable for that time. The AEC conducted a radiation survey in 1947, after which the Medical Division recommended the following procedures for site clean-up (Ventron, 1982):

1. *Have Metal Hydride employees do the dismantling and cleanup in order to avoid possible difficulties arising from contractor's men working with active materials.*

2. *Divide the material into four groups.*

   a. *Send the metal and equipment desired by the Vitro Manufacturing Company to them with a clear understanding that it is contaminated and that they will accept responsibility for it as such.*

   b. *Allow Metal Hydrides to accept contaminated apparatus which has been cleaned as well as possible, on their responsibility, for use in other AEC work.*

   c. *Valuable but contaminated equipment which cannot be cleaned and is not wanted by Metal Hydrides or Vitro be accepted by the AEC for storage until a demand arises where the contamination is not a controlling factor.*

   d. *Scrap materials should be kept from the public. The pipes, ducts, conduit, concrete blocks, etc. should be piled on the bank of the bay until it is all accumulated, then taken by barge to a chosen spot in the ocean about 12 miles from shore and dumped. Scrap material which will not sink should be burned in an isolated spot, the ashes placed in a container and dumped with the other material.*

3. *The area should be vacuum cleaned, hosed down, and scrubbed with a detergent.*

4. *Another survey at the completion of this work should determine any other steps to be taken toward decontamination of the area.*

A second survey was completed in early 1948 after the contaminated equipment had been removed; the levels inside the main building (metal plant) were lower than the earlier survey (Ventron, 1982).

It was initially believed that all AEC work was terminated in 1948; however, documentation suggests that AEC contracts were ongoing into 1954. These contracts included a research contract to work with fissionable material that was to terminate in June 1954, and a lump-sum production contract (AT-(30-1)-1350) to terminate in July 1954 (Authority Review, 1985; Banus, 1953; Hayden, 1948). No records pertaining to close-out of these contracts have been found to date (Ventron, 1982). A 1953 report of research issuances of special material suggests that, in addition to uranium metal and uranium oxides, thorium metal and thorium tetrafluoride were in the Ventron inventory during this time period (Alexander, 1953).

Radiological surveys of the land and buildings were conducted by Oak Ridge National Laboratory (ORNL) in 1977 and 1980-82. In 1986, the Ventron site was designated for inclusion in the Formerly Utilized Sites Remedial Action Program (FUSRAP). Additional radiological surveys of the site were performed by ORNL in 1987-88, and in 1991 surveys were performed of properties in the vicinity of the site to determine if radiological contamination from plant operations had migrated off site. Further characterization of radiological and chemical conditions at the site was performed by Bechtel National, Incorporated (BNI) for DOE in 1992. In 1996, DOE and Morton International finalized a Memorandum of Agreement (MOA) regarding the allocation of clean-up responsibilities between the parties at the site. DOE radiological decontamination of the site concluded in 1997 (Certification, 2003; Post-Remedial Report, 2003).

“Hydramet” Process Description

Metal Hydrides’ hydride or “hydramet” process used calcium hydride, $CaH_2$, as the reducing agent for the ore-to-metal conversion. The raw material for the process was uranium ore. In contrast, the Ames Laboratory process in use during the same time period relied on the reduction of uranium tetrafluoride by the addition of granulated calcium metal (Ames, 1947). In 1940-41, the uranium ore uranitite was supplied by the Canadian Radium and Uranium Corporation of New York. Their source was a mine owned by Eldorado Gold Mines, Ltd., located on the shores of Great Bear Lake in the Canadian Northwest Territories. Some five hundred pounds of metal was produced using the raw black oxide (Alexander, post-1942). However, because the raw black ore was a mixture of $UO_2$ and $UO_3$ along with other metal and metallic-oxide impurities, the resulting uranium was of insufficient purity to sustain a successful fission chain reaction. The neutron-absorbing impurities had to be removed before pure uranium production could begin (Adams, 1994).

The ore was sent to the Mallinckrodt Chemical Company in St. Louis where the uranium ore was purified and chemically converted to the “brown oxide” $UO_2$. During 1942, the brown oxide was delivered by truck to the Beverly plant and subjected to the hydramet process. The oxide was mixed with calcium hydride in a grinder with an exhaust vent that evacuated to the outside of the building by a three-horsepower fan (Hayden, 1948). This mixture was then heated in an evacuated steel alloy retort at 960º C in an oil-fired furnace for 6-7 hours (Adams, 1994).

The product mixture was then chipped into pieces using an air hammer under a hood of unknown efficiency (Hayden, 1948) and dumped into a leaching tank containing distilled water and acetic acid to neutralize the CaO, thus bringing it into the aqueous solution. After filtering the pure uranium powder on a rack filter, it was manually scraped onto stainless steel trays to dry. Initially, the trays were placed in the open air to dry. However, due to recurring uranium fires, the process was modified so that drying occurred in an inert argon atmosphere. The purified uranium powder was then placed in one-quart metal containers, each holding six pounds of metal in argon (Adams, 1994).

The containers would then be transported to MIT in nearby Cambridge, where the powder was compressed into lumps one-inch square by ½ to ¾ inches thick. These lumps would be returned to Metal Hydrides where they were sintered into bricks at approximately 1500 º C before being sent to the University of Chicago for use in CP-1 (Adams, 1994).

At the University of Iowa in August 1942, Dr. Frank Spedding used calcium produced at Metal Hydrides to reduce $UF_4$ to pure uranium metal. The reaction heat was sufficient to melt both products, with the more dense uranium settling to the bottom of the reaction vessel and solidifying upon cooling. Because the Iowa process was rapid and yielded uranium metal in solid ingot form, it was used to supply the pure metal for the remainder of the Manhattan Project. In July 1943, Metal Hydrides was notified to stop production of uranium metal powders by September 1. The company was asked to keep the foundry operational to recast scrap metal and to leave the remaining equipment in standby condition (Ruhoff, 1943). Metal Hydrides shifted operations from production of uranium powder to recasting up to 500-1000 pounds of the pure metal per day into solid cylindrical ingots.

During the time period of metal production, Ventron weekly reports indicate that a maximum weekly average of 350 lbs. of cast metal was produced per day (Weekly Reports, 1942-1946). Weekly reports also track the stocks of ore on-hand during the December 1942 through September 1943 time period (Production Reports, 1942-1943).

Scrap Casting Process Description

Beginning in the summer of 1943, Metal Hydrides received shipments of the "heels" (unusable end portions) remaining from the fabrication of uranium slugs (one-inch by four-inch cylinders of uranium in aluminum cans used for reactor fuel) from both the Hanford, Washington and Oak Ridge, Tennessee laboratories. Metal Hydrides also received shavings from the Iowa process that were melted and recast (Adams, 1994). Scrap uranium metal was received at the plant in wooden boxes that were stored in the machine shop until ready for use. Pieces of scrap were hand-weighed and divided into charges of 150-175 pounds. Each charge was hand-carried to the recasting furnaces (Roboff, 1945).

The casting furnace fundamentally consisted of two parts: a graphite crucible to hold the crude metal, and a graphite mold to form the billet from the molten metal. The crude materiel was placed in the crucible that fit over the mold. The entire system was insulated and completely surrounded by a quartz shield that was sealed to permit evacuation of the system within it. The crucible mold and other parts of the system were completely evacuated before heating the metal. The actual heating was produced by a high-frequency coil surrounding the quartz shield. The crude uranium metal in the crucible was heated to a temperature of approximately l,250 C after which a stopper rod at the bottom of the crucible was removed, permitting the molten metal to flow into the mold. After pouring, the mold was cooled to such a temperature that the billet could be removed safely. The billet was then cropped to remove the porous section at the top which usually contained a high percentage of oxide and impurities (Gates, 1946, pdf p. 69).

