SEC Petition Evaluation Report
Petition SEC-00038

Report Rev # 0 Report Submittal Date 04-09-06

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Petition Administrative Summary

Petition Under Evaluation

Petition #	Petition Type	Qualification Date	DOE/AWE Facility Name
SEC-00038	83.13	September 23, 2005	Ames Laboratory

Feasible to Estimate Doses with Sufficient Accuracy?

Single Class				Multiple Classes				Determination Established for All Classes			
Yes		No	X	Yes		No	X	Yes		No	X

Petitioner Class Definition

All scientists, production workers, technicians, salaried graduate students, physical plant workers, maintenance, administrative and support staff, and subcontracted workers who worked at the Ames Laboratory, Ames Laboratory campus, and/or AEC/DOE facilities/locations including: Annex 1, the old women's gymnasium, "Little Ankeny," Chemistry Building, and/or Wilhelm Hall from January 1, 1942 through December 31, 1955.

Proposed Class Definition

Employees of the DOE or DOE contractors or subcontractors who were monitored or should have been monitored while working at the Ames Laboratory in one or more the following facilities/locations: Chemistry Annex 1 (also known as "the old women's gymnasium" and "Little Ankeny"), Chemistry Annex 2, Chemistry Building (also known as "Gilman Hall"), Research Building, or the Metallurgical Building (also known as Harley Wilhelm Hall) for a number of work days aggregating at least 250 work days during the period from January 1, 1942 through December 31, 1954, or in combination with the work days within the parameters established for one or more other classes of employees in the SEC.

Related Petition Summary Information

SEC Petition Tracking #(s)	Petition Type	DOE/AWE Facility Name	Petition Status
NONE			

Related Evaluation Report Information

Report Title	DOE/AWE Facility Name
NONE	

ORAU Lead Technical Evaluator: **(Document Owner)**	**Signature on file** *Mike Mahathy*	**4/09/2006** *Date*
Peer Review Completed By:	**Signature on file** *Lavon Rutherford*	**4/10/2006** *Date*
SEC Petition Evaluation Reviewed By:	**Signature on file** *Jim Neton*	**4/10/2006** *Date*
SEC Evaluation Approved By:	**Signature on file** *Larry Elliott*	**4/10/2006** *Date*

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Evaluation Report Summary: SEC-00038, Ames Laboratory

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 USC (EEOICPA) and 42 CFR 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-00038, qualified on September 23, 2005, requested NIOSH to consider the following class: *All scientists, production workers, technicians, salaried graduate students, physical plant workers, maintenance, administrative and support staff, and subcontracted workers who worked at the Ames Laboratory, Ames Laboratory campus, and/or AEC/DOE facilities/locations including: Annex 1, the old women's gymnasium, "Little Ankeny," Chemistry Building, and/or Wilhelm Hall from January 1, 1942 through December 31, 1955.*

NIOSH Proposed Class Definition

This evaluation defines a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. This class includes: *Employees of the DOE or DOE contractors or subcontractors who were monitored or should have been monitored while working at the Ames Laboratory in one or more of the following facilities/locations: Chemistry Annex 1 (also known as "the old women's gymnasium" and "Little Ankeny"), Chemistry Annex 2, Chemistry Building (also known as "Gilman Hall"), Research Building, or the Metallurgical Building (also known as Harley January 1, 1942 through December 31, 1954, or in combination with work days within the parameters established for one or more other classes of employees in the SEC.*

Feasibility of Dose Reconstruction

The feasibility determination for the class of employees covered by this evaluation report is governed by the requirements of the Energy Employees Occupational Illness Compensation Program Act of 2000 (EEOICPA) and 42 C.F.R. § 83.13(c)(1). This section of the rule states that "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."

NIOSH has established in this evaluation that it does not have access to sufficient information to estimate either the maximum radiation dose incurred by any member of the class or to estimate such radiation doses more precisely than a maximum dose estimate. The sum of information from the available resources is not sufficient to document or estimate the potential maximum internal and external exposure to members of the class, under plausible circumstances during the period of radiological operations at Ames Laboratory.

Health Endangerment

The health endangerment determination for the class of employees covered by this evaluation report is governed by 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 make a determination whether or not there is a reasonable likelihood that such radiation doses may have endangered the health of members of the class. The regulation requires NIOSH to assume that any duration of unprotected exposure may have endangered the health of members of a class when it has been established that the class may have been exposed to radiation during a discrete incident likely to have involved levels of exposure similarly high to those occurring during nuclear criticality incidents.

If the occurrence of such an exceptionally high level exposure has not been established, then NIOSH is required to specify that health was endangered for those 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 (excluding aggregate work day requirements).

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

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SEC Petition Evaluation Report for SEC-00038

1.0 Purpose and Scope

This report evaluates the feasibility of reconstructing doses for employees who worked at specified facilities during a specified time. It provides information and analyses germane to considering a petition for adding a class of employees to the congressionally-created Special Exposure Cohort (SEC).

This report does not provide any determinations concerning the feasibility of dose reconstruction that necessarily apply to any individual energy employee who might require a dose reconstruction from the National Institute for Occupational Safety and Health (NIOSH). This report does not make the final determination as to whether or not the proposed class will be added to the SEC (see Section 2.0).

This evaluation was conducted in accordance with the requirements of the *Energy Employees Occupational Illness and Compensation Program Act (EEOICPA)*, 42 U.S.C. §§ 7384-7385, *Procedures for Designating Classes of Employees as Members of the Special Exposure Cohort Under the Energy Employees Occupational Illness Compensation Program Act of 2000,* 42 C.F.R. pt. 83, and the guidance contained in the Office of Compensation Analysis and Support's *Internal Procedures for the Evaluation of Special Exposure Cohort Petitions,* OCAS-PR-004.

2.0 Introduction

EEOICPA and 42 C.F.R. pt. 83 require NIOSH to evaluate qualified petitions requesting the Department of Health and Human Services (HHS) to add a class of employees to the SEC. The evaluation is intended to provide a fair, science-based determination of whether or not it is feasible to estimate with sufficient accuracy the radiation doses of the class of employees through NIOSH dose reconstructions.[1]

42 CFR § 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 EEOICPA and 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, NIOSH must also make a determination whether or not there is a reasonable likelihood that such radiation doses may have endangered the health of members of the class. The regulation requires NIOSH to assume that any duration of unprotected exposure may have endangered the health of members of a class when it has been established that the class may have been exposed to radiation during a discrete incident likely to have involved levels of exposure similarly high to those occurring during nuclear criticality incidents. If the occurrence of such an exceptionally high level exposure has not been established, then NIOSH is required to specify that health was

[1] NIOSH dose reconstructions under EEOICPA are performed using the methods promulgated under 42 CFR 82 and the detailed implementation guidelines available at www.cdc.gov/niosh/ocas.

endangered for those workers who were employed for at least 250 aggregated work days either solely under the employment or in combination with work days within the parameters established for other SEC classes (excluding aggregate work day requirements).

NIOSH is required to document the evaluation in a report. For development of the evaluation report, NIOSH relies on its own dose reconstruction expertise as well as technical support from Oak Ridge Associated Universities (ORAU). Upon completion, the report is provided to the petitioners, the public, and to the Advisory Board on Radiation and Worker Health. The Board will consider the NIOSH evaluation report, together with the petition, petitioner(s) comments, and other information the Board considers appropriate, 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 decisions on behalf of HHS. The Secretary of HHS will make final decisions, taking into account the NIOSH evaluation, the advice of the Board, and the proposed decision issued by NIOSH. The petitioner(s) may also seek a review of certain types of final decisions issued by the Secretary of HHS.[2]

3.0 Petitioner Requested Class/Basis and NIOSH Proposed Class/Basis

Petition SEC-00038, qualified on September 23, 2005 requested that NIOSH consider the following class: *All scientists, production workers, technicians, salaried graduate students, physical plant workers, maintenance, administrative and support staff, and subcontracted workers who worked at the Ames Laboratory, Ames Laboratory campus, and/or AEC/DOE facilities/locations including: Annex 1, the old women's gymnasium, "Little Ankeny," Chemistry Building, and/or Wilhelm Hall from January 1, 1942 through December 31, 1955.*

The petitioner provided information and affidavit statements in support of the petitioner's belief that it is not feasible to estimate the radiation doses of this class of employees with sufficient accuracy. NIOSH considered the following information and affidavit statements to be sufficient to qualify SEC-00038 for evaluation.

