SEC Petition Evaluation Report
Petition SEC-00018

Rev # 0 Submittal Date: 06-13-2005

Petition Administrative Summary											
Petition Under Evaluation											
Petition #		Petition Type		Submittal Date		DOE/AWE Facility Name					
SEC-00018		83.13		02-24-05		Y-12 Plant					
Feasible to Estimate Doses with Sufficient Accuracy?											
Single Class				Multiple Classes				Determination Established for All Classes			
Yes		No	X	Yes		No		Yes	X	No	

Initial Class Definition
All Control Operators that worked in building 9201-5 and the Beta Building at Y-12 from January, 1944 through December, 1945.

Proposed Class Definition (Abbreviated)
All DOE, DOE contractors, or subcontractors, or AWE employees who worked in uranium enrichment operations or other radiological activities at the Y-12 facility in Oak Ridge, Tennessee from March, 1943 through December, 1947.

Related Petition Summary Information			
SEC Petition Tracking #(s)	Petition Type	DOE/AWE Facility Name	Petition Status
SEC-00026	83.13	Y-12 Plant	Evaluation Completed
SEC-00028	83.13	Y-12 Plant	Evaluation in Progress

Lead Technical Evaluator:	**Signature on File** *LaVon Rutherford*	**6/10/2005** *Date*
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Approved By:	**Signature on File** *Larry J. Elliott*	**6/13/2005** *Date*

Evaluation Summary

This evaluation report by the National Institute for Occupational Safety and Health (NIOSH) covers a class of employees proposed for addition to the Special Exposure Cohort (SEC) in Petition 00018, which qualified for evaluation on February 3, 2005. This petition requested NIOSH to consider all "control operators" that worked in building 9201-5 and the Beta Building at the Y-12 facility in Oak Ridge, Tennessee from January 1944 through December 1945. Subsequently, two additional petitions on behalf of employees at the Y-12 facility qualified for evaluation. Petition 00028 qualified for evaluation on April 29, 2005; the initial proposed class definition was "all steamfitters, pipefitters and plumbers who worked at Y-12 from October, 1944 through December, 1957." Petition 00026 qualified for evaluation on May 9, 2005; the initial proposed class definition was "all Tennessee Eastman Corporation employees at the Y-12 Plant that conducted laboratory equipment cleaning work from 1943 through 1947." Based on knowledge of facility records and information available for years prior to and after the petition class time frames and the operating years of the calutrons, the evaluation was expanded to cover the entire "calutron" period of uranium enrichment operations at the Y-12 facility. In addition, the class start date was established based on the completion of the Pilot Plant building shell in March 1943. Therefore, this evaluation covers the time period of March 1943 through December 1947.

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 lacks 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. Although NIOSH has completed dose reconstructions for workers employed during the 1943 – 1947 time period, these reconstructions were either for individuals who worked in areas and operations not involving radioactive materials and exposures or they were for individuals for whom the limited information available to NIOSH was sufficient for dose reconstruction, based on the type of cancer the individual incurred and the individual's complete work history, which may have involved work during other time periods and other facilities. NIOSH is not able to estimate the maximum internal radiation doses, however, for all cancer types for members of the class specified under the class definition established by NIOSH below. Specifically, members of this class may have had intakes of uranium compounds associated with calutron operations, for which existing area monitoring data and source term and process information are inadequate to estimate maximum radiation doses. In addition, members of this class may have had intakes of radionuclides and external radiation exposures associated with other radiological activities occurring during the petition time period, as mentioned in a 1946 TEC History report including:

- Developing and distributing beneficial radioactive isotopes,
- Developing a neutron monitor and testing the monitor with a neutron source,
- Maintenance and use of a large ^{226}Ra sealed source for radiographic examinations, and
- Extraction of Thorium.

There are no area monitoring data, source term, or process information for these radiological activities to estimate the maximum radiation doses associated with these activities. On these bases, NIOSH finds that it is not feasible to estimate radiation doses with sufficient accuracy for members of the class.

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).

This 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, as described above. NIOSH is not aware of any report of such an occurrence at the facility until 1958. NIOSH finds the primary radiation exposure hazard to employees involved in the calutron activities resulted from episodic inhalations of radionuclides that cumulatively result in chronic exposures. Members of the class involved in other radiological activities would also have incurred internal and external chronic radiation exposures. Consequently, NIOSH has specified 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.

Proposed Class Definition

This evaluation defines a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy and whose health may have been endangered by such radiation doses. This class includes employees of DOE or DOE contractors or subcontractors who worked in uranium enrichment operations or other radiological processes at the Y-12 facility in Oak Ridge, Tennessee during the period from March 1943 through December 1947 and who were employed for a number of work days aggregating at least 250 work days or in combination with work days within the parameters (excluding aggregate work day requirements) established for classes of employees presently included in the SEC. Under this proposed class definition, "working in uranium enrichment operations or other radiological activities" means any work in which the employee might have been routinely present, during the specified period, within the uranium enrichment buildings or other buildings where radiological activities occurred.

1.0 Purpose

The purpose of this report is to provide an evaluation of the feasibility of reconstructing the doses for employees who worked in uranium enrichment operations or other radiological activities at the Y-12 facility in Oak Ridge, Tennessee from March 1943 through December 1947. The evaluation was initially based on SEC Petition 00018 which defines a class limited to "All Control Operators that worked in Building 9201-5 and the Beta Building at Y-12 from January 1944 through December 1945." Subsequently, two additional petitions on behalf of employees at the Y-12 facility qualified for evaluation. Petition 00028 qualified for evaluation on April 29, 2005; the initial proposed class definition was "all steamfitters, pipefitters and plumbers who worked at Y-12 from October, 1944 through December, 1957." Petition 00026 qualified for evaluation on May 9, 2005; the initial proposed class definition was "all Tennessee Eastman Corporation employees at the Y-12 Plant that conducted laboratory equipment cleaning work from 1943 through 1947." Based on information obtained regarding data availability for the period during which uranium was enriched at the facility using "calutrons," NIOSH expanded the scope of this evaluation to cover the entire period of these operations and all buildings where these or other radiological operations occurred from 1943 through 1947.

This evaluation was conducted in accordance with the requirements of EEOICPA, 42 C.F.R. pt. 83 and the guidance contained in NIOSH's Internal Procedures for SEC Evaluations, OCAS-PR-004. It provides information and analyses germane to considering a petition for adding a class of employees to the SEC. It does not provide any determinations concerning the feasibility of dose reconstruction that necessarily apply in the particular case of any individual energy employee who might require a dose reconstruction from NIOSH.