The resulting billet was again manually weighed before workers removed an egg, a laboratory sample, and cropped the billet to the appropriate size by use of a power saw. Any scraps or sawdust resulting from these cutting operations were added to the scrap charges for re-melting, while any oxides that formed during casting were collected and sent to the Hanford Recovery Plant (Roboff, 1945). After cropping and packing, the billets were shipped to the DuPont Chemical Company in Hanford and Oak Ridge for further treatment and processing (Adams, 1994). This work continued until December 31, 1947 when Contract W-7405 ENG 8 expired (Ventron, 1979). During the scrap re-casting years, 3,000 – 3,200 lbs of metal were handled per day (Randall, 1947). It is unclear how much material was stored on site during this time period.

## 5.2 Radiological Exposure Sources from Ventron Operations

MED-related activities at the Ventron site conducted between November 1, 1942 and 1947 were limited to the use of uranium. Morton was licensed to handle uranium ore before and after the MED-related activities, which allows for the possibility of radium contamination of the buildings and facilities during the AWE operations period. However, significantly larger quantities of uranium appear to have been used for the MED-related activities. MED-related activities did not reference thorium material; however, Morton was licensed to handle thorium following the MED-related activities. In addition, a 1946 memo indicates that Ventron had also been involved in non-AEC manufacturing of thorium powder at the rate of pounds per month for use in thoriated tungsten filaments for radio tubes produced by Sylvania, Raytheon, and RCA (Morse, 1946). Neither the MED nor Morton licenses/contracts referenced radium as a source material used at the site. Radium residuals at the site may have occurred as a result of radium being: (1) a byproduct of ore concentrates used prior to MED-related activities; (2) a byproduct of significant quantities of oxides used during the MED processes; (3) a byproduct of pitchblende ore and oxides used after MED processes; or (4) less significantly, a decay product from any natural uranium used by Morton (DOE, 1995).
The following subsections provide an overview of the internal and external exposure sources for the Ventron class under evaluation.

### 5.2.1 Internal Radiological Exposure Sources from Ventron Operations

The primary source of internal radiological exposure resulting from Ventron operations during the AWE period was inhalation and/or ingestion of uranium and thorium radionuclides. Uranium was present at Ventron as a solid metal and in various uranium compounds, uranium tetrafluoride, uranium dioxide powder, and uranium ore. Exposure to uranium posed a potential internal exposure hazard. Documentation indicates that that the uranium tetrafluoride received at Ventron was derived solely from naturally-occurring ores (DOE, 1992). Natural uranium refers to uranium consisting of approximately 0.7% U-235, 99.3% U-238, and a very small residual amount of U-234, by weight. In terms of radioactivity, natural uranium contains approximately equal percentages of U-238 (48.6%) and U-234 (49.2%). These radionuclides emit alpha particles with primary emission energies of 4.20 MeV and 4.15 MeV (U-238), and 4.77 MeV and 4.72 MeV (U-234) (Rad Health, 1970). The radioactivity contribution from U-235 is much smaller (approximately 2.2%) relative to U-238 or U-234. U-235 emits alpha particles with energies of 4.40 MeV and 4.37 MeV.

Other alpha-emitting radionuclides, including radon and progeny, occur naturally as part of the U-238 decay process. Radon and radon progeny would have been produced on site during the AWE period from:

- uranium ore contamination remaining on site from pre-AWE period work (1940 through 1942).
- on-site use of high-grade pitchblende ores to complete a MED contract beginning in mid-1947.

In addition, although it appears that thorium was processed for commercial use, workers may have been exposed to thorium during their AEC-related tasks. Thorium-232 is the parent radionuclide in the thorium series. Thorium-232 decays by alpha emission into Ra-228, emitting two primary alpha particles of 3.95 MeV (24% abundance) and 4.01 MeV (76% abundance). The natural thorium decay series includes six progeny that emit alpha particles with energies ranging from 5.34 MeV to 8.78 MeV.

### 5.2.2 External Radiological Exposure Sources from Ventron Operations

Based on information and documentation available to NIOSH, the potential for external radiation doses from uranium and uranium decay products existed at the Ventron site. The uranium was solely derived from naturally-occurring ores, and thus exhibited a natural isotopic abundance. The following subsections provide an overview of the external exposure sources. In addition, although it appears that thorium was processed for commercial use, workers may have been exposed to thorium during their AEC-related tasks.

Natural uranium emits both beta particles (electrons) and photons (X-ray and gamma photons), as shown in Table 5-1. The two primordial components of natural uranium are U-238 and U-235, but some of their decay products grow into equilibrium quickly enough to contribute to worker exposures during metal processing.

#### 5.2.2.1 Photon

Uranium metal, uranium ore, and uranium tetrafluoride were handled by Ventron employees. 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 Health, 1970). Note that 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 travel with the parent and will not be considered separately. Uranium-235 emits alpha particles and gamma photons in about 70% of its transitions, but occurs as 0.7200 atom percent in natural uranium. Photon emissions from uranium ore present during the period under evaluation would include emissions from uranium and uranium progeny (mainly Ra-226 and radium progeny).

The majority of the photons from natural uranium metals and natural uranium ores are in the 30-250 keV energy range (ORAUT-OTIB-0004). Uranium, present as a solid object, ore, or as chemical compounds provides considerable shielding of the lower-energy photons and will tend to harden the spectrum, causing the majority of photons emitted from uranium to have energies greater than 250 keV. While it is recognized that solid uranium sources will have a hardened photon spectrum, exposure to a thin layer of uranium on a surface will result in a larger fraction of exposure to lower-energy photons (Battelle-TBD-6000).

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.

Table 5-1 lists the beta and gamma emissions of the radionuclides of major external exposure concern. Exposure to these photons was possible during the period under evaluation from direct radiation during ore-handling, metal-handling, and from submersion in contaminated air.

**Table 5-1: Beta and Gamma Emissions of Primary Interest**

| Radionuclide | Beta Energy (MeV, max.) | Gamma Energy (MeV) |
|---|---|---|
| Uranium-238 | None | None |
| Thorium-234 | 0.10 (19%) | 0.063 (3.5%) |
| | 0.193 (79%) | 0.093 (4%) |
| Protactinium-234m | 2.28 (99%) | 0.766 (0.2%) |
| | | 1.00 (0.6%) |
| Uranium-235 | None | 0.144 (11%) |
| | | 0.163 (5%) |
| | | 0.186 (54%) |
| | | 0.205 (5%) |
| Thorium-231 | 0.205 (15%) | |
| | 0.287 (49%) | 0.026 (15%) |
| | 0.304 (35%) | 0.084 (6.5%) |
| Uranium-234 | None | 0.053 (0.1%) |
| Thorium-230 | None | 0.0667 (0.37%) |
| | | 0.142 (0.07%) |
| | | 0.144 (0.045%) |
| Radium-226 | None | 0.186 (3.28%) |
| Radon-222 | None | 0.510 (0.078%) |
| Polonium-218 | 0.33 (0.02%) | 0.837 (0.0011%) |
| Lead-214 | 0.67 (48%) | 0.2419 (7.5%) |
| | 0.73 (42.5%) | 0.295 (19.2%) |
| | 1.03 (6.3 %) | 0.352 (37.1%) |
| Astatine-218 | None | 0.786 (1.1%) |
| | | 0.053 (6.6%) |
| Bismuth-214 | 1.42 (8.3%) | 0.609 (46.1%) |
| | 1.505 (17.6%) | 1.12 (15.0%) |
| | 1.54 (17.9%) | 1.765 (15.9%) |
| | 3.27 (17.7%) | 2.204 (5.0%) |
| Polonium-214 | None | 0.7997 (0.010%) |
| Thalium-210 | 1.32 (25%) | 0.2918 (79.1%) |
| | 1.87 (56%) | 0.7997 (99%) |
| | 2.34 (29%) | 0.860 (6.9%) |
| | | 1.110 (6.9%) |
| | | 1.21 (17%) |