> An affidavit asserted that there were periods of inadequate radiological monitoring at Ames Laboratory and periods for which radiological monitoring records and data are unavailable, respective to the operation of this facility from 1942 through 1955 (Affidavit, 2005). The petitioner's belief was justified during NIOSH's review of available monitoring data for the period of operations at Ames Laboratory from January 1, 1942 through December 31, 1955. Although limited uranium urinary excretion data (studies from 1942-1945), thorium air sampling data (from 1952-1953), personal external radiation exposure data (starting in October 1952), and area radiological monitoring data (from 1942-1943 and post 1951) exist, there are many apparent gaps in dosimetry information.

Based on its research, NIOSH revised the requested class to include two additional buildings, Chemistry Annex 2 and the Research Building; both were associated with the Atomic Energy Commission (AEC) activities at Ames Laboratory. In addition, it was identified that "Little Ankeny," the old women's gymnasium, and Annex 1 (Chemistry Annex 1) were the same building. The worker

[2] See 42 CFR 83 for a full description of the procedures summarized here. Additional internal procedures are available at www.cdc.gov/niosh/ocas.

description was also modified to include all people who worked for DOE or under DOE contractors; this includes all former AEC workers. Based on the information provided in *History and Current Radiological Condition of the Ames Laboratory* (Voss, 1979) and *An Assessment of the Causes, Mitigation Efforts, and Current Status of Thorium-232, Uranium-238, and Beryllium Contamination in Wilhelm Hall at Ames Laboratory* (Hokel, 1998), all AEC related operations were terminated at Ames by 1954. The end date of AEC operations at Ames was therefore assumed to be December 31, 1954 for the purposes of this evaluation. Therefore, the NIOSH-proposed class includes employees of the DOE or DOE contractors or subcontractors who were monitored or should have been monitored while working at the Ames Laboratory in one or more of the following facilities/locations: Chemistry Annex 1 (also known as "the old women's gymnasium" and "Little Ankeny"), Chemistry Annex 2, Chemistry Building (also known as "Gilman Hall"), Research Building, or the Metallurgical Building (also known as Harley Wilhelm Hall) for a number of work days aggregating at least 250 work days during the period from January 1, 1942 through December 31, 1954, or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

Based on the discussions with individuals who were interviewed and documentation obtained by NIOSH during research for this report, dosimetry information that would permit the performance of dose reconstructions with sufficient accuracy for the period immediately following AEC operations at Ames is available. However, as this information is outside of scope of this evaluation, based on the petitioner and proposed class definitions, further evaluation of this information has not been included in this report as to permit evaluation of the proposed class in a timely manner.

4.0 Data Sources Reviewed by NIOSH

NIOSH identified and reviewed data sources to determine the availability of information relevant to determining the feasibility of dose reconstruction for the class of employees requested by this petition. This included determining the availability of information on personal monitoring, area monitoring, industrial processes, and radiation source materials. The following sections summarize the data sources identified and reviewed.

4.1 Site Profile Technical Basis Documents (TBDs)

A site profile has not been written for Ames Laboratory. Not having a site profile does not automatically lead to a determination that dose reconstructions cannot be completed, nor is a site profile necessary to complete dose reconstructions.

4.2 ORAU Technical Information Bulletins (OTIBs)

An ORAU Technical Information Bulletin (OTIB) is a general working document that provides guidance concerning the preparation of dose reconstructions and particular sites or categories of sites. NIOSH reviewed the following OTIBs describing the methods for dose reconstruction to consider their usefulness for reconstructing doses of members of the proposed Ames SEC class:

- *OTIB: Internal Dose Overestimates for Facilities with Air Sampling Programs*, ORAUT-OTIB-0018; August 9, 2005
- *OTIB: Analysis of Coworker Bioassay Data for Internal Dose Assignment*, ORAUT-OTIB-0019; October 7, 2005

- *OTIB: Estimation of Neutron Dose Rates from Alpha-Neutron Reactions in Uranium and Thorium Compounds*, ORAU-OTIB-0024; April 7, 2005
- *OTIB: Application of Internal Doses Based on Claimant-Favorable Assumptions for Processing as Best Estimates*, ORAU-OTIB-0033; April 20, 2005

4.3 Facility Employees and Experts

NIOSH interviewed a former Health Physicist at Ames Laboratory on November 1, 2005 (Personal Communication, 2005). The health physicist reported that until the early 1950s, personal monitoring for radiological exposure was only performed as part of the annual medical physical. He believes that little or no documentation exist regarding the actual history of the Health Physics Program at Ames Laboratory for the period of 1942 through the early 1950s, which includes the time period of uranium and thorium operations. He said that during his tenure, thorium production operations were mostly limited to the Metallurgical Building (now Harley Wilhelm Hall). Some thorium research was also conducted in the Chemistry Building. He also stated that when external monitoring was put in place, everyone with a potential for external exposure was monitored. However, there was no indication of how the exposure potential was determined. The information gained from the telephone conference with a former Ames Health Physicist is consistent with the documentation reviewed by NIOSH during the evaluation of SEC Petition 00038.

NIOSH interviewed nine staff members from Ames Laboratory on October 17 and October 18, 2005. These staff members provided a history of early work performed at Ames Laboratory and also provided a walking tour of Ames Laboratory in which they discussed buildings that had been used in the MED/AEC work, or where these buildings had been located. These staff indicated that additional documentation and data had been sent several years ago to the University of Rochester, the Health and Safety Laboratory (HASL) Records Center, and Argonne West (Wessels, 2005). Records that were once stored at the University of Rochester and the HASL Records Center have since been sent to the Atlanta Records Center and the Germantown Records Center where NIOSH previously searched for Ames Laboratory documents. NIOSH identified one memorandum during the Atlanta Records Center search that discussed medical monitoring for the applicable period but no additional individual monitoring records were discovered for the period evaluated in this report. NIOSH did not locate radiological monitoring or exposure data pertinent to 1942 through 1952 operations at Ames Laboratory during the records search at the Germantown Records Center. In addition, Health and Safety staff from Ames Laboratory indicated that certain medical monitoring records may be stored in the Department of Energy (DOE) Oak Ridge Operations (ORO) records vault (Payne, 1992). NIOSH performed a search for Ames Laboratory records at the DOE ORO records vault and did discover several Ames related documents. However, none of these documents contained individual monitoring data or records pertinent to this evaluation report.

4.4 Previous Dose Reconstructions

NIOSH reviewed its dose reconstruction database, NIOSH OCAS Claims Tracking System (NOCTS), to identify dose reconstruction cases under EEOICPA that might provide information relevant to the petition evaluation. Table 4-1 provides a results summary of this review for the period of January 1, 1942 through December 31, 1954 (Data available as of: March 6, 2006).

Table 4-1: Ames Laboratory Claims Submitted Under Dose Reconstruction Rule[1]	
Description	**Totals**
Total number of cases submitted for energy employees who meet the proposed class definition criteria	36
Number of dose reconstructions completed for energy employees who were employed during the years identified in the proposed class definition[2]	2
Number of cases for which internal dosimetry records were obtained for the identified years in the proposed class definition	2
Number of cases for which external dosimetry records were obtained for the identified years in the proposed class definition	4

Note:
[1]The first AMES EEOICPA claim was received in NOCTS on May 17, 2002. This table includes claims in NOCTS dating from May 17, 2002 through March 6, 2006.
[2]One dose reconstruction was completed for an individual having both Ames and ORNL employment. However, the dose reconstruction was completed using only ORNL data.

NIOSH reviewed each individual claim to determine whether internal and/or external personal monitoring records could be obtained. NIOSH was not able to obtain personal radiological monitoring data representative of the class of workers defined in the SEC Petition for an employee represented in an individual claim that has been submitted for dose reconstruction under EEOICPA for the time period from January 1, 1942 through December 31, 1954. Twenty claims filed for this period contained medical X-ray information.

4.5 NIOSH Site Research Database

The NIOSH Site Research Database (SRDB) was reviewed for documents to support the evaluation of the proposed class. The documents identified during this review were evaluated for pertinence to this petition. Identified documents contained event histories, external dosimetry data from 1952 through 2004, air sampling/dust sampling data from 1942 and 1952, bioassay/urinalysis results from 1952 through 1953, process descriptions, materials handled, and Ames Laboratory activities from 1942 through 2004.