2.0 Introduction

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,* requires NIOSH to evaluate qualified petitions requesting 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] If it is not feasible, the regulation requires NIOSH to make a determination with respect to the health endangerment of the class of employees.

NIOSH is required to document the evaluation in a report, which is provided to the petitioners and to the Advisory Board on Radiation and Worker Health. The Board will consider the NIOSH evaluation report, together with the petition, comments of the petitioner(s) and such other information as 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,

[1] 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 www.cdc.gov/niosh/ocas.

and the proposed decision issued by NIOSH. As part of this final decision process, the petitioner(s) may seek a review of certain types of proposed decisions issued by NIOSH.[2]

This NIOSH report provides a summary of the methods and findings of the NIOSH SEC petition evaluation for employees of DOE or DOE contractors or subcontractors who worked in uranium enrichment activities or other radiological processes at the Y-12 Plant in Oak Ridge, Tennessee over the period of operation from March 1943 through December 1947. The Y-12 facilities' primary mission during this time period was the enrichment of uranium using an electromagnetic isotope separator known as a calutron.

3.0 Initial Class Definition and Petition Basis

SEC Petition 00018, qualified on February 3, 2005, requested HHS to consider the addition to the SEC a class of employees including all control operators that worked at Y-12 in Oak Ridge, Tennessee in building 9201-5 and the Beta Building from January 1944 through December 1945. The petitioner, who worked at the facility during this time period, asserted by affidavit that the petitioner did not receive or witness monitoring of radiation exposures or radiation doses of control operators. Records available to NIOSH support the petitioner's statement that such employees were not personally monitored by radiation badges, urinalysis, or other means. Although the facility did have a program of area monitoring during the time period specified, a review by NIOSH of the records from this program had already identified concerns about their adequacy for dose reconstruction for the time period during which the calutrons (discussed below) and associated radiological operations were in operation, from March 1943 through December 1947. Accordingly, the evidence provided by the petitioner qualified the petition for further consideration by NIOSH, the Board, and HHS and NIOSH expanded the scope of the evaluation to cover the entire period from March 1943 – December 1947 and to cover all employees with apparent potential for radiation exposures.

4.0 Data Resources

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

Site Profile or Technical Basis Documents

NIOSH reviewed portions of the site profile NIOSH issued on November 24, 2004 for the facility covered by the petition: *Technical Basis Document for the Y-12 National Security Complex – Y-12 Site Profile* (ORAU 2004d). The Technical Basis Documents (TBDs) contained within this Site Profile 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 facility.

Previous Dose Reconstructions

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

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 1 below provides a results summary of this review for the March 1943 – December 1947 time frame.

Table 1: Y-12 Claims Submitted Under Dose Reconstruction Rule for 1943-1947

Description	Total
Number of cases submitted for energy employees who meet the revised class definition employment period criteria.	810
Number of dose reconstructions completed for energy employees who were employed at Y-12 during the years identified in the revised class definition.	135
Number of cases for which internal dosimetry records were obtained for the identified years in the revised class definition.	0
Number of cases for which external dosimetry records were obtained for the identified years in the revised class definition.	0

NIOSH reviewed each claim to determine whether NIOSH had been able to obtain internal and/or external personal monitoring records on the employee or area monitoring data that could be used in the place of personal data. NIOSH had not been able to obtain any personal monitoring records but had obtained some area monitoring data for use in conducting dose reconstructions. NIOSH also reviewed the interviews conducted with claimants for these cases to determine whether they had provided relevant information for dose reconstruction. The interviews provided some information that might be useful for dose reconstructions (i.e., work locations, hours worked, and hazards encountered).

The 135 cases for which NIOSH has completed dose reconstructions involving employees who worked for Y-12 during (but not limited to) the March 1943 – December 1947 "calutron" period involved circumstances that allowed for the use of either an overestimating or an underestimating dose reconstruction methodology, as described in NIOSH internal procedure OCAS-PR-003, *Performing and Reporting Dose Reconstructions*. These methods make use of relatively limited and case-specific information that are not necessarily sufficient to demonstrate the feasibility of estimating radiation doses for a class of employees, which may include individuals for whom these methods are inappropriate.

More specifically, the overestimating methodology uses overestimates of radiation exposures to limit the need for additional research and analysis for cases that apparently did not involve a compensable level of radiation dose and, hence, for which a more precise determination of the doses received by the employee would delay without any benefit to the claimants the completion of the dose reconstruction and the resolution of the related claims. The underestimating methodology similarly uses underestimates of radiation exposures to limit the need for additional research and analysis, but in this case the dose reconstruction process is abbreviated at the point it becomes apparent that the case involved a compensable level of radiation dose, allowing the claimants to be compensated more expeditiously. Neither of these methods is useful when only a comprehensive and maximally detailed dose reconstruction can establish whether or not the individual incurred a compensable level of radiation dose.

NIOSH and ORAU Research Documents

The NIOSH and ORAU site research databases were reviewed for documents to support the evaluation of the petitioning class. The documents identified for review from this search are listed in Attachment 1. The reports include information on dust studies, radon sampling, dose rate surveys, urinalysis data, the radiological control program, medical monitoring, feed materials, and process description information for the Y-12 site.

Documentation and/or affidavits provided by the Petitioners

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

1) An affidavit received on November 24, 2004 from the petitioner documenting the petitioner's belief that neither area nor personal radiation monitoring was conducted for the proposed class of employees. [SEC 00018]
2) Documents received on February 8, 2005 from the petitioner indicating that radiation exposures and doses to members of the initial proposed class were not monitored, including technical reports that identified dosimetry and related information that are unavailable. [SEC 00026]
3) An affidavit received on March 28, 2005 from the petitioner documenting the petitioner's inability to obtain monitoring records for certain members of the initial proposed class of employees. [SEC 00028]

5.0 Summary of Available Monitoring Data

Only area monitoring techniques were used to measure and provide data to support the control of radiation exposure to workers during the March 1943 – December 1947 operating period. No personal internal or external monitoring data are available for Y-12 employees working prior to 1948 (Souleyrette, 2003). The area monitoring data include condenser R chamber results measuring external penetrating exposures adjacent to the control cubicles in the alpha- and beta-calutron buildings and approximately 900 records of area monitoring results on radiological dust concentrations associated with the various uranium enrichment processes.