| Table 5-1: Beta and Gamma Emissions of Primary Interest | | |
|---|---|---|
| **Radionuclide** | **Beta Energy (MeV, max.)** | **Gamma Energy (MeV)** |
| | | 1.310 (21%) |
| | | 1.410 (4.9%) |
| | | 2.010 (6.9%) |
| Lead-210 | 0.016 (80%) | 0.0465 (4%) |
| | 0.063 (20%) | |
| Bismuth-210 | 1.161 (~100%) | None |
| Polonium-210 | None | 0.802 (0.0011%) |
| Thalium-206 | 1.571 (100%) | 0.803 (0.0055%) |
| Thorium-232 | None | 0.059 (0.19%) |
| | | 0.126 (0.04%) |
| Radium-228 | 0.0389 (100%) | 0.0067 (6 x $10^{-5}$%) |
| Actinium-228 | 0.983 (7%) | 0.338 (11.4%) |
| | 1.014 (6.6%) | 0.911 (27.7%) |
| | 1.115 (3.4%) | 0.969 (16.6%) |
| | 1.17 (32%) | 1.588 (3.5%) |
| | 1.74 (12%) | - |
| | 2.08 (8%) | - |
| | (+33 more βs) | - |
| Thorium-228 | None | 0.084 (1.19%) |
| | | 0.132 (0.11%) |
| | | 0.166 (0.08%) |
| | | 0.216 (0.27%) |
| Bismuth-212 | 1.59 (8%) | 0.040 (1%) |
| | 2.246 (48.4%) | 0.727 (11.8%) |
| | - | 1.620 (2.75%) |
| Lead-208 | None | 2.614 (100%) |

Source: Radiological Health Handbook, 1998. A more complete list for uranium and thorium progeny can be found in the referenced document.

#### 5.2.2.2 Beta

Radiation fields from uranium are frequently dominated by contributions from daughter product radionuclides. For example, nearly all of the beta radiation field from depleted uranium comes from the daughter radionuclide Pa-234m, and to a lesser extent from Th-234. During melting and casting operations, these daughter elements may concentrate on the surface of the castings and equipment, producing beta radiation fields up to 20 rad per hour.

Table 5-1 shows the principal beta emitters and their energies for the uranium and thorium present at Ventron. As indicated, there are a significant number of high-energy beta radiations that represent a shallow dose exposure concern for site workers. Workers who handled the uranium and thorium would have received shallow dose exposures. The primary exposure areas would have been the hands and forearms, the neck and face, and other areas of the body that might not have been covered.

#### 5.2.2.3 Neutron

There was a small potential for personnel neutron exposures from Ventron uranium operations. As described in Section 5.2.1, site personnel received and handled uranium tetrafluoride. Low-atomic-number elements (such as fluorine) emit neutrons of approximately 2 MeV energy when struck by alpha particles (referred to as alpha-neutron [“α-n”] reactions). The intensity of the radiation field from these reactions increases as a function of the enrichment. Because only uranium with a natural isotopic ratio (or “natural enrichment”) was used at Ventron, the neutron radiation field was significantly lower than the gamma component; therefore, neutrons are not considered a significant exposure concern and are not addressed further in this evaluation.

### 5.2.3 Incidents

NIOSH did not identify any documented accidents at Ventron that resulted in exceptionally-high personnel exposure levels (such as a criticality event). However, the pyrophoricity of the uranium metal, especially when in fine powder form, led to recurring fires in the early days of the process. Early attempts at storing the powdered metal underwater led to oxidation of the metal, the resulting heat of which was sufficient to ignite the metal even underwater. One report suggests that, over the course of multiple fires, several hundred pounds of material were lost through burning (Alexander, unknown date).

This phenomenon was also noted in the settling basins outside the factory buildings. Brown oxide is not a uniform powder and cannot be ground to such in a ball mill. The oxide is composed of sub-micrometer diameter particles, intermediate–sized particles, and very large particles in the form of hollow spheres. During the acid-leaching process, the finer particles would become partially oxidized and were left suspended in the leaching liquid that was drained into the settling basins (Alexander, unknown date). According to a former area engineer for the Manhattan Engineer District, periodically, the fine uranium in the outside settling basin would catch fire. Initially, the water on top would bubble. Then, spontaneous ignition led to a spectacular column of flames many feet in the air. It is believed that these fires scattered fine uranium material throughout the plant (Duffey, 1981).

In the earliest days of the process, the material was allowed to air-cool in stainless steel filter trays. However, due to recurring uranium fires, the process was modified so that drying occurred in an inert argon atmosphere (Adams, 1994). In other instances, hand scooping of the dried metal powder into its containers led to spontaneous ignition of the metal. When this occurred, the entire tray of metal was thrown out the side door of the building and allowed to burn itself out (Hayden, 1948).

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

The following subsections provide an overview of the state of the available internal and external monitoring data for the Ventron class under evaluation.

## 6.1 Available Ventron Internal Monitoring Data

The primary data used for determining internal exposures are derived from personal monitoring data, such as urinalyses, fecal samples, and whole-body counting results. If these are unavailable, the air monitoring data from breathing zone and general area monitoring are used to estimate the potential internal exposure. If personal monitoring and breathing zone area monitoring are unavailable, internal exposures can sometimes be estimated using more general area monitoring, process information, and information characterizing and quantifying the source term.

<u>Medical Records</u>

During the period under evaluation, the MED recommended that any individuals exposed directly to special materials should receive a yearly chest X-ray, blood analysis once every six months, and a monthly urinalysis (Warren, 1943). In 1945, the urinalysis requirement was relaxed somewhat to once every three months (Mears, 1945a). NIOSH has access to 254 individual employee medical files spanning from 1942 through 1947 (Monitoring Results, 1942-1947; Monitoring Results, 1942-1945; Monitoring Results, 1943-1945). These files contain employee names and occupations as well as the results of pre-employment and yearly physicals, blood tests, urinalyses, and chest X-rays. While the urine samples appear to have been microscopically analyzed, there is no indication that uranium assays were conducted.

On November 11, 1943, wax finger impressions were taken of all individuals employed in the metal operations at Metal Hydrides. The intent was to perform a repeat impression of each of these individuals after a year of working on the project, as well as a control group of individuals of similar age, sex, and weight with no exposure to uranium. Consequently, 71 impressions were taken on February 28, 1945, and 30 impressions were taken on November 1, 1945 (Fingerprint Impressions, 1943-1946; Howland, 1944).

<u>Bioassay Data</u>

NIOSH has found no indication that a routine uranium or thorium urinalysis program was in place during the Ventron operational period. NIOSH has the results of uranium urinalyses performed on a single individual on June 26, 1945 and again for four sequential days from August 7 through August 10, 1945 (Mears, 1945c; Mears, 1945d). It appears that these urinalyses were conducted in response to significant weight loss on the part of the employee and a desire to determine whether this weight loss might be a result of exposure to uranium metal (Mears, 1945b).

Additional references in the site documentation to periodic urine samples were probably referring to non-radiological medical tests as part of medical monitoring (Howland, 1946; Mears, 1945a).