4.6 Ames Laboratory Website

NIOSH was granted access to the Ames Laboratory website, known as the Ames Laboratory Documents for Former Worker Program Review, which provided Adobe PDF images of Ames documents (with title, author, and year) detailing the history of Ames Laboratory, the processes used, the locations of processes, and some references to additional documents that may contain information regarding personnel health and safety (Ames Web, 2005).

4.7 ORISE Center for Epidemiologic Research Database

Medical examination data for 104 Ames Laboratory employees are available in a dataset at the Oak Ridge Institute for Science and Education (ORISE) Center for Epidemiology Research (CER) for the time period of 1943 through1947 (ORAU, 2006).

4.8 Documentation and/or Affidavits Provided by Petitioners

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

1. *Submission - Form B Standard OMB* (SEC Form B, 2005); SECIS Document ID: 9075
2. *Occupational Exposures to Thorium and Beryllium*, Paul Klevin, Ames Laboratory, Ames Laboratory, pages 1–73; SECIS Document ID: 9074
3. *The Ames Project, Administering classified research as part of Manhattan Project at Iowa State College, 1942 – 1945*, Carolyn Stilts Payne, Iowa State University, 1992, pages 1- 298; SRDB Ref ID: 18851
4. *Urinary Excretion Studies*, published in *Industrial Medicine on the Plutonium Project, Survey and Collected Papers* Edited by Robert S. Stone, M.D., McGraw-Hill Book Co. 1951, pp. 243-255; SECIS Document ID: 9087
5. Affidavit from submitter to OCAS containing notarized affidavit stating that no monitoring records exist for Ames Laboratory employees in the 1942 – 1955 period except for small subsets for limited time periods and with no documented methods or protocols; SECIS Document ID: 9119 (Affidavit, 2005).

5.0 Radiological Operations Relevant to the Proposed Class

The following subsections summarize the radiological operations at the Ames Laboratory from January 1, 1942 to December 31, 1954 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 and quantities of each radionuclide of concern, and information describing the process through which the radiation exposures of concern may have occurred and the physical environment in which they may have occurred. The information included within this evaluation report is meant only to be a summary of the available information.

5.1 Ames Laboratory Plant and Process Descriptions

In 1942, a small metallurgical research program was established at Iowa State College (now Iowa State University) for the purpose of supporting the atomic energy activities at the University of Chicago. The original contract with the Office of Scientific Research and Development included development of a process for production of large quantities of high purity uranium for use as fuel in piles (nuclear reactors) and fundamental studies of the properties of materials to be used in these piles. Work under this contract was initially conducted in the Chemistry Building. It was in this facility that a process for producing highly pure metallic uranium was developed. The process was so successful that the contract was expanded to include production of the uranium metal on a pilot plant scale. As a result, the Ames Laboratory was established and the contract was transferred from the Office of Scientific Research and Development to the Manhattan Engineer District (MED). Since 1942, the Ames Laboratory has continued to support the MED and atomic energy and nuclear development activities of the U.S. Atomic Energy Commission and its successor organizations, the Energy Research and Development Agency and the Department of Energy. However, production of uranium ended by 1946 and production of thorium materials ended by 1954 (Voss, 1979; Hokel, 1998).

In the fall of 1942, a pilot plant was set up in a remodeled single-story wooden building that had been previously used as a women’s gymnasium and also as a garage for college vehicles. This pilot plant,

which became known as Physical Chemistry Annex #1 or "Little Ankeny," was used to produce large quantities of uranium metal and to cast uranium metal into the desired/necessary shapes for use in the development of fuels for nuclear reactors. During the early years, 1942 and 1943, of operation at Physical Chemistry Annex #1, the open porch was enclosed (to control dusty operations), and additions were constructed to accommodate increases in uranium production levels and new projects (Payne, 1992). The uranium production and casting operations at the Ames Laboratory continued in Physical Chemistry Annex #1 until early 1945 when uranium production was turned over to commercial firms (IS-T 2564).

The machining of uranium metal to produce the shapes required for atomic piles resulted in large quantities of turnings and other scrap. As a result, in 1943, a method for the recovery of uranium from machining waste and scrap was developed at Ames. In 1944, a production-scale operation was established in a newly constructed one-story brick building, known as Physical Chemistry Annex #2. This uranium recovery operation continued until December 1945 (ISC-10).

Thorium was a potential alternative to uranium and plutonium as a source of "fuel" for nuclear piles (ISC-10; Hokel, 1998). Soon after start-up of the uranium production at Ames Laboratory, development of a process for producing thorium metal was initiated. In 1943, thorium production was initiated at Physical Chemistry Annex #1 facility. Refinement of the thorium process continued through late 1946. By that time, approximately 4,500 pounds of thorium metal had been produced by the Ames Laboratory (ISC-10). In 1947, Ames was declared a major AEC research facility and the primary focus of the Ames Laboratory production program shifted from uranium production to thorium production. In 1949, production of thorium was relocated to the newly constructed Metallurgy Building where production continued until 1954 (Hokel, 1998).

Beginning in 1942, along with uranium and thorium production operations, the Ames Laboratory conducted a variety of metallurgical research and bench-scale studies related to MED/AEC nuclear energy programs. Separation and purification of rare earths, such as yttrium, cerium, scandium, gadolinium, and lanthanum were the primary metallurgical research activities conducted at Ames Laboratory. The production and fabrication of beryllium crucibles and other special forms was another major operation. Ames Laboratory also conducted studies on properties of thorium and uranium alloys and corrosion-resistant coatings for uranium metal and alloys. Many of these activities continued beyond the end of World War II. The Chemistry Building was originally the site of these activities (ISC-10). In May 1947, the AEC established Ames Laboratory as one of its major laboratories for materials research. With the establishment of Ames Laboratory as one of AEC's major laboratories, the Metallurgy Building was constructed to house some of the major activities of the newly formed center. Research and development activities continued to be conducted in the Chemistry Building and in the Metallurgy Building (Hokel, 1998).

Available documents from January 1, 1942 through February 29, 1952 do not address the disposal of radioactive waste or the control and monitoring of air and liquid effluents. There are references to an incident involving the release of thorium to the sanitary drain system in the 1951/1952 time frame, resulting in contamination at the Ames City Wastewater Treatment Facility (Voss, 1979; Hokel, 1998). Uranium tetrafluoride contamination of the ground surface around Annex #1 required removal and off-site disposal of the contaminated soil (Payne, 1992).

A summary of AEC activities at Ames Laboratory during the period covered by the petition are presented in Table 5-1.

Table 5-1: Timeline of Ames Activities

Operation	Dates[1]	Building	Activity
Uranium Metal Production	February 1942 – August 1942	Chemistry	Process Development
Uranium Metal Production	August 1942 – December 1942	Chemistry	Production
Uranium Metal Production	December 1942 – August 1945	Annex I	Production
Uranium Scrap Recovery	Late 1943 – Early 1944	Chemistry	Process Development
Uranium Scrap Recovery	Early 1944 – December 1946	Annex 2	Production
Uranium Metal Casting	December 1942 – January 1945	Annex 1	Process Development and Production
Thorium Metal Production	August 1943 – June 1946	Annex 1	Process Development
Thorium Metal Production	June 1946 – Late 1949	Annex 1	Production
Thorium Metal Production	Early 1950 –December 1954	Metallurgy	Production
Studies of Plutonium Properties	Summer 1943 –December 1947[2]	Research	Research
Plutonium/Fission Product Separations	Start Date Unknown –December 1954[2]	Research and Chemistry	Research and Hot Cell Work
Thorium Metal Casting	June 1946 – Late 1949	Annex 1	Production
Thorium Metal Casting	Early 1950 – Late 1954	Metallurgy	Production
Studies of Uranium and Thorium Properties	Spring 1942 – December 1954[2]	Chemistry	Research
Development of Analytical Procedures	Spring 1943 – December 1954[3]	Chemistry	Research
Annex 1 Demolition	1953	NA	NA

Notes:
[1]Exact start/end dates may vary, depending on reference. Those listed are the most common or the apparent consensus. Also, seasons, rather than months, were often provided.
[2]No end dates provided in references. Also, no documentation to show these activities were conducted past 1954.
[3]No end dates provided in references. Also, it is reasonable to assume development of lab procedures would have continued using low level laboratory sources.