Several retrospective radiological exposure studies have been conducted at Y-12 in the past. [See the ORAU Centers for Epidemiologic Research site reports: http://www.orau.gov/cer/reports.htm] Records used in these studies have been retrieved, maintained, and are available for use to reconstruct certain radiation doses.

Condenser R Chamber Measurements

Records indicating a concern about exposure to X rays for personnel adjacent to the calutrons were located commencing August 11, 1943 (Sterner 1943, Hall 1943, Schmidt 1944a and 1944b, Hull 1944, Marks 1944a and 1944b, Brosemer 1944). This radiation was generated primarily from the rectifier units within high voltage circuitry of the calutrons. Initial exposure measurements appear to have been made using Kodak photographic film (Sterner 1943). Hall (1943) refers to exposure measurements that had been made indicating elevated X-ray exposures both in front (cubicle operator's position) and back sides of the cubicles. Metal shielding had been installed over the glass on the back side of the cubicle in response to these measurements. Apparently, General Electric conducted similar tests that were in the "same order of magnitude" as the earlier measurements. Later, Marks (1944a 1944b) conducted measurements using 0.25 R, condenser R chambers (Victoreen Manufacturing Co.). These measurements indicated that, due to variations in the rectifier tubes, there were similar variations in exposures adjacent to the cubicles, but that typically the position of the control operators in front of the cubicle did not exceed the 0.1 R/d tolerance level. The maximum safe stay-time next to the rear doors of the cubicle was 4 hours in a day (Schmidt 1944a). These measurements taken sporadically during the evolving development of the calutrons indicated that the external radiation exposure hazard from the rectifier tubes (X ray) was known in the Fall of 1943. It is not clear when engineering controls were initiated, but most of the monitoring conducted in the spring of 1944 was conducted to test what appears to have been "sight glasses" for the operators. Measurements were conducted with no glass present, regular glass, "ruby" glass, and lead glass. At some time during the operation of the calutron units prior to 1944, lead glass was installed in the operator area and measured exposure rates were reported as "negligible" (Kerr 2005). Additional information (Tankersley 2005) indicated that leaded glass was installed at the viewing ports to reduce exposure rates at that location to less than the tolerance level. Documentation also indicates there was a "metal back, which is always in place when the cubicle is in operation" that reduced exposure rates to "0.1 - 0.2 R/d." The maximum dose rate to which a worker could be exposed appears to have occurred at the window or viewing ports.

Area Dust Monitoring Data

Dust concentration measurements were first performed at the Y-12 plant in May 1944; however a formal air dust monitoring program was not established until April 1945. Prior to the establishment of the program, samples were collected only at selected locations. The samples were initially collected using a “polaragraph” supplied by Eastman Kodak and later via ionization chambers.

The formal dust monitoring program established in 1945 provided a system for monitoring all production buildings. Each building was divided into separate sections or rooms in which permanent monitoring stations utilizing air filtration collection devices were placed. Based on the documents reviewed, sampler locations were chosen to be proximate to locations where personnel spent the majority of their time. In addition to routine monitoring, some monitoring targeted specific operations. However, all dust monitoring conducted from 1944 through 1947 appears to have consisted of general area air sampling, based on the sampling documentation available. NIOSH has not located documentation indicating that any of the samples measured breathing zone exposures. NIOSH also lacks information on the frequency of the sampling during this period. An ORAU report (ORAU 2001) does indicates that workers employed at the Y-12 Plant from 1943-1947 had a high potential for internal intakes because of the processes performed at the facility and the dust monitoring data is consistent with this report. The data indicates that uranium dust was a substantial exposure problem and indicates the relative differences in exposure levels for different areas and operations. Sampling results for some operations indicated essentially no dust exposure hazards during most sampling periods. For example, calutron operators appear to have been exposed to very little or no contaminated dust during normal operating conditions, which is consistent with the fact that the interior of the calutrons was maintained in a vacuum state during their operation. However, concentrations of several hundred and several thousand percent above the calculated maximum air concentration (MAC) were measured during some calutron cleaning and uranium recycling operations.

NIOSH has not located any area dust monitoring for the other radiological processes covered under Section 6.1.4 of this report.

6.0 Summary of Radiological Operations Relevant to the Class

The following subsections summarize the radiological operations at the Y-12 facility from March 1943 to December 1947 and the information available to NIOSH to characterize particular processes and radioactive source materials. The principal source of information for these sections is the Y-12 site Profile (ORAU 2004d) which contains process and source descriptions. It also presents available information regarding the identity and quantities of each radionuclide of concern, as well as information describing the process through which the radiation exposures of concern may have occurred and the physical environment in which they may have occurred.

6.1 Plant and Process Descriptions

The Y-12 Plant, now the Y-12 National Security Complex, was initially constructed in the fall of 1942 by engineers of the Manhattan Engineering District (MED) of the U.S. Army corps of Engineers. The specific mission of Y-12 was to separate fissionable isotopes of uranium (^{235}U) from uranium feedstock, using an electromagnetic separation process within a "calutron", for use in the Hiroshima atomic bomb. The Y-12 Plant is located at the eastern section of the Oak Ridge Reservation in Oak Ridge, Tennessee. The plant occupies approximately 811 acres (0.67 mile wide and 3.2 miles long). The Stone and Webster Construction Co. of Boston, MA served as the general engineering contractor for the facility which eventually reached a cost of well over $400 million. Tennessee Eastman Company (TEC) of Kingsport, TN was selected as the operating contractor for the facility. Production of elements of the calutrons and the supporting infrastructure were divided between three major contractors to avoid overload and to increase the rate at which installation could proceed. General Electric produced power supply equipment, Allis-Chalmers produced the magnets and electrical generators, and Westinghouse produced the process tanks and other mechanical parts.

6.1.1 Construction and Facilities Summary

The priority associated with the wartime mission to develop an atomic bomb created a need for rapid production of enriched uranium. The physical theory, process chemistry, and methods of construction for each building or set of calutron units were developed concurrently with construction and operation, so that each set of units served as a pilot plant for the next group. Just as soon as buildings were completed, TEC moved its people in to operate them. During its mission, the uranium enrichment operations were in a constant state of improvement and innovation which resulted in major increases in the number and efficiency of operational calutrons. At its peak in mid-1945, the Y-12 Plant employed over 22,000 workers, including administrative and support staff, calutron operators, calutron chemical recycle operators, machinists, construction staff, and scientific research staff. Over the March 1943 – December 1947 time period, the Y-12 Plant employed over 50,000 individuals.