Blood counts were part of the required physical examinations before starting work; they were repeated at three-month intervals (Howland, 1946). Blood counts were used in the early years to monitor potential radiation damage to the hematopoietic system. Note: Blood count information is not normally used as bioassay data for the purpose of radiological dose reconstruction.

Air Sample Data

NIOSH has not located any documentation indicating that Ventron Corporation conducted a routine air sampling program for uranium, thorium, or radon during Ventron operations. However, a limited number of uranium air sample results were discovered for the Ventron operational period. These air samples were collected using an impinger and were analyzed by gross alpha counting (Dust Measurements, 1943-1944). They are listed in Table 6-1 along with their source documents.

**Table 6-1: Available Uranium Air Sample Results for the Ventron Operational Period**

| Sample Date | Sample Location | Result (μg/m$^3$) | SRDB Ref ID |
|---|---|---|---|
| March 5, 1943 | Leaching drum during washing down | 38.8 | SRDB 5843 |
| | Over open filter while scraping | 328.4 | |
| | Over furnace in foundry while loading | 169.5 | |
| | In front of hood in foundry while cutting gates | 7.1 | |
| | Filling cans in drying room | 353.1 | |
| | Office near window by drawing desk | 84.8 | |
| | Dust house while emptying charge | 381.4 | |
| | General room sample in drying room | 120.1 | |
| | Drying furnace door | 151.9 | |
| | Under furnace in foundry during loading | 434.4 | |
| | Dust house during chipping and crushing | 67.1 | |
| | Reduction furnaces | 130.7 | |
| June 15, 1944 | Billet cooling table and crucibles being burned out (at nose level) | 226 | SRDB 10265 |
| | Taking billet from mould (1.5 ft from mould at nose height) | 2450 | |
| | Removing billet from furnace (2 ft from billets) | 550 | |
| | Screening scrap metal, oxides, and graphite (2 feet from screen at nose level) | 7200 | |
| | Sawing and packing room | No result given | |

## 6.2 Available Ventron External Monitoring Data

Personal monitoring data from film badges or thermoluminescent dosimeters (TLDs) are the primary data used to determine such external exposures. If there are no personal monitoring data, exposure rate surveys, process knowledge, and source term modeling can sometimes be used to reconstruct the potential exposure.

NIOSH has no indication that a personnel external dosimetry program was in place at Ventron during the period under evaluation. However, NIOSH has access to limited radiation exposure monitoring records for the period 1942 through 1948 at Ventron. In June 1944, a set of three measurements of stockpiled materials located outside the plant buildings, and a set of three measurements taken in working areas were recorded (Marvin, 1944). In order to determine whether additional precautions needed to be implemented in the handling of scrap materials, measurements were taken at the surface of an undetermined quantity of six-inch billets and at the surface of an undetermined quantity of six-foot rods in June 1945. The readings indicated that the material was of natural enrichment (Mears, 1945e). The results of these measurements are presented in Table 6-2.

**Table 6-2: Available Area Survey Results for the Ventron Operational Period**

| Sample Date | Sample Location | Gamma (r/8-hour day) | Beta/Gamma (T-Units) | SRDB Ref ID |
|---|---|---|---|---|
| June 15, 1944 | One-half foot from 14,000 pounds of scrap | 0.04 | - | SRDB 5855 |
| | One foot from 34,000 pounds of scrap | 0.04 | 0.5 | |
| | One-half foot from 13 tons of recast metal | - | 0.5 | |
| | Working Area: Furnace room table | - | 0.2 | |
| | Working Area: 1 foot from loaded furnace | - | 0.2 | |
| | Working Area: 4 inches from a can of scrap graphite | - | 0.2 | |
| **Sample Date** | **Sample Location** | **Gamma (r/hour)** | **Beta/Gamma (r/hour)** | **SRDB Ref ID** |
| June 26, 1945 | Surface of 6 inch billets | 0.02 | 0.24 | SRDB 10232 |
| | Surface of 6 foot rods | 0.02 | 0.04 | |

In December 1947, 25 measurements were taken at various locations throughout the Ventron plant. Another 24 measurements were taken on January 12, 1948 after some of the processing apparatus had been removed (Wolf, 1947; Wolf, 1948). These surveys, while limited, provide evidence of widespread contamination throughout the facility. The results of these measurements are presented in Table 6-3.

**Table 6-3: Available Area Survey Results for the Ventron Operational Period**
(This table spans two pages)

| Sample Date | Sample Location | Beta/Gamma[1] (mrep/hr) | Gamma[1] (mrep/hr) | Alpha[2] (d/m) | SRDB Ref ID |
|---|---|---|---|---|---|
| December 19, 1947 | Second level office floor | 0.29 | - | 4,000 | SRDB 8934 |
| | Second level office desk | | - | 0 | |
| | Second level background 3 feet from floor | 0.08 | - | - | |
| | Ground 20 feet S of vent duct | 0.5 | - | - | |
| | Change house background 3 feet from floor | 0.3 | - | - | |
| | Change house floor at 1 inch | 1.9 | - | 13,000 | |
| | Change house lockers at 1 inch | <background | - | - | |
| | Storage shed background at 3 feet from floor | 0.2 | - | - | |
| | Storage shed floor at 1 inch | 1.0 | - | - | |
| | Guard house west of Change house, background | 1.16 | - | - | |
| | Guard house west of Change house floor at 1 inch | 1.35 | - | - | |
| | Carbon shop south end background 3 feet from floor | 0.7 | - | - | |
| | Carbon shop south end floor at 1 inch | 2.1 | - | 14,000 | |
| | Burning room background 3 feet from floor | 7.0 - 20.0 | - | - | |
| | Furnace room background 3 feet from floor | 1.5 | - | - | |
| | Furnace room floor at 1 inch | 2.0 | - | - | |
| | Concrete platform E side of building at 1 inch | 1.5 | - | 7,200 | |
| | Yard near bay bank, over old dry well at 1 inch | 0.5 | - | - | |
| | Yard near bay bank, background 3 feet above surface | 0.15 | - | - | |
| | Dust under outside stairs at 2 inches | 1.3 | - | - | |
| | Outside concrete steps to office at 2 inches | 1.0 | - | - | |
| January 12, 1948 | Balcony floor at 2 feet | 2 | 0.7 | - | SRDB 8934 |
| | Wall over balcony at 2 feet | 0.5 | - | - | |
| | Background 3 feet above balcony | 0.5 | 0.03 | - | |
| | Balcony floor | - | - | 28,000 | |
| | Furnace area floor | 15-20 | 0.15 | 28,000 | |

| Table 6-3: Available Area Survey Results for the Ventron Operational Period (This table spans two pages) | | | | | |
|---|---|---|---|---|---|
| **Sample Date** | **Sample Location** | **Beta/Gamma[1] (mrep/hr)** | **Gamma[1] (mrep/hr)** | **Alpha[2] (d/m)** | **SRDB Ref ID** |
| | Main plant, leaching pit, filter box | 2 | - | - | |
| January 12, 1948 (cont.) | Main plant, leaching pit, floor | | - | 16,000 | SRDB 8934 (cont.) |
| | Main plant, leaching pit S.G. | 0.1 | - | - | |
| | Main plant, leaching pit, floor | 0.2 | - | - | |
| | Main pant, laboratory, sink & drainboard | 2-15 | 0.1 | - | |
| | Main plant, laboratory, hood bottom | 2.0 | 0.1 | - | |
| | Main plant, shower room bench | - | - | 7,000 | |
| | Main plant, locker room, floor | - | - | 4,400 | |
| | Main plant, locker room, sink | - | - | 1,000 | |
| | Main plant, shower room, floor | - | - | 1,000 | |
| | Main plant, shower room, drain | 0.7 | - | - | |
| | Main plant, wash room, drain | 1.5 | - | - | |
| | Main plant, window screen, SE side | 1.0 | - | - | |

1 Beta/gamma measurements taken with a Victoreen-263 meter without shield. Gamma-only measurements taken with a Victoreen-263 meter with shield in place.