For the period evaluated in this report, the number of staff at Ames Laboratory peaked at about 600 workers. The approximate production totals for this time period included the following: uranium metal, 2,000,000 pounds; uranium scrap recovery, 600,000 pounds; and thorium metal, 130,000 pounds (through December 31, 1953). In 1953, following the termination of uranium metal production and the relocation of thorium production, the Chemistry Annex #1 was demolished. Thorium production continued to be done in the Metallurgy Building (Harley Wilhelm Hall). In 1972, Physical Chemical Annex #2 was also demolished. The Chemistry Building (currently known as Gilman Hall), the Research Building, and the Metallurgy Building are still being used by Ames Laboratory and the Iowa State University (Payne, 1992; Hokel, 1998).

5.2 Ames Functional Areas

Ames Laboratory operations included the following functional areas:

- Uranium Metal Production
- Uranium Metal Casting
- Uranium Scrap Recovery

- Thorium Metal Production
- Thorium Metal Casting
- Studies of Uranium and Thorium Properties
- Studies of Plutonium Properties
- Development of Analytical Procedures

5.2.1 Uranium Metal Production

The process for production of uranium metal, developed by Ames Laboratory, utilized the reduction of uranium tetrafluoride by calcium metal. Uranium tetrafluoride was finely ground and mixed with an excess of metal calcium powder. This mixture (or charge) was placed into a refractory-lined iron container. A fuse wire, inserted into this charge, was electrically heated to initiate a thermite reaction, which resulted in molten uranium metal and calcium fluoride. The more dense uranium collected in a "biscuit" at the bottom of the container. Later improvements to the process replaced calcium with magnesium and entailed preheating the charge before the thermite reaction was initiated. The final process was capable of producing biscuits weighing up to approximately 42 pounds. Large quantities of highly pure uranium metal were produced at a reduced cost by this process. In July 1943, the production rate peaked at approximately 130,000 pounds per month (ISC-10).

5.2.2 Uranium Metal Casting

Casting of the metal into ingot shapes was performed by placing biscuits of uranium metal into a graphite crucible, heating the metal charge in a vacuum to melt it, and allowing the liquid metal to flow from the crucible into a graphite mold. This process resulted in uranium ingots up to 100 pounds that were both cast and machined on site or were provided to other fabrication facilities to produce desired shapes for use in atomic piles (ISC-10).

5.2.3 Uranium Scrap Recovery

Machine turnings and scrap were sorted by hand to remove large pieces of uranium metal, large foreign objects, and non-uranium scrap. A magnetic separator was then used to remove magnetic impurities, such as pieces of iron. Turnings were then cut, washed, rinsed, and dried and, again, hand inspected and passed over the magnetic separator to remove foreign matter. The remaining turnings and scrap were then pressed into small briquettes about one inch long and four and a quarter inches in diameter. The briquettes were cast into larger ingots in the same manner as described in Section 5.2.1 for the biscuits of uranium metal (ISC-10). This work was isolated to Annex 2.

5.2.4 Thorium Metal Production

The initial process implemented in 1943 for producing thorium metal, developed by the Ames Laboratory, was similar to that for production of uranium metal. This process utilized the reduction of powdered thorium tetrafluoride with calcium metal. The metallic calcium was later replaced with zinc chloride and calcium fluoride. This mixture (or charge) was placed into a refractory-lined container and the reduction reaction was initiated by preheating the materials in a gas-fired furnace. The resulting thermite reaction produced a biscuit of thorium-zinc metal alloy, weighing approximately 39

pounds. Further heating of the thorium-zinc alloy drove off the zinc, leaving pure thorium metal (ISC-10).

Ames Laboratory prepared the purified feed for the reaction by dissolving thorium nitrate in nitric and oxalic acids, precipitating the thorium oxalate, drying the precipitate in trays, hydrofluorinating the precipitate to thorium tetrafluoride and crushing the thorium tetrafluoride to a fine powder. This process was used until thorium operations ceased at Ames Laboratory.

5.2.5 Thorium Metal Casting

Casting thorium into ingot shapes was performed by placing biscuits of thorium metal into a beryllia crucible, heating the metal charge in a vacuum to melt it, and allowing the liquid metal to flow from the crucible into a graphite mold. This process resulted in ingots of up to approximately 150 pounds being produced that were either machined on site or provided to other fabrication facilities to produce desired shapes for use in atomic piles (ISC-10; Kelvin, 1952).

5.2.6 Studies of Uranium and Thorium Properties

Ames Laboratory conducted a wide variety of research projects related to the chemical and physical properties of uranium and thorium. These projects included studies of the properties of thorium and uranium metal alloys, studies of thorium refractories, and studies regarding the properties of corrosion coatings for uranium metal and alloys (ISC-10; Iowa State University, date unknown). These studies also included the use of reprocessed uranium in quantities around 200 micrograms at a time. It should be noted that several employees could be working with these size samples concurrently. The work was conducted in the basement of the Chemistry Building (Fourtes, 2006).

5.2.7 Studies of Plutonium Properties

Ames Laboratory conducted laboratory studies on the physical and chemical properties of plutonium. These studies resulted in the development of techniques for separating plutonium and fission products from uranium metal and also resulted in the development of methods for analyzing plutonium, fission, and activation products. Chemical processes for large-scale separation of plutonium and fission products from the irradiated uranium power reactor fuel rods were also developed and tested.

A shielded “hot canyon” handling facility with remote manipulators, capable of handling irradiated fuel containing up to five curies of fission products, was added in the Iowa State University’s Research Building to support the separations work (ISC-10; Iowa State University, date unknown). The research work associated with plutonium ended with the termination of AEC related activities at Ames in 1954 (ISC-10; Hokel, 1998).

5.2.8 Development of Analytical Procedures

Methods for routine analysis of fission products were developed at the Ames Laboratory. These activities resulted in the discovery of previously unidentified isotopes of phosphorus-33, promethium-144, antimony-125, and five total isotopes of ruthenium and rhodium. Research on the parent-daughter relationship of strontium-90/yttrium-90 was also conducted.

Pioneering research in applications of alpha and beta spectroscopy and mass spectroscopy to identify specific radionuclides was part of the development of laboratory methods. A process for separating uranium-233 from thorium rods was also developed at Ames Laboratory (ISC-10; Iowa State University, date unknown; Iowa State University, 1961). The uranium-233 work ended with the termination of thorium processing work at Ames in 1953 (ISC-10; Hokel, 1998).

5.3 Characterization of Radiological Exposure Sources from Ames Operations

The potential sources of radiological exposure from operations that were performed at Ames Laboratory from January 1, 1942 through December 31, 1954 included uranium metal production, uranium scrap recovery, uranium and thorium metal casting, thorium metal production, uranium and thorium metal machining, and other special projects.

Uranium and thorium metal production involved several dusty operations that resulted in work-area contamination and potential worker inhalation and ingestion (ISC-10). The principal sources of surface contamination and airborne dust were from the processes of grinding uranium fluoride into a fine powder, transferring the uranium fluoride powder from the grinder, and then mixing and loading the powder charge into the reduction crucible. Because the uranium had been separated from radium and its decay chain, radon-222 was not a potential inhalation concern (ISC-10). The principal sources of thorium surface contamination and airborne dust were from the processes of preparing and drying the fine powder and mixing and loading the powder charge into the reduction crucible.

Examples of controls that were implemented at the Ames Laboratory include the use of local exhaust ventilation for potentially dusty uranium production operations. Exhaust ventilation was also provided for the general work areas at the Ames Laboratory. *Ames Research Laboratory Occupational Exposure to Thorium and Beryllium* suggests that these ventilation systems were initially considered inadequate and improvements were recommended (Klevin, 1952). Recommendations regarding surface cleaning were also made. The recommendations included replacing dry sweeping and the use of compressed air with methods that would reduce the potential for generating airborne dust (Klevin, 1952). However, the records do not clearly indicate the extent (if any) to which these recommendations were implemented.

There were also frequent small explosions and fires associated with the uranium metal production process (Payne, 1992). In *The Ames Project: Administering Classified Research as a Part of the Manhattan Project at Iowa State College, 1942-45* (Payne, 1992), it was cited that as many as six small fires occurred in a single day; these fires contributed to work-area contamination and potential airborne uranium exposures. There are no records indicating that sampling for radiation exposure associated with these fires was performed.