Table 2 presents a brief chronological summary of significant developments at Y-12 and descriptions of buildings involved in the enrichment operation. As indicated in Table 3 the first building shell completed was the Pilot Plant 9731 in March 1943. Although the bulk treatment facility 9202 was not completed until October 1943, initial testing and storage of radiological material may have occurred in the Pilot Plant.

Table 2: Process Chronology and Building Descriptions

Date[a]		Building	Event Description/Building Use
February	1943		Ground breaking and construction begins at Y-12.
March	1943	9731	The first building shell is completed. The building is known as the Pilot plant. Initial testing would have started in this facility.
October	1943	9202	Bulk treatment facility designed to convert UO_3 (from Mallinckrodt Chemical Works) to UO_2, to UCL_5, to UCl_4 – the feed material used in the alpha calutron sources. The chemical conversions (reduction, chlorination, sublimation) are carried out on a large scale.
October	1943	9203	^{235}U Analysis (mass spec.), control analyses, and initial product processing.
October	1943	9205	Uranium isotopic analysis (fission count).
November	1943	9731	Known as the Pilot Plant, the first calutron units built at Y-12 (2 alpha, 2 beta) are constructed here. The building was used as a training facility.
January	1944	9201-1	Contained alpha – 1 calutron tracks 1 and 2. Track 1 first operational in January, track 2 operational by following March.
March	1944	9204-1	Contained beta calutron tracks 1 and 2. Track 1 first operational in March, track 2 operational by following June.
March	1944	9201-2	Contained alpha – 1 calutron tracks 3 and 4. Track 3 first operational in March, track 4 by following April.
March	1944		First shipment of partially enriched uranium goes to Los Alamos.
Spring	1944		The peak of construction work in Oak Ridge – 47,000 workers (Wilcox, 1997).
June	1944	9201-3	Contained alpha – 1 calutron track 5.
July	1944	9201-4	Contained alpha – 2 calutron tracks 6 and 7. Track 6 first operational in July, track 7 by following August.
September	1944	9204-2	Contained beta calutron tracks 3 and 4. Track 3 operational in September, track 4 operational by following November.
September	1944	9201-5	Contained alpha – 2 calutrons tracks 8 and 9. Track 8 operational in September, track 9 operational by October.
November	1944	9206	Beta chemical recycling and product processing.
November	1944	9733-3	Chemical control analysis.
November	1944		Y-12 starts converting HEU oxide (final product from the beta calutrons) to green salt for shipment.
December	1944	9204-3	Contained beta calutron tracks 5 and 6. Track 6 operational by December, track 5 operational by following January ('45).
January	1945	9207	Uranium salvage operations.
February	1945	9733-4	Chemical control analysis.
May	1945		Peak Y-12 operating workforce reached at this time (22,482 employees).
September	1945		All alpha calutrons utilized for producing low-enriched uranium are shut down. The gaseous diffusion plant (K-25) is now supplying required enriched uranium suitable for use as beta calutron feed.
November	1945	9212	Beta product processing
November	1945	9204-4	Contained beta calutrons tracks 7 and 8. Track 8 operational by November, track 7 operational by following January ('45)
January	1946	9211	Uranium salvage.
December	1946		All beta calutrons stop production of enriched uranium, K-25 is supplying all the highly enriched uranium needed. One track of 36 beta calutrons (in 9204-3) and the experimental calutrons in 9731 are left operational and utilized for several more years on an experimental basis trying to improve efficiency of the calutrons.
May	1947		TEC's contractor duties end. TEC is replaced by Carbide & Carbon Chemicals Co., a predecessor to Union Carbide.
Mid-year	1947 - 1951		Y-12 overall mission shifts towards reducing K-25 enriched uranium to metal and subsequent machining to produce weapons components. Additionally, salvage operations involved recovering EU from all non-product components or byproduct of the calutron operations. Calutron parts and associated equipment containing small amounts of uranium were cleaned and decontaminated. These operations were primarily done in Buildings 9206, 9207, and 9211

[a] Dates associated with buildings reflect time of initial operation. Information sources: 1991 Compere; 1997 Wilcox.

6.1.2 Alpha and Beta Calutron Operations

During the March 1943 – December 1947 time period, the operations at Y-12 primarily involved the use of the electromagnetic separation process to enrich uranium in ^{235}U, with the enriched product being shipped to Los Alamos for production of atomic weapons. The electromagnetic separation process involved the use of "calutrons" which were essentially production scale mass spectrographs. In the calutron, atoms or groups of atoms contained in a uranium source ("charge bottle") are ionized and accelerated to a given electrical potential. The ions are then introduced into a magnetic field through which they move at a velocity which is a function of their mass and charge. Ions are then collected in receivers positioned at locations that can be predicted on the basis of the ion's size and charge.

Major items required for efficient calutron operation are well designed magnets and associated power supplies, high-voltage triodes for close current control, a special high voltage, high current x-ray cable, and large vacuum systems to keep the materials processed in the calutron contained under negative pressure. Major constraints on the efficiency of the separation process were the recycle, handling, and chemical separations of the enriched uranium deposited on the walls of the calutrons. Though improvements were made, initially only about 4 % of the uranium in the source actually arrived in the receivers through the electromagnetic separation process; 96% remained in the source, coated the electrodes, or splattered all over the liner of the calutron. The remaining uranium had to be recovered from the equipment though labor intensive cleaning operations involving 20 persons per calutron.

Until the latter part of 1945, Y-12 converted UO_3 to UCl_4, which then served as the feed material enriched in ^{235}U using two calutron stages, termed "alpha" and "beta." Enriched product (~ 10% ^{235}U) obtained from the alpha calutrons was used as feed for the beta calutrons which then further processed the product until it was sufficiently enriched for use in weapons

Eventually, the Y-12 plant came to contain five alpha enrichment buildings and 4 beta enrichment buildings. The calutrons were generally arranged within these buildings in continuous oval or rectangular arrangements called "racetracks". Each alpha track consisted of 96 calutron tanks with electromagnets between, arranged in an oval (alpha-1) or rectangle (alpha-2). Oval alpha tracks were 122 ft long, 77 ft wide and 15 ft high. The beta tracks consisted of 36 units each, in the form of a rectangle. At the peak, there were a total of 1,152 production calutrons at Y-12.