2 Alpha measurements taken with a Zeuto detector. To discriminate between alpha and beta counts, two sets of measurements were made. The first was made with the detector by itself and the second was taken with a sheet of paper between the source and the detector. The difference between the two measurements was taken to be the alpha reading (Wolf, 1947).

# 7.0 Feasibility of Dose Reconstruction for the Class Evaluated by NIOSH

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

In determining feasibility, NIOSH begins by evaluating whether current or completed NIOSH dose reconstructions demonstrate the feasibility of estimating with sufficient accuracy the potential radiation exposures of the class. If the conclusion is one of infeasibility, NIOSH systematically evaluates the sufficiency of different types of monitoring data, process and source or source term data, which together or individually might assure that NIOSH can estimate either the maximum doses that members of the class might have incurred, or more precise quantities that reflect the variability of exposures experienced by groups or individual members of the class as summarized in Section 7.5.

This approach is discussed in DCAS's SEC Petition Evaluation Internal Procedures which are available at http://www.cdc.gov/niosh/ocas.

The next four major subsections of this Evaluation Report examine:

- The sufficiency and reliability of the available data. (Section 7.1)
- The feasibility of reconstructing internal radiation doses. (Section 7.2)
- The feasibility of reconstructing external radiation doses. (Section 7.3)
- The bases for petition SEC-00198 as submitted by the petitioner. (Section 7.4)

## 7.1 Pedigree of Ventron 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 discussed in Section 6.1, NIOSH has not located any documentation indicating the existence of routine air sampling or internal monitoring programs for uranium or thorium during the operation of the Metal Hydrides plant. The MED Data Sheet for Industrial Hazards indicates that air sampling, dust counts, area monitoring, urinalysis, and personnel film badge monitoring were not required for the scrap-casting operations at this facility (Data Sheet, unknown date, pdf p. 41). Therefore, an internal monitoring data sufficiency and pedigree evaluation is not possible for the internal monitoring data type.

The air sampling data from the MED/AEC are contained in original reports and are, therefore, primary data sources. The results of 12 samples taken on March 5, 1943 and four samples taken on June 15, 1944 are recorded in units of micrograms of metal per cubic foot of air (Dust Measurements, 1943-1944; Dust Measurements, 1944). However, due to a lack of detailed inventory data spanning the entire period under evaluation, NIOSH could not draw a conclusion about the representativeness of the samples for the purpose of estimating personnel intakes.

#### 7.1.2 External Monitoring Data Pedigree Review

NIOSH did not locate any personnel external dosimetry data for the operational period under evaluation (August 13, 1942 through December 31, 1948). The MED Data Sheet for Industrial Hazards indicates that air sampling, dust counts, area monitoring, urinalysis, and personnel film badge monitoring were not required for the scrap-casting operations at this facility (Data Sheet, unknown date, pdf p. 41). Therefore, a data sufficiency and pedigree evaluation is not possible for this data type for this period.

The area survey data from the MED/AEC are contained in original reports and are, therefore, primary data sources. The results of six samples taken on June 15, 1944 are recorded in r/8 hour day and T units (Marvin, 1944). NIOSH is interpreting the T unit to be a measurement of beta radiation. In this case, a T unit is defined as "0.25 R/hr" (i.e., rep/hr) of beta radiation only, which is derived from the beta dose rate on contact with natural uranium metal (tuballoy). The four measurements taken of two types of material on June 26, 1945 are recorded in units of r per hour (Mears, 1945e). A total of 49 measurements were collected in December 1947 and January 1948 with 24 of those measurements being collected after various pieces of process equipment were removed from the site. Beta and gamma measurements from the December 1947 and January 1948 surveys are recorded in units of mrep per hour, while alpha measurements for the same surveys are reported in d/m (Wolf, 1948). However, due to a lack of detailed inventory data spanning the entire period under evaluation, NIOSH could not draw a conclusion about the representativeness of the samples for the purpose of estimating personnel intakes.

### 7.2 Evaluation of Bounding Internal Radiation Doses at Ventron

The principal source of internal radiation doses for members of the class under evaluation was inhalation and ingestion of uranium, thorium, and uranium progeny contained in dust and fumes associated with cutting and smelting operations, and from uranium ores. The following subsections address the ability to bound internal doses, methods for bounding doses, and the feasibility of internal dose reconstruction.

#### 7.2.1 Evaluation of Bounding Process-Related Internal Doses

Metal Hydrides workers were potentially exposed to thorium metal dust, uranium metal dust, uranium oxides, progeny from uranium ores, and uranium fumes resulting from smelting operations. NIOSH has found no indications that bioassay measurements were collected for the period under evaluation. NIOSH has also been unable to locate any records indicating that breathing zone or area air sampling was conducted during any of the spontaneous fires that occurred either in the processing areas or outside in the settling basin.

NOISH has not been able to confirm what operations were being performed during the time available samples were being collected. NIOSH has also been unable to determine whether the samples were representative of all work areas throughout the Metal Hydrides plant. A 1948 discussion of the health aspects of working with powdered uranium noted that the process area is not isolated from the rest of the plant where non-AEC work was being conducted (Hayden, 1948). NIOSH has not located any information indicating that there were physical or administrative access controls that would limit workers from other areas of the plant from entering the uranium production areas.

Due to a lack of detailed inventory data spanning the entire period under evaluation, NIOSH could not draw a conclusion about the representativeness of the samples for the purpose of estimating personnel intakes even for the work spaces in which the samples were acquired.

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

#### 7.2.1.1 Urinalysis Information and Available Data

The uranium urinalysis sample results available to NIOSH are for a single individual. It is unclear from the available documentation where in the operational process the sampled individual was employed. These urinalysis results are not comprehensive and do not constitute representative sampling of Ventron activities.

#### 7.2.1.2 Airborne Levels

NIOSH has not located any documentation indicating that Ventron conducted a routine air sampling program for uranium or thorium during Ventron operations. NIOSH has also been unable to locate any records indicating that breathing zone or area air sampling was conducted during any of the spontaneous fires that occurred either in the processing areas or outside in the settling basin.

NIOSH has obtained a limited number of uranium air sampling results for 1943 and 1944, which were analyzed by alpha counting. However, those results were found to be inadequate to bound internal intakes during the period under evaluation (Dust Measurements, 1943-1944; Dust Measurements, 1944). Neither set of air sampling measurements gives clear indication that these samples were representative of the air concentrations that could be encountered by workers in each of the three principal process buildings. Due to a lack of detailed inventory records, NIOSH cannot determine the quantity of material present when the sampling was performed; therefore, the relevance or representativeness of those samples for the evaluated class cannot be established.

### 7.2.2 Methods for Bounding Operational Period Internal Dose at Ventron

NIOSH has determined that the available data are inadequate to reconstruct worker exposures to uranium, thorium, and uranium daughter products resulting from smelting activities performed during the Ventron operational period under evaluation.

Uranium internal exposures during the operational period cannot be bounded using measured air concentration data. The available air concentration data cover a very limited duration of time and may not be representative of the air concentrations encountered by the maximally-exposed individual. Furthermore, there is no indication that air samples were taken during any of the fire events that could reasonably be expected to have dispersed particulate oxides throughout the plant.

### 7.2.3 Internal Dose Reconstruction Feasibility Conclusion

NIOSH has evaluated the available personnel and workplace monitoring data and source term information and has determined that there are insufficient data for estimating internal exposures, as described below.