Personal protection used in potential dusty operations included the use of laboratory-provided clothing and gloves as well as restrictions on eating and smoking in areas where radioactive materials were handled. Although respiratory protection measures, such as gas masks and dust masks, were provided and their use was encouraged, the use of respiratory protection measures was not rigidly enforced at the Ames Laboratory. It was also indicated that personnel were recommended to shower (or bathe) at the end of the workday, but records suggest that all workers did not comply with this recommendation (Klevin, 1952; SEC Form B, 2005; Payne, 1992).

The specific sources of exposure are relayed in the following sections.

5.3.1 Alpha Particle Emissions

Alpha particle emissions from the radioactive materials handled at Ames Laboratory present the greatest potential for exposure through internal deposition via inhalation and ingestion (alpha particles do not present an external exposure hazard). The principal alpha-emitting radioactive materials associated with Ames Laboratory operations were natural uranium and natural thorium. Processed natural uranium consists of approximately equal activities of uranium-238 (4.20 MeV and 4.15 MeV alpha particles) and uranium-234 (4.77 MeV and 4.72 MeV alpha particles) (Radiological Health, 1970). There are smaller amounts of uranium-235 (approximately 1/20 of the activity levels of uranium-238 or uranium-234) with alpha particles of 4.40 MeV and 4.36 MeV. Thorium-232 emits alpha particles of 4.01 MeV and 3.95 MeV, and the natural thorium decay series includes 6 daughter products that also emit alpha particles with energies ranging from 5.34 MeV to 8.78 MeV. The abundance of these daughter product emissions depends on the state of equilibrium with the thorium-232 parent, which is, in turn, a factor of the time elapsed since the thorium process feed material was separated: a parameter which has not been determined from the review of available documents.

The preparation and loading uranium and thorium powders into reduction crucibles were dusty operations with a potential for airborne contamination and surface contamination of facilities, equipment, and personnel. Machining of metallic uranium and thorium also had a potential for producing airborne and surface contamination. Chip fires associated with uranium machining resulted in airborne contamination. Research and development on plutonium separations processes and plutonium properties presented potential exposures to plutonium-239, with alpha emissions of 5.46 MeV and 5.16 MeV. However, these operations were typically performed wet and involved smaller quantities of radioactive materials than those used for uranium and thorium production operations (Iowa State University, date unknown).

5.3.2 Beta Radiation Fields

Beta radiation was the dominant external source of radiation associated with activities involving contact with unshielded sources of uranium, such as the uranium metals production, uranium scrap recovery, and uranium machining processes at Ames Laboratory.

For processed natural uranium, the dominant beta radiation was likely from the uranium-238 decay products. The most energetic of these beta particles is 2.29 MeV from Pa-234m. Thorium metal production and machining operations also involved unshielded contact with sources of beta radiation. While thorium-232 itself does not emit beta particles, five of the daughter radionuclides in the natural thorium decay series do have beta emissions, ranging in energy up to a maximum of 2.26 MeV (Radiological Health, 1970). The abundance of these daughter product emissions depends on the state of equilibrium with the Th-232 parent, That, in turn, is a factor of the time elapsed since the thorium process feed material was separated. The ratios of thorium to daughters were not documented in the information reviewed by NIOSH for this evaluation report.

5.3.3 Neutron Exposures

Neutron exposure could have resulted from plutonium research and development activities. This work was performed in the Hot Canyon, but details on the experiments and separations are not available (ISC-10; Iowa State University, date unknown). Ames Laboratory performed varying extraction and reduction experiments, including the plutonium research, for which the neutron levels and energy spectra were not recorded or documented.

5.3.4 Photon Exposures

Photons from processed natural uranium are primarily from the Th-234 daughter of U-238 and are in the energy range of 30 – 250 KeV. There are higher energy photons – up to 1.00 MeV - from another uranium-238 daughter, Pa-234m, but the abundance of these photons is less than 1%. Thorium-232 itself has no photons; however, many of the daughter radionuclides in the natural thorium decay series do emit photons. These photons have an energy range up to a maximum of 2.61 MeV (Radiological Health, 1970). The abundance of these daughter product photon emissions depends on the state of equilibrium with the thorium-232 parent, which is, in turn, a factor of the time elapsed since the thorium process feed material was separated. This parameter has not been determined from the review of available documents.

Photon exposure rates up to 22 mR/h were reported for a thorium storage area, suggesting that this raw material for the thorium production operations was not newly separated. Research and development activities also entailed work with radioactive materials having photon emissions. The available documents do not include sufficient details of such activities to determine the levels and energies of the associated photon emissions.

6.0 Summary of Available Monitoring Data for the Proposed Class

Some personal and area monitoring data for the proposed class of Ames Laboratory employees evaluated in this report are available for intermittent periods from January 1, 1942 through December 31, 1954. These data have been compiled in the NIOSH Site Research Database and are summarized below.

6.1 Ames Laboratory External Monitoring Data

Two film badge results were identified for 1944 with results in units of “Average Roentgens/8 hour days during week” (Tyrout, 1944) which were applicable to this evaluation. No other external dosimetry data appears to be available before October 1952. In *An Assessment of the Causes, Mitigation Efforts, and Current Status of Thorium-232, Uranium-238, and Beryllium Contamination in Wilhelm Hall at Ames Laboratory* (Hokel, 1998), the AEC made a recommendation from a March 1952 study to install a personnel monitoring service which would include film badge service and radiation monitoring. Based on this recommendation NIOSH assumes that prior to that date there was not a routine external radiation monitoring program at Ames Laboratory in Wilhelm Hall, the Chemistry Building, the Research Building, Annex 1, and Annex 2.

1953 records indicate about 166 workers were monitored with a total of about 3,200 results, most of which were reported as total dose. NIOSH found over 7,800 results for about 190 workers in 1954.

These results are reported in a mixture where some have beta and gamma results and some are reported in total dose only. This data was collected at the origin of a formal monitoring program at Ames and provides general film badge and direct reading (pocket chamber) data. Although some quality check records are available, this documentation and data does not provide sufficient supporting information that relates to the early operations that were performed during the time period evaluated in this report. Therefore, further evaluation and development of this data, as it relates to the later period work, was not performed.

Although NIOSH obtained neutron monitoring results for workers in the Ames Laboratory Research Building for part of 1953 and 1954, there is no documentation to indicate these workers were involved with thorium research or other AEC sponsored activities. NIOSH discovered no evidence of individual neutron monitoring, or the acknowledgement of potential neutron exposures, prior to 1953.

The personnel interview of November 1, 2005, as described in Section 4.3, indicated that although there was no indication obtained of how exposure potential was determined, once an external monitoring program was initiated, everyone with a potential for external exposure was monitored. Based on the information reviewed for this evaluation, the formal personnel monitoring program at Ames was not fully developed until after the period evaluated in this report.

6.2 Ames Laboratory Internal Monitoring Data

A search of all documents and data available to NIOSH located limited bioassay data for the period from January 1, 1942 through December 31, 1954. As summarized below, only limited *in vitro* bioassay data, and the associated analysis of the monitoring data is available for 1942 through 1943 and 1952 through 1953.

6.2.1 Uranium Internal Monitoring

Ames Laboratory initially monitored employees for radiation exposure by medical testing to look for abnormalities in blood chemistry (Payne, 1992). This practice was discontinued in 1946 (Payne, 1992). No direct mention of radiological monitoring was identified in individual medical monitoring records. However, a specific code (the letter “T”) appears to have been used to identify uranium blood test results for Ames Laboratory employees. This was a medical test that looked for abnormal albumin results as an indicator of exposure to uranium. The 1946 Myers correspondence reports that highly exposed employees were sampled monthly by urinalysis and other employees were sampled quarterly through 1945 (Myers, 1946). Only thirty-four uranium bioassay records have been found for Ames Laboratory employees for that time period.

The thirty-four bioassay samples were collected by the Army Corps of Engineers in July, August, and September of 1944 and were analyzed for uranium (“X ion”). The analytical results ranged from 0 Mg/l to 0.3 Mg/l, but no information was provided on the method used to analyze these samples. The Army Corps of Engineers stated that at that time, no tolerance value had been established for the X ion, but that the report results were about the same as those obtained from other groups handling the same special materials (Tyrout, 1944).

In addition to these results, a uranium excretion study was performed at Ames Laboratory between 1943 and 1945 (Industrial Medicine, 1951). This study was part of a Manhattan Engineer District

(MED) study of 86 individuals exposed to different uranium compounds at Ames, Chicago, and Oak Ridge. Forty-eight individuals from Ames Laboratory were sampled. Exposure was determined to be mostly due to uranium tetrafluoride salt (green salt). Only men were sampled for the study. The individuals in the test were put into one of four groups according to their presumed exposure to uranium, with Group one (1) having the highest exposure potential and Group four (4) having the lowest. Results of the study for the four groups are shown in Tables 6-1 and 6-2.