In late 1945, Y-12 discontinued the use of the alpha calutron stage, changing the process to receive UF_6 from the Oak Ridge Gaseous Diffusion Plant ("K-25" Plant), which was converted to UCl_4 and used directly as feedstock in the beta calutrons. After 1947 the calutron were no longer used to support production. One track of 36 beta calutrons and the experimental calutrons were left operational and utilized experimentally for several more years in an attempt to improve efficiency of the calutrons.

6.1.3 Calutron-related Enrichment Processes

Significant efforts were required to produce feed material for the calutrons, to salvage and recycle uranium, and to produce the final material suitable for use in an atomic weapon. A very brief discussion of these operations is presented here; detailed discussions are available in Compere, 1991.

Feed Preparation and Product Processing

Volatile UCl_4 was the uranium chemical form fed to alpha and beta electromagnetic enrichment operations. UCl_4 was produced using one of two chemical conversions involving UO_3 and carbon tetrachloride. The first method was liquid phase chlorination in which uranium and carbon tetrachloride were heated under pressure. The UCl_4 crystals formed were collected and placed in charge bottles which were then loaded into calutrons for U enrichment. A second method was vapor phase chlorination in which carbon tetrachloride was gradually added to UO_3 and under heated conditions inside a chemical reactor bowl for roughly eight hours and then purged with nitrogen to exhaust phosgene vapors from the system. UCl_4 crystals were collected and loaded into "charge bottles" to be placed into calutrons.

Uranium Recovery and Purification

Enriched uranium salvage and recycle chemistry was a small batch operation. The operation was divided into several phases, which included calutron dismantling and washing, calutron component salvage, housekeeping salvage, uranium purification, chlorination, and hexafluoride conversion.

The recovery and purification efforts were extensive because, even with the most efficient of the calutrons, only 20% of the charge material reached the receiver; the rest of the ionized uranium halide vapor had to be recovered from wherever it settled and condensed into various chemical forms. The calutron liner, the ion source, and the receiver contained a variety of uranium compounds, including tetrachloride, oxychloride, carbides, and oxides, as well as loose metal. Operations to recover uranium included vacuum cleaning, concentrated nitric acid leaching, and several manual cleaning operations using dilute nitric acid.

All of the operations described above had a common characteristic shared by many other Y-12 operations: they reclaimed uranium primarily in the form of a uranyl nitrate-nitric acid solution. After uranium was removed from process equipment and put into recycle streams, a variety of processes were used to purify and concentrate it so that it could be oxidized, chlorinated and returned to the calutrons. The nitrate solutions, together with salvage and reclamation from laundry, plant cleanup operations, and floor drains represented a significant uranium stream.

Final Product Production

The highly enriched uranium obtained from the beta calutrons was recovered as uranium oxide and then converted to UF_4 (green salt) prior to shipment. The process involved a high temperature reduction of the UO_3 to UO_2, followed by hydrofluorination with anhydrous HF.

6.1.4 Other Radiological Activities

Inherent to the developmental nature of the uranium enrichment process, TEC scientists performed a variety of radiological experiments, tests and special projects. Examples of some of these activities, documented in a second quarter 1946 TEC History Report are:

- A program for developing and distributing beneficial radioactive isotopes began during the first half of 1944;
- Development of a battery operated neutron monitor;
- Maintenance and use of a large ^{226}Ra source for radiographic examinations;
- Assaying of samples of enriched isotopes of iron, chromium, and lithium;
- A study of the relative behavior of thorium and uranium in ether extractions; and
- Development of a rapid procedure for the separation of trace amounts of thorium from large amounts of uranium prior to colorimetric estimation with "Thoron."

NIOSH has been unable to obtain any detailed information concerning these activities and any associated radiological safety procedures and occupational exposures.

6.2 Radiological Exposure Sources

The most substantial radiological exposures documented at Y-12 for the period covered by this report were potential internal intakes, resulting from inhalation of particles comprised of various forms of uranium. The primary exposure pathway was via inhalation of particles contaminated with uranium in various forms during operations involving handling and preparation of feed materials and during the recovery, recycling, and salvage processes. Uranium-bearing chemicals present at the facility during the subject time period included (but are not limited to):

- Uranium oxide (U_3O_8)
- Uranium dioxide (UO_2)
- Uranium trioxide (UO_3)
- Uranium hexafluoride (UF_6)
- Ammonium diuranate [$(NH_4)_2U_2O_7$]
- Uranyl nitrate [$UO_2(NO_3)_2$]
- Uranium peroxide ($UO_4 \cdot 2H_2O$)
- Uranium tetrachloride (UCl_4)
- Uranium pentachloride (UCl_5)
- Uranium tetrafluoride (UF_4)

The ^{235}U and ^{238}U contained in these compounds are primarily alpha emitters; ^{235}U also emits a 185-keV photon in 54% of its decays and short lived ^{238}U decay products (^{234}Th, ^{234m}Pa, and ^{234}Pa) are beta and photon emitters.

6.2.1 Raw Materials Sources

Materials used as feed materials for calutron operations varied over time. Ultimately, both alpha and beta calutron charge bottles were loaded with UCl_4 which was obtained from processing UO_3 via various chemical processes (liquid- or vapor-phase chlorination). Initially, UO_3 (natural quality) was obtained from Mallinckrodt Chemical Works for this purpose. Calutron wash solutions (uranyl nitrate-nitric acid solution) obtained during cleaning (recycling) operations were also converted to back to UO_3 for subsequent conversion to UCl_4. Starting in late 1945, UO3 was obtained from hexafluoride conversion of enriched UF_6 obtained from the Oak Ridge Gaseous Diffusion Plant ("K-

25” Plant). The UCl_4 ultimately obtained from this conversion was sufficiently enriched for use as feed for the beta calutrons and the alpha stage of the refinement process was shut down.

6.2.2 Calutron Operations

The calutrons units were closed systems, operated under a high vacuum, and therefore provided little potential for internal exposure to the operators during operation. As discussed in section 5.0, the primary hazard to calutron control operators during operations (typically located on stools in front of control panels) was due to X-rays generated from the high voltage equipment. Surveys were performed and results were documented in a series of memos (Kerr 2005). Specific sources of the X rays were determined to be rectifier tubes in both the alpha and beta control cubicles. Based on the documents reviewed, the maximum radiation occurred at the rear of the cubicle (where it did not present a significant exposure potential) and at lower level ports. Lead glass was installed over the ports to reduce the radiation levels at some point prior to 1944.