As discussed in Section 5.3, NIOSH has identified limited urinalysis results for a single individual analyzed for uranium during the AWE operational period, but has not found documentation that describes the sampling or analysis protocols used for that set of bioassay data. Beyond this single set of bioassay results, no other personnel bioassay monitoring results have been located. These limited internal personnel monitoring data are for a single individual, and there is no evidence to indicate these data are representative of the most highly-exposed workers at the Ventron facility, nor is there a way to verify that the available sample results are representative of all workers.

In the absence of other personnel monitoring data for the period 1942 through 1948, NIOSH has insufficient personnel monitoring data to appropriately characterize internal radiation intakes during Ventron operations.

NIOSH has not located any documentation indicating that Ventron conducted a routine air sampling program for uranium or thorium during Ventron operations. However, a limited number of uranium air sample results were discovered for the years 1943 and 1944 only. The available air concentration data cover a very limited duration of time and may not be representative of the air concentrations encountered by the maximally-exposed individual. Furthermore, there is no indication that air samples were taken during any of the fire events that could reasonably be expected to have dispersed particulate oxides throughout the plant.

In the absence of adequate internal dose monitoring criteria and adequate personnel monitoring data, NIOSH has not found sufficient general area air sampling, breathing zone air sampling, site survey, or source term information to allow it to bound potential exposures, or to demonstrate that workers were adequately monitored for potential exposures to radioactive materials at Ventron during the MED/AEC operational period. NIOSH has determined that reconstruction of the total internal doses received from exposures to uranium, thorium, and uranium progeny is not feasible using the information available to NIOSH for the period under evaluation from November 1, 1942 through December 31, 1948.

Although NIOSH found that it is not possible to completely reconstruct internal radiation doses for the period from November 1, 1942 through December 31, 1948, NIOSH intends to use any internal monitoring data that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures). Dose reconstructions for individuals employed at Ventron during the period from November 1, 1942 through December 31, 1948, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

## 7.3 Evaluation of Bounding External Radiation Doses at Ventron

The principal source of external radiation doses for members of the evaluated class was exposure to beta and gamma radiation emanating from uranium-bearing and thorium-bearing materials. The following subsections address the ability to bound external doses, methods for bounding doses, and the feasibility of external dose reconstruction.

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

### 7.3.1 Evaluation of Bounding Process-Related External Doses

NIOSH has not identified any personal dosimetry data associated with the uranium processing or thorium handling that occurred during the period under evaluation. NIOSH has access to a limited set of radiation level surveys for this time period. These measurements include surveys of materials, surveys of equipment, and a general area survey of three working areas. No survey data are available for the time period in which uranium metal was being produced using the hydramet process. Similarly, no survey data are available for the time period in which thorium was used for the commercial production of thoriated tungsten filaments. It is important to note that no information is recorded regarding what quantities of materials were being handled or which specific process steps were being performed during sampling. Accordingly, NIOSH is unable to determine whether these survey results are representative of the radiation field present during the entire operational period.

NIOSH has not identified sufficient documentation to define and quantify the total external source term for Ventron during the period under evaluation. Without additional documentation, NIOSH cannot make reasonable assumptions about the relative amounts of materials that would have been encountered at the site during the specified period. Thus, NIOSH finds that it is infeasible to completely reconstruct external doses for the class under evaluation due to insufficient monitoring data. Therefore, there is insufficient information available to NIOSH to bound external exposures for the period from November 1, 1942 through December 31, 1948.

### 7.3.2 Ventron Occupational X-Ray Examinations

It is known that pre-employment radiographs of the chest were required for Ventron employees as early as May 11, 1943 (Friedell, 1943). By August 1945, Ventron Corporation was repeating the chest X-rays annually (Mears, 1945a) and in August 1946, the MED Medical Section standardized its policies to require both a pre-employment and termination chest X-ray of any individuals who would be engaged in processing uranium ores and compounds (Howland, 1946). NIOSH has access to 254 employee medical files containing indications that each employee received a pre-employment chest X-ray. These files span the years 1943 through 1947 and contain data on a variety of worker types, from stenographers and guards to foundry and furnace operators (Monitoring Results, 1942-1947; Monitoring Results, 1942-1945; Monitoring Results, 1943-1945).

NIOSH does have indications that performance of the required chest radiographs involved the Beverly Hospital (Beverly Hospital, 1945), but NIOSH does not have sufficient information to verify that all medical X-ray examinations performed as a condition of employment at Ventron were performed off-site. In the absence of documentary evidence about where X-rays examinations were performed, it is NIOSH policy to assume that X-rays were taken onsite; therefore, occupational medical exposure is to be included in dose reconstruction for Ventron workers.

### 7.3.3 Methods for Bounding Operational Period External Dose at Ventron

There is an established protocol for assessing external exposure when performing dose reconstructions:

- Photon Dose
- Beta Dose
- Neutron Dose
- Medical X-ray Dose (as applicable per Section 7.3.3)

NIOSH has not identified any external monitoring records or personal dosimetry data associated with the uranium processing or thorium handling conducted during the period under evaluation. This was a unique project for which there were no operational logs, minimal descriptions of activities, and little corresponding radiological data. NIOSH has not located any information documenting or describing a regular workplace monitoring program. No records of any routine monitoring or area survey program have been located.

NIOSH has determined that it lacks sufficient personnel monitoring data, area monitoring data, or source term data needed to bound external photon, beta, or neutron doses that Ventron workers potentially received from natural uranium, thorium metal, uranium residues, and uranium progeny. Therefore, NIOSH has not identified a method for bounding external doses at Ventron for the period from November 1, 1942 through December 31, 1948.

Medical X-ray Dose

NIOSH will perform reconstruction of medical dose using the available X-ray data and the claimant-favorable assumptions in the Technical Information Bulletin, *Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures* (ORAUT-OTIB-0006)

### 7.3.4 External Dose Reconstruction Feasibility Conclusion

NIOSH does not have access to sufficient personnel monitoring, workplace monitoring, or source term data to estimate potential external exposures to uranium, thorium, or uranium progeny during the period of refining and smelting operations. Therefore, NIOSH finds that it is infeasible to completely reconstruct external doses from November 1, 1942 through December 31, 1948 due to insufficient monitoring data.

Although NIOSH found that it is not possible to completely reconstruct external radiation doses for the period from November 1, 1942 through December 31, 1948, NIOSH intends to use any external monitoring data that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures). Dose reconstructions for individuals employed at Ventron during the period from November 1, 1942 through December 31, 1948, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

## 7.4 Evaluation of Petition Basis for SEC-00198

The following assertion was made on behalf of petition SEC-00198 for the Ventron Corporation:

Lack of Monitoring Data

SEC-00198: *To the best of my knowledge, there was no monitoring at Ventron Corp.*

Personal internal, external monitoring, and/or area monitoring data are not always required to develop an exposure model for a given facility. However, if these monitoring data are not available, NIOSH must have access to source term information and detailed process information in order to develop a sufficiently accurate exposure model.

NIOSH has determined that it does not have adequate internal monitoring data for members of the class under evaluation, nor does it have enough source term or process information to develop a sufficiently accurate model for dose reconstruction for these exposures during the relevant timeframe. (See Sections 7.1.1, 7.1.2, 7.2.1, 7.2.1.2 and 7.3.3 for further discussions.)

## 7.5 Summary of Feasibility Findings for Petition SEC-00198

This report evaluates the feasibility for completing dose reconstructions for employees at the Ventron Corporation site from August 13, 1942 through December 1948. NIOSH found that the available monitoring records, process descriptions and source term data available are not sufficient to complete dose reconstructions for the evaluated class of employees. During its research, NIOSH also obtained documentation showing that the MED took over cognizance of weapons-related metal production at the site on November 1, 1942; therefore, the start of the NIOSH-proposed class was changed to that date.