Table 6-1: Uranium Excretion Study Results Grouped by Potential/Severity

Group 1			Group 2			Group 3			Group 4		
Sample #	**Case**	**Amount (µg/l)**	**Sample #**	**Case**	**Amount (µg/l)**	**Sample #**	**Case**	**Amount (µg/l)**	**Sample #**	**Case**	**Amount (µg/l)**
1	1	40	1	12	15	1	32	24	1	43	<3
2	1	96	2	13	17	2	33	27	2	44	<3
3	2	52	3	14	13	3	34	7	3	45	7
4	3	86	4	15	38	4	35	9	4	46	<3
5	3	50	5	16	21	5	36	19	5	47	<3
6	4	100	6	17	40	6	37	22	6	48	9
7	4	44	7	18	21	7	38	22	—	—	—
8	4	70	8	19	33	8	38	18	—	—	—
9	4	200	9	19	58	9	38	3	—	—	—
10	5	126	10	20	33	10	38	3	—	—	—
11	5	96	11	21	54	11	39	5	—	—	—
12	5	74	12	22	64	12	40	16	—	—	—
13	6	84	13	23	10	13	41	15	—	—	—
14	6	200	14	23	16	14	42	33	—	—	—
15	6	73	15	24	11	—	—	—	—	—	—
16	7	48	16	24	11	—	—	—	—	—	—
17	7	40	17	25	87	—	—	—	—	—	—
18	8	29	18	25	64	—	—	—	—	—	—
19	9	25	19	25	80	—	—	—	—	—	—
20	10	12	20	26	130	—	—	—	—	—	—
21	11	31	21	27	80	—	—	—	—	—	—
—	—	—	22	28	108	—	—	—	—	—	—
—	—	—	23	29	64	—	—	—	—	—	—
—	—	—	24	29	64	—	—	—	—	—	—
—	—	—	25	30	28	—	—	—	—	—	—
—	—	—	26	31	43	—	—	—	—	—	—
75 (average)			**46 (average)**			**16 (average)**			**<5 (average)**		

Note:
— indicates no data

Table 6-2: Results Summary for Ames Laboratory Individuals in MED Uranium Excretion Studies							
Group	Number of Individuals	Number of Samples	% of samples containing uranium per liter				
			0-10 µg	10-20 µg	20-40 µg	40-80 µg	80-200 µg
4	6	6	100	0	0	0	0
3	11	14	35	29	35	0	0
2	20	26	0	23	27	31	19
1	11	21	0	5	14	43	38

Source: Industrial Medicine, 1951

The Manhattan Engineer District performed a separate urinary excretion study of one male Ames Laboratory employee from March 1943 though June 1945 (Industrial Medicine, 1951). At that time, the Laboratory believed this employee had received the most exposure to uranium of any Ames employee at the facility, although the support for this belief was not included in the reference document. Results from 10 analyses made from September 1944 through June 1945 ranged from 24 to 200 µg/liter of uranium. Large scale operations involving uranium were curtailed at Ames Laboratory in June 1945. Results of 50 urine samples obtained after the end of exposure starting in August 1945 ranged from 5 to 10 µg/liter of uranium.

6.2.2 Thorium and Thoron Internal Monitoring

NIOSH has identified ninety bioassay (urine) samples that were collected in March 1952 by AEC and analyzed for thorium (AEC, Urine Samples; AEC, Various Samples). NIOSH has also identified approximately 70 bioassay (urine) samples were collected by AEC in 1953 and analyzed for thorium (AEC, Urine Samples; AEC, Various Samples). NIOSH did not, however, identify any thorium bioassay analysis prior to March 1952.

6.2.3 Plutonium Internal Monitoring

The potential for plutonium exposures existed during the plutonium property studies performed at Ames. The plutonium property studies were performed concurrently with the period when uranium metal processing studies occurred at Ames (through 1946). NIOSH did not identify any indication that plutonium bioassay analyses were performed for any period when the potential for plutonium exposures existed at Ames Laboratory.

6.3 Ames Laboratory Air Sampling Data

NIOSH has not located any documentation indicating that Ames Laboratory conducted a routine air sampling program for uranium, plutonium, or thorium during the period evaluated in this report. However, NIOSH did find twenty-two general area air dust (uranium) samples that were collected in a special study performed in May, June, and July of 1943 by the Army Corp of Engineers (Friedell, 1943, Iowa State College, 1943. The purpose of the sampling was not identified in the documentation associated with the sampling results. These results are shown in Table 6-3.

Table 6-3: 1943 Uranium Air Samples (General Area)					
Sampled Area	**Job Function**	**Analyte**	**Sample Date**	**Sample Flow Rate (Cu ft./min)**	**Sample Activity ($\mu g/m^3$)**
Slow Set Room	—	Not Specified	5/10/1943	3	4,360
Magnesium Room	—	Not Specified	5/10/1943	3	188
Loading Dock	—	Not Specified	5/10/1943	3	615
Near Jolter	Bomb loading	Not Specified	6/16/1943	3	2,830
Near Micro-pulverizer	Grinding (Lime, Slow Set)	Not Specified	6/16/1943	3	37,100
Near Riffle	Magnesium Processing	Not Specified	6/16/1943	3	3,420
Near Jolter	Bomb Loading	Uranium	6/28/1943	3	53.3
Near Micro-pulverizer	Grinding (Lime, Slow Set)	Uranium	6/28/1943	3	1,080
Near Riffle	Magnesium Processing	Uranium	6/28/1943	3	85
Sample Room	Metal Grinding	Not Specified	7/10/1943	3	707
Cut-off Room	Metal Cutting	Not Specified	7/12/1943	3	2,240
Slag Room	Opening Bomb	Not Specified	7/12/1943	3	3,300
Cut-off Room	Metal Cutting	Uranium	7/15/1943	3	420
Sample Room	Metal Grinding	Uranium	7/15/1943	3	63.5
Slag Room	Opening Bomb	Uranium	7/15/1943	3	153
Slag Room	Opening Bomb	Uranium	7/15/1943	3	153
Cut-off Room	Metal Cutting	Uranium	7/31/1943	3	420
Sample Room	Metal Grinding	Uranium	7/31/1943	3	63.5
Slag Room	Opening Bomb	Uranium	7/31/1943	3	153

Note:
— indicates no known data

NIOSH also has approximately 700 general air samples (thorium samples collected in an AEC study performed in March 1952 (Klevin, 1952), approximately 270 breathing zone air samples (collected during this same time frame/study), and air sampling for Wilhelm Hall (performed by Iowa State University in February 1953 (Hokel, 1998). The AEC study includes thorium, although the specific radionuclide can not be assumed without equilibrium data and thoron results (Klevin, 1952). The methodology in use at that time for estimating thoron concentrations was dependent on assumptions of thorium decay series equilibrium and equivalent sample collection efficiency for the various members of the thorium decay series present in airborne dust (Klevin, 1952). Because of the lack of

source information that would permit validation of the estimates of the actual thoron concentrations, NIOSH did not perform further evaluation of the thoron data provided in the AEC study.

6.4 Ames Laboratory Area Surveys

The March 1952 study documented in *Ames Research Laboratory Occupational Exposure to Thorium and Beryllium* (Klevin, 1952), documents alpha, beta, and gamma radiation measurements were made and documented in the thorium refining and processing areas (separate surveys of the same areas have been performed and documented in more recent years). The data demonstrate that Wilhelm Hall was contaminated from thorium operations. Further confirmation is available from a roof survey in 1984 and survey of exhaust ducts in the basement of the Hall in 1991 (Hokel, 1998). NIOSH has not located documentation indicating contamination levels in Annex 1 at the times of its demolition in 1953.

6.5 Summary of Monitoring Data

A summary of monitoring data obtained for Ames Laboratory from January 1, 1942 through December 31, 1955 is provided in Table 6-4.