6.2.3 Miscellaneous Chemical Processing

Radiation exposures at Y-12 during the 1943 to 1947 time period resulted from uranium in various forms and occurred primarily in locations where uranium was either received, analyzed, chemically converted, recycled and/or purified. Section 6.1.1 contains a table summarizing the building locations in which these various activities occurred. Document sources (Tankersley 2005) indicate a potential for particularly high exposure to UCl_4 in the alpha chemistry sublimation and bottle filling operations and during the beta chemistry UCl_4 production and bottle filling work. Document sources indicate a potential for high exposure to uranium oxides (via dust inhalation) during UCl_4 production and during the recovery of uranium salts from the calutrons in preparation for the recycling process (Tankersley 2005).

7.0 Evaluation of Feasibility of Dose Reconstruction

The feasibility determination for the class of employees covered by this evaluation report is governed by EEOICPA and 42 C.F.R. § 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 of members of the class more precisely than a maximum dose estimate. If NIOSH were to have 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 (identified in section 6.0 of this report). 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 (NIOSH 2004) 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 class.

7.1 Completed Dose Reconstructions

As discussed under section 4.0 of this evaluation, the 135 cases for which NIOSH has completed dose reconstructions involving employees who worked for Y-12 during (but not limited to) the 1943-1947 period involved circumstances that allowed for the use of either an overestimating or an underestimating dose reconstruction methodology. The completion of these dose reconstructions is not sufficient to demonstrate the feasibility of estimating radiation doses for the class of employees covered by this evaluation. In particular, the overestimates of radiation dose included in some of these dose reconstructions do not establish estimates of the maximum radiation dose, for every type of cancer, for members of the class defined in this evaluation, nor do they demonstrate that NIOSH can estimate the radiation doses of the class more precisely than an estimate of the maximum radiation doses. The overestimates applied to employees who did not routinely work in the uranium enrichment buildings or radiological processes at the Y-12 facility or who incurred cancers for which the maximum relevant radiation doses can be estimated. The overestimates would not apply to employees who worked routinely in the uranium enrichment buildings of the facility.

7.2 Internal Radiation Doses

No individual monitoring records (either *in vivo* or *in vitro*) are available indicating either direct or indirect measurement of internal exposures at the Y-12 Plant prior to 1948. As indicated in section 5.0, workers employed at the Y-12 Plant during the 1943-1947 period had a high potential for internal intakes because of the processes performed at the facility. The principal source of internal radiation doses for members of the class was uranium particulate material aerosolized through enrichment and chemical processing activities. This aerosolized dust could be inhaled by individuals in the area which would be deposited in the respiratory tract. This dust would also settle onto surfaces and be available for resuspension back into the air where it could be inhaled or ingested in the body by transfer from contaminated surfaces via hand to mouth. There were other radiological activities identified in 6.1.4 (e.g., Thorium extraction) where internal exposure could have occurred as well, although these other radiological activities were conducted on a laboratory or pilot scale.

It appears that uranium compounds exhibiting all solubility classes would have been present in various operations at the Y-12 Plant prior to 1948 (ORAU 2004f). Chemically soluble forms in solution, moderately soluble compounds, and relatively insoluble compounds could have been encountered by site workers. Monitoring of urine to assess internal exposure, however, did not commence at Y-12 until 1948.

The subsections below summarize the extent and limitations of information available for reconstructing the internal doses of members of the class. Most of the information summarized below is provided in greater detail in the individual TBDs available for the Y-12 Plant.

7.2.1 Urinalysis Information and Available Data

No urinalyses data are available for the Y-12 Plant prior to 1948 (ORAU 2001). Urine sampling began at the Y-12 Plant in 1948 to identify internal exposures to personnel.

Although NIOSH has assessed the use of surrogate urinalysis data for use in reconstructing dose (ORAU 2005a), NIOSH finds that the urinalysis data for the later years would not be representative of the urine activity during the 1943 to 1947 time period when the calutrons were in operation. In some cases, dosimetry data (i.e., urine data, film badges, fecal sampling) obtained from a later period or different location or facility can be applied as a surrogate for data that are unavailable, using statistical models to account for potential differences. Use of such "surrogate" data, however, requires that the processes and radiological materials involved in the different time periods be similar and comparable. Although NIOSH has access to urinalysis data at Y-12 during later periods, the processes during later periods are not similar or comparable to the processes during the 1943 to 1947 time period, when the calutrons were operating. The calutron operations required significant manual work to recover the uranium from the calutrons.

7.2.2 Information and Available Data Regarding Other Types of Bioassay

NIOSH has not located any additional records of *in vitro* (e.g., fecal, sputum, nasal, etc.) or *in vivo* (e.g., whole body, lung, or other organ count) analyses.

7.2.3 Airborne Dust Levels

As discussed in section 5.0, NIOSH has access to approximately 900 air sample results for the time frame covered by the petition (ORAU 2001). These records comprise general area air samples taken in various locations within buildings and also during various operations. The sampling strategy and frequencies used are not known and hence NIOSH cannot determine whether the data represents high, low, or average concentrations to which a worker would be exposed. Nor do the records indicate whether there was monitoring for dust concentrations during non routine activities. Furthermore, NIOSH cannot determine whether operations personnel who had low radiation exposure potential while operating the calutrons, supported the recycling and cleaning activities that involved high radiation dust exposures, or whether these operators were present during the cleaning. NIOSH does have documentation, however, indicating that the operation of some calutrons continued while recycling and cleaning activities were conducted at other calutrons, indicating a potential for operators to be exposed to high dust levels.

NIOSH reviewed the available site information that described process activities conducted during the time period of the proposed class. The calutron operations were unique among uranium production and enrichment operations. The inefficiency of the calutron operations, coupled with the continuous attempts at increasing the production efficiency, required a substantial amount of time for disassembly, recovery of product, and maintenance activities. These operations would have exposed the workers to substantial airborne concentrations, as indicated by the general area air sampling results that are available to NIOSH. However, without breathing zone measurements for these manual activities, NIOSH cannot establish maximum exposure scenarios. Similarly, surrogate data from later years at Y-12 or a similar facility cannot be used because the operations involving the calutrons during the 1943 to 1947 time period were unique.

NIOSH also cannot establish maximum exposure scenarios based on source term and process data. As discussed above, the levels of enrichment of the source materials and the production rate of the operations varied substantially and are not documented for this period of operations. The manual recycling and cleaning activities are not comparable to any operations for which NIOSH has access to adequate monitoring data.