Table 7-1 summarizes the results of the feasibility findings at Ventron for each exposure source during the revised time period November 1, 1942 through December 1948.

**Table 7-1: Summary of Feasibility Findings for SEC-00198**
November 1, 1942 through December 31, 1948

| Source of Exposure | Reconstruction Feasible | Reconstruction Not Feasible |
|---|---|---|
| **Internal**[1] | | **X** |
| - U | | X |
| - Rn | | X |
| - Th | | X |
| **External** | | **X** |
| - Gamma | | X |
| - Beta | | X |
| - Neutron | | X |
| - Occupational Medical X-ray | X | |

[1] Internal includes an evaluation of urinalysis (in vitro), airborne dust, and lung (in vivo) data

As of June 4, 2012, a total of nine claims have been submitted to NIOSH for individuals who worked at Ventron during the period under evaluation in this report. Dose reconstructions have been completed for nine individuals (100%).

Although NIOSH found that it is not possible to completely reconstruct radiation doses for the proposed class, NIOSH intends to use any internal and external monitoring data that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures). Therefore, dose reconstructions for individuals employed at Ventron during the period from November 1, 1942 through December 31, 1948, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

# 8.0 Evaluation of Health Endangerment for Petition SEC-00198

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

NIOSH has determined that members of the proposed class were not exposed to radiation during a discrete incident likely to have involved levels of exposure similarly high to those occurring during nuclear criticality incidents. However, the evidence reviewed in this evaluation indicates that some workers in the class may have accumulated chronic radiation exposures through intakes of uranium or from direct exposure to these radioactive materials. NIOSH's evaluation determined that it is not feasible to estimate radiation dose for members of the NIOSH-evaluated class with sufficient accuracy based on the sum of information available from available resources. Therefore, the resulting NIOSH-proposed SEC class must include a minimum required employment period as a basis for specifying that health was endangered.

# 9.0 Class Conclusion for Petition SEC-00198

Based on its full research of the class under evaluation, NIOSH has defined a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. The NIOSH-proposed class to be added to the SEC includes all Atomic Weapons Employees who worked in all buildings owned by the Ventron Corporation in Beverly, Massachusetts, from November 1, 1942 through December 31, 1948 for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more classes of employees included in the Special Exposure Cohort.

NIOSH has carefully reviewed all material sent in by the petitioner, including the specific assertions stated in the petition, and has responded herein (see Section 7.4). NIOSH has also reviewed available technical resources and many other references, including the Site Research Database (SRDB), for information relevant to SEC-00198. In addition, NIOSH reviewed its NOCTS dose reconstruction database to identify EEOICPA-related dose reconstructions that might provide information relevant to the petition evaluation.

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

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# Attachment 1: Data Capture Synopsis

**Table A1-1: Data Capture Synopsis for Ventron Corporation**

| Data Capture Information | General Description of Documents Captured | Date Completed | Uploaded To SRDB |
|---|---|---|---|
| Primary Site / Company Name: Ventron Corporation; AWE 1942-1948; Residual Radiation 1949-1985; 1987-1995; DOE 1986; 1996-1997 (remediation)<br><br>Alternate Site Names:<br>Ventron Div.<br>Morton Thiokol, Inc.<br><br>Physical Size of the Site: 3 Acres<br>Site Population: 107 (1942-43) | No relevant documents identified. Continuing effort with Dow Chemical as potential source of records. | OPEN | 0 |
| State Contacted: Massachusetts Department of Public Health [Phone No. redacted] | Characterization of radiation dose, health study for Goat Hill, radiation survey, uranium guideline, engineering evaluation/cost analysis, and a uranium cleanup guideline recommendation. | 04/12/2012 | 13 |
| Brookhaven National Laboratory | Uranium and Thorium Powder Metallurgy Fabrication Program. | 11/26/2008 | 1 |
| Claimant Provided | A FOIA request which includes medical information. | 04/18/2005 | 1 |
| Department of Labor / Paragon | Operational Surety Program and chemical and hazardous material inventories. | 01/23/2012 | 2 |
| DOE Germantown | Health aspects of preparation of powdered uranium, disposition of scrap, monthly accountability report, fire survey of Metal Hydrides, uranium work, and a radiation survey. | 01/23/2004 | 9 |
| DOE Legacy Management - Grand Junction Office | Urinalysis, radon, breath, and air dust samples, shipping documents, materials accountability, contract W-7405-Eng-8, thorium tetrafluoride for Metal Hydrides, Inc., radiological surveys, verification survey, post-remedial action report, source material license number R-112, certificate of disposition of materials STB-180, disposal of offsite-generated defense radioactive waste, newspaper articles, uranium guidelines for the Ventron site, Metal Hydrides history, notice of stopping production, personnel medical records, chest x-rays, progress reports, raw materials and production reports, contractor code names, Metallurgical Project bulletins, progress reports, and trip reports. | 08/30/2011 | 133 |
| DOE Legacy Management - MoundView (Fernald Holdings, includes Fernald Legal Database) | Major thorium campaigns and a proposed work program for New Brunswick Laboratory. | 05/21/2008 | 2 |

| Table A1-1: Data Capture Synopsis for Ventron Corporation | | | |
|---|---|---|---|
| **Data Capture Information** | **General Description of Documents Captured** | **Date Completed** | **Uploaded To SRDB** |
| DOE Oak Ridge Operations Office | Employee and key personnel interviews. Data request ORO-FY12-007 is in process. Three of five sources have been searched and no information identified yet. | OPEN | 2 |
| DOE Oak Ridge Operations, Records Holding Task Group | NIOSH notes on location holdings. | 12/10/2012 | 1 |
| DOE OSTI | Production, melting, and casting uranium metal. | 01/23/2012 | 2 |
| EM File Room | Weekly project reports and uranium activities. | 09/11/2002 | 1 |
| Federal Records Center - Kansas City | TLD reports, weekly reports, and a monthly material accountability report. | 08/11/2008 | 4 |
| Federal Records Center - Lenexa | Ventron characterization, contaminated soil to be removed, contract W-7405-Eng-8, dose assessment of buildings A and A-1, radiological survey, news articles, NRC material license STB-180 amendment, sample collection logbook, radioactive waste profile, and dose calculation and remedial action approach. | 03/04/2009 | 18 |
| Hagley Museum and Library | History of X metal plant development and The Hanford Story. | 10/01/2012 | 2 |
| Hanford | Monthly accountability report. Awaiting response to Hanford Data Capture Activity 66. | OPEN | 1 |
| Internet - Defense Technical Information Center (DTIC) | No relevant documents identified. | 04/19/2012 | 0 |
| Internet - DOE Comprehensive Epidemiologic Data Resource (CEDR) | No relevant documents identified. | 04/18/2012 | 0 |
| Internet - DOE Hanford Declassified Document Retrieval System (DDRS) | A Hanford monthly report and alpha extrusion at Revere Copper and Brass Company. | 03/25/2010 | 3 |
| Internet - DOE Legacy Management Considered Sites | Transfer of FUSRAP site from DOE to U.S. Army Corp of Engineers, long-term surveillance and maintenance needs, certification docket for the remedial action performed at Chapman Valve site, and Metals Hydrides, Inc. and the Dawn of the Atomic Age. | 01/29/2012 | 6 |
| Internet - DOE National Nuclear Security Administration (NNSA) - Nevada Site Office | No relevant documents identified. | 01/06/2012 | 0 |
| Internet - DOE OpenNet | Linking Legacies and Manhattan Engineer Project history. | 12/31/2007 | 2 |
| Internet - DOE OSTI Energy Citations | Overview of U.S. decommissioning experience. | 04/08/2009 | 1 |
| Internet - DOE OSTI Information Bridge | Management of wastes generated, experiment design for GTR-20 radiation effects, quarterly report on the reduction of uranium oxides, implementation plan environmental restoration, and the effect of soil erosion on long-term stability of near-surface waste-burial sites. | 01/29/2012 | 10 |