Table 6-4: Summary of Monitoring Data[1] for the Ames Laboratory

	Available Data	Qualifications on Data
External Dosimetry Data	Limited monitoring data has been identified for external exposures resulting from Ames Laboratory work performed in 1953 through 1954, but no work area assignment or location has been designated in that data.	No data, applicable to reconstructing thorium or plutonium dose for the proposed class, are available for Ames Laboratory workers prior to 1953.
Neutron Dosimetry Data	No data has been identified for monitoring neutron exposure from the uranium or thorium operations or the bench scale processing of plutonium performed at Ames during the period evaluated in this report.	None
Internal Dosimetry Data	Results from a uranium excretion study in 1943 through 1945 and samples collected by the Army Corps of Engineers in 1944 for uranium exposure. Limited data on thorium and thoron exposures are available for the period of March 1952 through 1953.	No data, applicable to reconstructing thorium or plutonium dose for the proposed class, are available for Ames Laboratory workers prior to 1952.

Table 6-4: Summary of Monitoring Data[1] for the Ames Laboratory		
	Available Data	**Qualifications on Data**
Air Sampling/ Environmental Sampling Data	Limited air (dust) sampling data is available for uranium operations in 1943. These uranium samples were taken in 1943.	Limited thorium/ thoron and no plutonium (pre-1947) air sample results exist for the period prior to March 1952. Limited data are available for the period of March 1952 through 1953.

Note:
[1]Summary is for January 1, 1942 through December 31, 1954

7.0 Feasibility of Dose Reconstruction for the Proposed Class

The feasibility determination for the proposed class of employees covered by this evaluation report is governed by EEOICPA and 42 CFR § 83.13(c)(1). Under this Act and rule, NIOSH must establish whether or not it has access to sufficient information to either, 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, then it would be determined that it was feasible to conduct dose reconstructions.

In making determinations of 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 not, NIOSH systematically evaluates the sufficiency of different types of monitoring data, process and source or source term data, which together or individually might assure NIOSH can estimate either the maximum doses members of the class might have incurred, or more precise quantities that reflect the variability of exposures experienced by groups or individual members of the class. This approach is specified in the SEC Petition Evaluation Internal Procedures available at www.cdc.gov/niosh/ocas.

The evaluation that follows examines separately the availability of information necessary for reconstructing internal and external radiation doses of members of the proposed class.

7.1 Analysis of Data Sufficiency and Reliability

Performing internal and external dose reconstructions requires worker monitoring data or source term and process information. Worker monitoring data includes data from members of the proposed class as well as data from workers outside the proposed class who were performing jobs with higher exposure potentials. Using worker monitoring data provides a means of calculating claimant-favorable and maximum potential radiation doses for class members who were unmonitored or have gaps in their monitoring records. In the case of this evaluation, the thorium and plutonium data sets are insufficient to permit a complete evaluation for the purposes of estimating internal and external

exposures with sufficient accuracy for members of the proposed class. Therefore, further evaluation of the pedigree of any of the data (including the uranium data) was not performed.

7.2 Internal Radiation Doses at Ames Laboratory

The principal source of internal radiation doses for members of the proposed class would have been due to inhalation and ingestion of radiological contaminants during the performance of pilot projects, uranium laboratory and production activities, and thorium laboratory and production activities. Other potential sources of internal exposure at Ames Laboratory included bench scale work associated with plutonium separation experiments.

Information in the NIOSH Site Research Database, information obtained from the Ames Laboratory website, and information in the affidavit provided by the petitioner indicates a substantial potential for internal exposure hazard from thorium and uranium (and their progeny) while performing work at the Ames Laboratory. In addition, the potential for thoron exposures existed during the time period evaluated in this report. The potential for these exposures is supported by the radiological conditions discovered during the performance of more recent contamination surveys and 1988 decontamination efforts at the Ames Laboratory facilities (Hokel, 1998). The authors of *An Assessment of the Causes, Mitigation Efforts, and Current Status of Thorium-232, Uranium-238, and Beryllium Contamination in Wilhelm Hall at Ames Laborato*ry (Hokel, 1998) assumed that the spread of contamination was (at least in part) a result of airborne contaminants transported throughout the Ames Laboratory facilities as a result of the radiological activities that occurred from January 1, 1942 until thorium operations was discontinued in 1954.

Limited individual monitoring records are available for uranium exposures, and no individual monitoring records are available for thorium or plutonium exposures at Ames Laboratory from January 1, 1942 through February 1952. Limited individual and area results for thorium and thoron sampling are available after that period but the data are not sufficient for reconstruction of internal doses. As a result of these limitations and changes in processes and exposures prior to the 1952 monitoring, and with routine monitoring beginning in the 1954-1955 timeframe, NIOSH cannot establish a maximum internal exposure scenario that addresses all of the internal exposure potential for the petitioning class, and therefore cannot estimate their internal doses with sufficient accuracy. The subsections below summarize the extent and limitations of information available for reconstructing the internal doses of members of the class evaluated in this report.

7.2.1 Process-related Internal Doses at Ames Laboratory

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

7.2.1.1 Urinalysis Information and Available Data

Ames Laboratory initially monitored employees for radiation exposure by medical testing to look for abnormalities in blood chemistry (Payne, 1992). This practice was discontinued in 1946 (Payne, 1992). No direct mention of radiological monitoring was identified in individual medical monitoring records. However, a specific code (the letter “T”) appears to have been used to identify uranium blood test results for Ames Laboratory employees. This was a medical test that looked for abnormal albumin

results as an indicator of exposure to uranium. The 1946 Myers correspondence reports that highly exposed employees were sampled monthly by urinalysis and other employees were sampled quarterly through 1945 (Myers, 1946).

The data from the uranium excretion studies for the workers at the Iowa State College, summarized in Section 6 of this report, were reviewed for their potential application in reconstructing dose for the class in this petition. This excretion study also included an evaluation of the highest exposed individual at Ames for the period of September 1944 to July 1945. This individual's exposures ranged from 24 to 200 µg/l (Industrial Medicine, 1951).

Although this uranium internal data would be useful in estimating internal uranium doses for Ames workers, further development/evaluation of this data as not performed based on the lack of thorium and plutonium data for the same time period, which prevents bounding/establishing a maximum internal exposure scenario for the proposed class evaluated in this report.

Routine air monitoring data can be used to support development of an internal exposure model. As discussed in Section 6, NIOSH has uranium air sample data from 1943 and thorium air sample data from 1952. No air sampling data was available for any plutonium activities. Based on NIOSH's review of the available data, there is no indication that a routine air sampling or monitoring program existed at Ames prior to 1953. After review of the air sample data, NIOSH has determined the data does not provide sufficient information to support establishing a bounding exposure scenario. As a result, the estimation of doses resulting from internal exposures to uranium, thorium, thoron, or plutonium, from the available air monitoring data, for the period of January 1, 1942 through December 31, 1954 can not be reconstructed or estimated with sufficient accuracy for the proposed class defined in this evaluation.

7.2.2 Ambient Environmental Internal Radiation Doses at Ames Laboratory

There is no evidence that any environmental or ambient air monitoring for the purpose of internal exposure assessment was performed at Ames Laboratory prior to March 1952. As discussed in Section 8.2.2, some thorium and thoron area air sampling was performed for a limited time frame after that period. Given the lack of adequate process-related air monitoring data and bioassay data, NIOSH did not further evaluate the feasibility of dose reconstruction for environmental/ambient exposures received at Ames during the period evaluated in this report.

7.3 External Radiation Doses at Ames

The principal source of external radiation doses for members of the proposed class would have been due to exposures to photon (gamma) and electron (beta) radiation. Likely, the primary source of gamma radiation exposures would have been from the thorium activities. The primary source of beta radiation exposures would have been from the uranium activities. As discussed in Section 6, neutron exposures are also possible.

Other than two film badge monitoring results from 1944, no individual external monitoring records are available for the class of Ames Laboratory workers who worked during the period from January 1, 1942 through September 1952. Although NIOSH has some source term information for this period, this information is inadequate to reconstruct maximum exposure scenarios. The limited data available

for the period from October 1952 through December 31, 1954 are also inadequate for estimating doses from external exposures with sufficient accuracy. The subsections below summarize the extent and limitations of information available for reconstructing the external doses of members of the class evaluated in this report.

7.3.1 Process-related External Radiation Doses at Ames Laboratory

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

7.3.1.1 Beta and Gamma Characterization

As discussed in Section 5, the most dominant source of beta radiation was associated with uranium work, primarily hands-on work associated with unshielded processing and machining work that occurred until 1946 at Ames. The specific source of beta radiation from this work was from the uranium-238 decay products. The most energetic of these beta particles was 2.29 MeV. In addition, the potential for beta exposures also existed during unshielded production and machining of thorium. This beta exposure would have been due to emissions from thorium daughter radionuclides ranging in energy up to a maximum of 2.26 MeV (Radiological Health, 1970). As previously discussed throughout Sections 5, 6, and 7, source term information relating to thorium operations and processing, which prevents the identification of the ratios or abundance of thorium daughters, is not adequate to permit reconstructing dose for the proposed class with sufficient accuracy.