As indicated in section 6.1.4, NIOSH has documentation that supports that other radiological activities were occurring at Y-12 during the evaluation period. NIOSH has no air monitoring data, source term, or process information associated with these activities. Therefore, NIOSH cannot establish a maximum internal exposure scenario for these activities.

7.2.4 Radon

NIOSH has not located records of area radon concentrations for the Y-12 Plant during this time period. During site operations prior to 1948, radon levels at the site would be close to environmental background levels due to the receipt of pre-processed uranium compounds (primarily UO_3). The pre-processing of uranium compounds removed the radium from the material. The radium is the parent radionuclide for radon and has a 1600 year half life. There would be minimal buildup during the time the ore was processed and the material leaving the Y-12 site. Also, NIOSH has not located any records indicating that radium bearing ores or wastes were received or processed at Y-12 during the time period covered by this evaluation.

NIOSH can estimate maximum doses associated with such potential exposure using surrogate data from other uranium metal plants. NIOSH has radon data from later years at uranium processing facilities that processed material with similar radium content in greater quantities. Therefore, for the purpose of estimating radon exposures, the data would be similar and comparable to that at Y-12 during the 1943 – 1947 time period. Hence, these surrogate data would enable NIOSH to develop claimant-favorable estimates of the potential radon exposure at Y-12 during the 1943 to 1947 time period.

As mentioned in section 6.1.4, Maintenance and use of a large ^{226}Ra source for radiographic examinations was occurred at Y-12 during the evaluation period. However, this source was a sealed source and would not have provided a significant potential for radon exposure.

7.3 External Radiation Doses

As discussed in Section 6.2, potential external radiation exposures at Y-12 during the 1943 – 1947 time period would have occurred primarily in buildings and areas where uranium was either received, analyzed, chemically converted, enriched, recovered as final product or for recycling, processed as waste, and/or packaged/shipped from the site. External exposures from material processing could have occurred in the control operators' cubicles of the calutron tracks, any of the material handling operations, chemical operators that converted oxides of uranium to uranium tetrachloride for feed material into the calutrons, and from miscellaneous activities adjacent to these areas.

Exposure to neutron radiation also was possible at Y-12. Neutron exposures would have occurred primarily from (α, η) reactions with the alpha particles emitted from highly enriched uranium interacting with low-Z material (e.g., fluorides and oxides of uranium), but also from other neutron sources that were present at the site, as indicated in 6.1.4. These sources included both neutron emitting instrument calibration sources (e.g. Po-Be, Pu-Be, Ra-Be, and Am-Be), particle accelerators, and neutrons emitted from fissile material testing that took place onsite.

Occupational medical exposures to x rays, when such screening x rays are a condition of employment, are also included in EEOICPA dose reconstructions. During this time period, individuals at the Y-12 site were required to have pre-employment, annual, and termination chest X-ray examinations. The

X-ray examinations were performed at the Y-12 clinic or the Oak Ridge Hospital using a Type 1 Photoflourographuc unit.

The subsections below summarize the extent and limitations of information available for reconstructing external doses of members of the worker classes addressed by this report. More information is provided in greater detail in the Y-12 Site Profile and additional reports (ORAU 2004b and c) that have been written supporting the site external dosimetry TBD (ORAU 2003).

7.3.1 Film Badge Monitoring

Information in the site external dosimetry TBD documents that film badge monitoring did not commence at the Y-12 site until 1948. [A database maintained by ORAU's Center for Epidemiologic Research (CER) indicates individual external dosimetry records beginning the first week of January 1948.]

As discussed earlier, in some cases, dosimetry data obtained from a later period or different location can be applied as a surrogate for data that are unavailable, using statistical models to account for potential differences. Use of such "surrogate" data, however, requires that the processes and radiological materials involved in the different time periods be similar and comparable. Although NIOSH has access to dosimetry data on external radiation exposures at Y-12 during later periods, the processes during later periods are not similar or comparable to the processes during the 1943 – 1947 time period, when the calutrons were operating. The later activities at Y-12 were primarily associated with uranium metal manufacturing and processing. Hence, the surrogate external dosimetry data cannot be used for estimating external exposure for workers during the period covered by this report.

7.3.2 Gamma/X-ray, Beta, and Nonspecific Beta-Gamma Exposures

The external radiation dose at the Y-12 site arose primarily from personnel X-ray exposure adjacent to the calutrons during enrichment activities and the handling and processing of uranium as feed and product. As documented in claimant interviews and photographs of the operation, calutron control operators were positioned immediately in front of the calutron control panels. The majority of the operator's day was spent in this position, observing the calutrons to ensure that the equipment was operating properly. The primary radiation hazards to these individuals came from exposure to X rays generated from the high voltage units used for the operation of the calutrons.

NIOSH has access to the results of fixed location radiation surveys conducted at Y-12 conducted in 1943 to 1944 (ORAU 2001). As indicated in section 5.0, these radiation surveys were performed around the calutrons to determine the necessary controls needed to reduce the operator's external exposures through improvements in shielding, such as the selection of lead glass for the window and ports to reduce operator exposure. NIOSH can establish a maximum potential exposure for this activity for the March 1943 – December 1947 time period using the dose rate information from these surveys.

Personnel were also involved in chemically converting uranium oxide compounds (typically UO_3) received from atomic weapons employer (AWE) sites into volatile uranium tetrachloride at Y-12 for use as feed material into the calutron tracks. Further chemical processing of these materials was also necessary to recover the product material. This material was also later converted into other chemical forms for use in metal production. Contact exposure rate measurements are available for uranium compounds that were processed at Y-12 during this period and are sufficient for estimating external exposures.

Employees at Y-12 would have received some exposure to beta radiation. These beta exposures would have arisen from the uranium progeny ^{234}Pa, ^{234}Th, and ^{234m}Pa from the forms of uranium feedstock used during this period at Y-12. The UO_3 produced at Mallinckrodt Chemical Works and received at Y-12 for conversion into UCl_4 feed material for the calutrons would have originally been relatively pure uranium, devoid of the early progeny. These early progeny would build back into equilibrium conditions over an approximate 5 month period of time during shipping/storage and would be available to cause contact, absorbed dose rates of approximately 204 mrad/hr (HEW 1970) when handled. Similar contact, absorbed dose rates of approximately 200 mrad/hr would be associated with other uranium compounds at the Y-12 Plant during the 1943 to 1947 calutron operations.