| Table A1-1: Data Capture Synopsis for Ventron Corporation | | | |
|---|---|---|---|
| **Data Capture Information** | **General Description of Documents Captured** | **Date Completed** | **Uploaded To SRDB** |
| Internet - Google | Minerals yearbook 1946, uranium and thorium section, Metal Hydrides company involvement in the development of the atom bomb, residual radioactivity evaluations for individual facilities, markets and technology trends, fact sheet for Ventron, radiological condition of the Ventron site, Morton Thiokol Inc, Ventron division summary report, and a monthly report. | 01/29/2012 | 36 |
| Internet - Health Physics Journal | No relevant documents identified. | 04/18/2012 | 0 |
| Internet - Journal of Occupational and Environmental Hygiene | No relevant documents identified. | 04/18/2012 | 0 |
| Internet - MA Department of Environmental Protection | Demolition of Building A and A-1 risk characterization report and a site investigation report. | 04/19/2012 | 3 |
| Internet - National Academies Press (NAP) | No relevant documents identified. | 01/06/2012 | 0 |
| Internet - NIOSH | Report on Residual Radioactive and Beryllium Contamination at Atomic Weapons Employer Facilities and Beryllium Vendor Facilities. | 01/25/2007 | 1 |
| Internet - NRC Agencywide Document Access and Management (ADAMS) | Environmental restoration wastes, financial assurance for decommissioning, impact statement, spent fuel and radioactive waste inventories, and response to questions on disposal of certain wastes. | 04/19/2012 | 12 |
| Internet - USACE/FUSRAP | No relevant documents identified. | 01/06/2012 | 0 |
| Internet - US Transuranium and Uranium Registries | No relevant documents identified. | 01/06/2012 | 0 |
| Landauer Client (site) List | No relevant documents identified. | 05/02/2012 | 0 |
| National Archives and Records Administration (NARA) - Atlanta | Shipments and receipts documents, health aspects of the preparation of powdered uranium, dust samples, weekly production reports, thorium related correspondence, monthly accountability and progress reports, radiation surveys, standardization of medical programs, and a trip report. | 05/12/2010 | 59 |
| National Archives and Records Administration (NARA) - College Park | Beryllium surveys, NIOSH data review notes, powder metallurgy work at Metal Hydrides involving uranium and thorium powders. | 08/19/2010 | 5 |
| National Archives and Records Administration (NARA) - Kansas City | Decontamination history, historical review of Ventron, radiological survey, and TLD reports. | 07/16/2008 | 9 |
| National Institute for Occupational Safety and Health (NIOSH) | List of articles on thorium. | 11/24/2009 | 1 |
| New York State Archives | Process Development Branch minutes reports. | 03/21/2012 | 1 |
| ORAU Team | Dingell notebook containing various documents. | 04/19/2012 | 3 |
| ORO Vault | List of papers on uranium. | 11/24/2003 | 1 |
| S. Cohen & Associates (SC&A) | Description of uranium producing processes. | 06/24/2010 | 1 |
| Southern Illinois University | Minerals yearbook and disposal of radioactive waste. | 10/29/2008 | 3 |

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|---|---|---|---|
| **Data Capture Information** | **General Description of Documents Captured** | **Date Completed** | **Uploaded To SRDB** |
| Unknown | Contract W-7405 Eng-8, decontamination and decommissioning review of Manhattan District history, disposal of offsite-generated defense radioactive waste, uranium processing operations, history and physical examination information, monthly production reports, trip reports, ORAU Project spreadsheet, radiological surveys, and a uranium - thorium branch semi-annual report to Congress. | 10/24/2003 | 32 |
| Unknown / SC&A | Medical information taken at Metal Hydrides. | 09/11/2002 | 1 |
| US Army Corp of Engineering (USACE) | No relevant documents identified. | 04/19/2012 | 0 |
| **TOTAL** | | | **382** |

| Table A1-2: Databases Searched for Ventron Corporation | | | |
|---|---|---|---|
| **Database/Source** | **Keywords / Phrases** | **Hits** | **Selected** |
| NOTE: Database search terms employed for each of the databases listed below are available in the Excel file called "Ventron Corporation Rev 01 (83 13) 05-23-12" | | | |
| Defense Technical Information Center (DTIC) https://www.dtic.mil/ COMPLETED 04/19/2012 | See Note above | 205 | 0 |
| DOE CEDR http://cedr.lbl.gov/ COMPLETED 04/18/2012 | See Note above | 0 | 0 |
| DOE Hanford DDRS http://www2.hanford.gov/declass/ COMPLETED 01/06/2012 | See Note above | 0 | 0 |
| DOE Legacy Management Considered Sites http://csd.lm.doe.gov/ COMPLETED 01/06/2012 | See Note above | 14 | 4 |

| Table A1-2: Databases Searched for Ventron Corporation | | | |
|---|---|---|---|
| **Database/Source** | **Keywords / Phrases** | **Hits** | **Selected** |
| DOE NNSA - Nevada Site Office<br>www.nv.doe.gov/main/search.htm<br>COMPLETED 01/06/2012 | See Note above | 0 | 0 |
| DOE OpenNet<br>http://www.osti.gov/opennet/advancedsearch.jsp<br>COMPLETED 01/06/2012 | See Note above | 0 | 0 |
| DOE OSTI Energy Citations<br>http://www.osti.gov/energycitations/<br>COMPLETED 01/06/2012 | See Note above | 112 | 0 |
| DOE OSTI Information Bridge<br>http://www.osti.gov/bridge/advancedsearch.jsp<br>COMPLETED 01/06/2012 | See Note above | 104 | 8 |
| Google<br>http://www.google.com<br>COMPLETED 01/29/2012 | See Note above | 141,926 | 26 |
| HP Journal<br>http://journals.lww.com/health-physics/pages/default.aspx<br>COMPLETED 04/18/2012 | See Note above | 0 | 0 |
| Journal of Occupational and Environmental Health<br>http://www.ijoeh.com/index.php/ijoeh<br>COMPLETED 04/18/2012 | See Note above | 0 | 0 |
| National Academies Press<br>http://www.nap.edu/<br>COMPLETED 01/06/2012 | See Note above | 8,077 | 0 |
| NRC ADAMS Reading Room<br>http://www.nrc.gov/reading-rm/adams/web-based.html<br>COMPLETED 04/19/2012 | See Note above | 54 | 5 |
| USACE/FUSRAP<br>http://www.lrb.usace.army.mil/fusrap/<br>COMPLETED 01/06/2012 | See Note above | 0 | 0 |

| Table A1-2: Databases Searched for Ventron Corporation | | | |
|---|---|---|---|
| **Database/Source** | **Keywords / Phrases** | **Hits** | **Selected** |
| U.S. Transuranium & Uranium Registries<br>http://www.ustur.wsu.edu/<br>COMPLETED 01/06/2012 | See Note above | 0 | 0 |

| Table A1-3: OSTI Documents Requested for Ventron Corporation | | | |
|---|---|---|---|
| **Document Number** | **Document Title** | **Requested Date** | **Received Date** |
| No documents requested. | | | |