Gamma radiation from processed natural uranium is primarily from the thorium-234 daughter of uranium-238 and is in the energy range of 30 KeV – 250 KeV. There are higher energy photons, up to 1.00 MeV, from another uranium-238 daughter, protactinium-234m. However, the abundance of these photons is less than 1%. Thorium-232 itself has no photons, but many of the daughter radionuclides in the natural thorium decay series do emit photons. These photons have an energy range up to a maximum of 2.61 MeV (Radiological Health, 1970), which could be assumed for dose reconstruction. However, the abundance of these daughter product photon emissions depends on the state of equilibrium with the thorium-232 parent, which is, in turn, a factor of the time elapsed since the thorium process feed material was separated. NIOSH does not have this information, and cannot estimate the quantity of these daughter product photon emission from thorium daughter radionuclides.

7.3.1.2 Neutron Field Characterization

The work associated with plutonium and the research associated with thorium and uranium in the laboratories had the highest potential for exposure to neutrons. While the potential for exposure to neutrons existed at Ames Laboratory, NIOSH has insufficient details, relating to source term information for the plutonium work or enrichment information relating to the thorium or uranium work, to characterize the possible neutron field or energies. NIOSH does not have this information, and cannot estimate the potential neutron exposures for this proposed class as evaluated in this report.

7.3.1.3 External Monitoring

There is no evidence that sufficient beta-gamma external radiation exposure monitoring (through personal dosimetry) or area radiation monitoring applicable to evaluating personnel external

exposures was performed for any Ames Laboratory personnel prior to October 1952.External exposure data, mostly penetrating, is available for some workers starting in October 1952. Although a health physicist who worked at Ames Laboratory indicated that everyone with exposure potential was monitored, data were not found for all potentially exposed workers.

Based on the knowledge of the processes and types of uranium handled at Ames coupled with the available data from other uranium processing facilities, sufficient uranium data exist. However, NIOSH did not proceed with the development of a uranium scenario because external doses from beta and gamma radiation resulting from exposure to thorium and its daughters or plutonium cannot be reconstructed due to the lack of information on the percentage of thorium daughter in-growth (up to 1954 when thorium operations ceased). Based on the limitations with the external exposure information, the conclusion is that NIOSH cannot bind the total external exposures or establish a sufficiently accurate dose reconstruction method for members of the proposed class evaluated in this report.

7.3.2 Ambient Environmental External Radiation Doses at Ames Laboratory

There is no evidence that any environmental or ambient external radiation exposure monitoring was performed for any Ames Laboratory area prior to March 1952. As discussed in Section 8.1, some limited external dosimetry data was available after that period. Given the lack of adequate process-related external exposure monitoring data, NIOSH did not further evaluate the environmental/ambient exposures received at Ames during the period evaluated in this report.

7.3.3 Ames Laboratory Occupational X-ray Examinations

As revealed in the NIOSH review of the current individual claims, twenty claims, for the timeframe evaluated in this report, contained medical X-ray information. However, the data supplied by DOE for these claims does not always indicate the purpose of the medical X-rays (whether the X-rays were pre-employment, routine, or non-routine). Based on a review of the claims for those cases where X-ray information exists, each employee in the class had (or should have had) a pre-employment chest X-ray, an annual chest X-ray, and an annual pelvic fluoroscopy exam. This is supported by the information in the PhD dissertation of Carolyn Stilts Payne and a memorandum concerning the progress of the Special Materials Division of the Medical Section (Payne, 1992; Ferry, 1944). In addition, to the pre-employment X-rays, termination chest X-rays were also given (Myers, 1946). Employees that worked with beryllium were given monthly x-rays through 1946 (Myers, 1946). Payne reported that employees also received annual chest x-rays (Payne, 1992).Employees handling fluorides, which would include at least some members of the proposed class, also received pre-employment and annual pelvic X-rays as a condition of employment. An upper bound for exposure for occupational medical X-rays can be established using the procedure titled *Occupational X-Ray Dose Reconstruction for DOE Sites*, as well as the stated requirements for pre-employment and annual X-rays.

In summary, NIOSH can reconstruct the medical X-ray dose for the class of Ames Laboratory workers in the class defined in this evaluation report with sufficient accuracy. All workers would be assigned pre-employed chest X-rays and termination chest-X-rays to all workers. Employees working with beryllium from 1942 through 1946 would be assigned monthly chest X-rays. Employees

handling fluorides would be assigned annual pelvic X-rays. Starting in 1950, all workers would be assigned annual chest X-rays.

7.4 Evaluation of Petition Basis for SEC-00038

The petition basis provided in petition SEC-00038 was that there were periods of inadequate and/or lack of monitoring.

Based on the description of processes and exposure scenarios in Section 5, workers involved in each of those processes should have been monitored for external (beta and gamma) exposures and for internal exposures to radionuclides, particularly uranium and thorium-232 and its daughters. As discussed in Section 6, very little monitoring data exist. Although it appears that internal doses from exposures to uranium production and casting can be reconstructed, external exposures resulting from production and casting of thorium metal for 1953 and 1954 cannot be reconstructed. Doses for all workers resulting from exposures to occupationally required medical X-rays can be reconstructed. There is insufficient monitoring data and source term information to reconstruct all other doses with sufficient accuracy. Therefore, NIOSH finds that the petition basis has been supported.

7.5 Summary of Feasibility Findings for Petition SEC-00038

This report evaluated the feasibility for completing dose reconstructions for employees at Ames Laboratory from January 1, 1942 through December 31, 1954. NIOSH found that the monitoring records, process descriptions and source term data available are not sufficient to perform complete dose reconstructions for the proposed class of employees.

Table 7-1 summarizes the results of the feasibility findings at Site Name for each exposure source for the time period January 1, 1942 through December 31, 1954.

Table 7-1: Summary of Feasibility Findings for SEC-00038

Source of Exposure	Dose Reconstruction is Feasible	Dose Reconstruction is NOT Feasible
Internal		X
-Uranium	X	
-Thorium/Plutonium		X
-Thoron		X
External		X
-Uranium Beta-Gamma	X	
-Thorium/Plutonium Beta-Gamma		X (except 1953 and 1954)
-Neutron		X
-Occupational Medical X-ray	X	

8.0 Evaluation of Health Endangerment for Petition SEC-00038

The health endangerment determination for the class of employees covered by this evaluation report is governed by EEOICPA and 42 CFR § 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. The regulation requires NIOSH to assume that any duration of unprotected exposure may have endangered the health of members of a class when it has been established that the class may have been exposed to radiation during a discrete incident likely to have involved levels of exposure similarly high to those occurring during nuclear criticality incidents. If the occurrence of such an exceptionally high level exposure has not been established, then NIOSH is required to specify that health was endangered for those 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.

This NIOSH evaluation did not identify any evidence from the petitioners or from other resources that would establish that the above class was exposed to radiation during a discrete incident or similar conditions resulting from the failure of radiation exposure controls and likely to have produced levels of exposure similarly high to those occurring during nuclear criticality incidents. NIOSH is not aware of any report of such an occurrence at the facility during this period. NIOSH finds the primary radiation exposure hazards to employees resulted from episodic inhalations of radionuclides, and from unmonitored exposures to beta, gamma and neutron radiation that cumulatively resulted in chronic exposures. Consequently, NIOSH is specifying that health was endangered for those workers covered by this evaluation who were employed for a number of work days aggregating at least 250 work days within the parameters established for this class or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

9.0 NIOSH Proposed Class for Petition SEC-00038

This evaluation defines a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. This class includes employees of the DOE or DOE contractors or subcontractors who were monitored or should have been monitored while working at the Ames Laboratory in one or more of the following facilities/locations: Chemistry Annex 1 (also known as “the old women’s gymnasium” and “Little Ankeny”), Chemistry Annex 2, Chemistry Building (also known as “Gilman Hall”), Research Building, or the Metallurgical Building (also known as Harley Wilhelm Hall) for a number of work days aggregating at least 250 work days during the period from January 1, 1942 through December 31, 1954, or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

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