NIOSH can develop a maximum beta exposure using the beta dose rates from the surface of cast uranium metal. As indicated above, a significant amount of information is known about the beta dose rates from uranium metal (EG&G 1988). NIOSH can use this dose rate as a maximum and/or NIOSH can use surrogate data from Y-12 data from later years. Although the processes were different the product or source, uranium metal was the same and therefore would have similar dose rates.

More detail addressing how gamma, beta, and neutron radiation doses could be estimated is provided in sections 6.4 and 6.5 of the Y-12 external dosimetry TBD (ORAUT 2003) and in supporting reports (ORAU 2004b and ORAU 2004c).

As indicated in section 6.1.4, NIOSH has documentation that supports that other radiological activities were occurring at Y-12 during the evaluation period. NIOSH has no external monitoring data, source term, or process information associated with these activities. Therefore, NIOSH cannot establish a maximum external exposure scenario for these activities.

7.3.3 Neutrons

Exposures to neutron radiation were a minor external exposure hazard during the period covered by this evaluation report (October 1943 through December 1947) at the Y-12 site. Exposure to neutron radiation was possible at Y-12 either directly from neutron sources that were present at the site or indirectly from (α, η) reactions during processing of enriched uranium. A report discussing the historical evaluation of the neutron measuring film badge (ORAU 2004c) indicates that in 1949 neutron sensitive films were added to the film badge (Souleyrette, 2003). No personal neutron measurements were made at Y-12 prior to that time.

NIOSH has estimated neutron exposures estimates for the types of uranium compounds that were handled and processed at Y-12 during the October 1943 – December 1947 time period (ORAU 2005c). These estimates are based on the (α, η) reactions and dose rates measured from these types of material. Similar estimates could be made at the Y-12 Plant that would provide an overestimate to individual neutron exposure.

As indicated in section 6.1.4, NIOSH has documentation that indicates that Y-12 was working on developing a battery operated neutron monitor during the evaluation period. The documentation indicates that a neutron generator was used for the calibration of this instrument. However, NIOSH has no monitoring or source term data concerning the dose rates associated with this neutron generator. Therefore, NIOSH cannot determine the maximum radiation exposure from this activity.

7.3.4 Occupational Medical X rays

As indicated in section 7.3, the x rays were performed during the 1943 to 1947 period at the Y-12 clinic or the Oak Ridge Hospital using a Type 1 Photoflourographuc unit. Although no exposure date is available for medical X rays at Y-12 during the 1943 to 1947 period, surrogate data was used in the Y-12 Site Profile (ORAU 2004a) to develop an exposure matrix. The site profile documents the method and feasibility of reconstructing these medical exposures. Therefore, NIOSH can determine the maximum exposures from occupational medical x rays.

7.4 Summary of Feasibility Findings

Table 4 below summarizes the results of the feasibility findings at the Y-12 site for each exposure source for the time period 1943 through 1947.

Table 3: Summary of Feasibility

Source of Exposure	Maximum Exposure can be determined	Maximum Exposure cannot be determined.
Internal		X
- Urinalysis		X
- Airborne Dust		X
- Radon	X	
External		X
- Gamma		X
- Beta	X	
- Neutron		X
- Occupational Medical X ray	X	

This report evaluated the feasibility for completing dose reconstructions for workers at the Y-12 site from the time that radioactive material might have first been brought onto the site (October 1943) through the end of routine enrichment operations using electromagnetic separation (December 1947). NIOSH found that records associated with determining internal and external exposures were insufficient to estimate doses with sufficient accuracy for this class of employees.

This conclusion was based, in part, on the finding that employees involved in the calutron uranium enrichment process were exposed to levels of airborne uranium products that cannot be determined because of the absence of bioassay data for the time period and the lack of air sampling sufficient to develop maximum exposure scenarios and hence to estimate maximum internal doses. Furthermore, NIOSH is unable to estimate such doses based on source term and process information for lack of documentation on the varying levels of enrichment of the source materials and on the production rate of the operations, and because the manual recycling and cleaning activities are unique and not comparable to any operations for which NIOSH has access to adequate monitoring data. Therefore, NIOSH is unable to estimate doses associated with internal exposures with sufficient accuracy for employees involved in the calutron uranium enrichment process operated at the Y-12 Plant during this period. NIOSH did find that external exposures associated with the calutron uranium enrichment process could be estimated through a combination of available dose rate data, measured dose rates from similar material, and source term information.

For employees involved in other radiological activities, mostly experimental and developmental in nature as indicated in Section 6.1.4 of this report, NIOSH is unable to estimate any radiation doses whether resulting from internal or external exposures. NIOSH has essentially no source term and process information, let alone any monitoring data, from which to estimate such doses.

Note: The determination by NIOSH that it cannot estimate radiation doses with sufficient accuracy for members of this class does NOT necessarily mean that NIOSH cannot estimate ANY radiation doses with sufficient accuracy for ALL members of this class. In a case in which a member of this class incurred a cancer not included among the 22 specified cancers covered by EEOICPA and hence requires a dose reconstruction (or would otherwise be left without a remedy), it is possible that NIOSH could reconstruct some or all of the radiation doses relevant to the individual's cancer in conformance with 42 C.F.R. pt. 82.

8.0 Evaluation of 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 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 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 hazard to employees resulted from episodic inhalations of radionuclides that cumulatively resulted in chronic exposures. This report documents substantial exposures from this hazard. Additionally, employees in the class involved in other radiological activities, separate from the calutron enrichment process, may have incurred substantial external, as well as internal, radiation 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 Proposed Class Definition

This evaluation defines a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy and whose health may have been endangered by such radiation doses. This class includes employees of DOE or DOE contractors or subcontractors who worked in uranium enrichment operations or other radiological processes at the Y-12 facility in Oak Ridge, Tennessee during the period from March 1943 through December 1947 and who were employed for a number of work days aggregating at least 250 work days or in combination with work days within the parameters (excluding aggregate work day requirements) established for classes of employees presently included in the SEC. Under this proposed class definition, "working in uranium enrichment operations or other radiological activities" means any work in which the employee might have been routinely present, during the specified period, within the uranium enrichment buildings or other buildings where radiological activities were present.

10.0 References

EEOICPA (Energy Employees Occupational Illness Compensation Program Act of 2000, as amended, 42 U.S.C. §§ 7384-7385).

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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; Final Rule, May 28, 2004

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