SEC Petition Evaluation Report
Petition SEC-00064

Report Rev #_1___ Report Submittal Date ____09-20-06___________

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Site Expert(s):	Not Applicable

Petitioner Administrative Summary			
Petition Under Evaluation			
Petition #	Petition Type	Petition A Receipt Date	DOE/AWE Facility Name
SEC-00064	83.14	July 17, 2006	General Atomics

Proposed Class Definition
All AWE employees who were monitored or should have been monitored for exposure to ionizing radiation while working at the following General Atomics locations: Science Laboratories A, B, and C (Building 2); Experimental Building (Building 9); Maintenance (Building 10); Service Building (Building 11); Buildings 21 and 22; Hot Cell Facility (Building 23); Waste Yard (Buildings 25 and 26); Experimental Area (Buildings 27 and 27-1); LINAC Complex (Building 30); HTGR-TCF (Building 31); Fusion Building (Building 33); Fusion Doublet III (Building 34); SV-A (Building 37); SV-B (Building 39); and SV-D (no building number) for a number of work days aggregating at least 250 work days from January 1, 1960, through December 31, 1969, or in combination with 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	

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Peer Review Completed By:	[Signature on file] *LaVon Rutherford*	9/26/06 Date
SEC Petition Evaluation Reviewed By:	[Signature on file] *Jim Neton*	9/26/06 Date
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Evaluation Report Summary: SEC-00064, General Atomics

This evaluation report by the National Institute for Occupational Safety and Health (NIOSH) addresses a class of employees proposed for addition to the Special Exposure Cohort (SEC) per the *Energy Employees Occupational Illness Compensation Program Act of 2000*, as amended, 42 U.S.C. § 7384 *et seq.* (EEOICPA) and 42 C.F.R. pt. 83, *Procedures for Designating Classes of Employees as Members of the Special Exposure Cohort Under the Energy Employees Occupational Illness Compensation Program Act of 2000*.

NIOSH-Proposed Class Definition

The NIOSH-proposed class includes all Atomic Weapons Employer (AWE) employees who were monitored or should have been monitored for exposure to ionizing radiation while working at the following General Atomics locations: Science Laboratories A, B, and C (Building 2); Experimental Building (Building 9); Maintenance (Building 10); Service Building (Building 11); Buildings 21 and 22; Hot Cell Facility (Building 23); Waste Yard (Buildings 25 and 26); Experimental Area (Buildings 27 and 27-1); LINAC Complex (Building 30); HTGR-TCF (Building 31); Fusion Building (Building 33); Fusion Doublet III (Building 34); SV-A (Building 37); SV-B (Building 39); and SV-D (no building number) for a number of work days aggregating at least 250 work days from January 1, 1960, through December 31, 1969, 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

Per EEOICPA and 42 C.F.R. § 83.14(b), NIOSH has established that it does not have sufficient information to complete dose reconstructions for individual members of the class with sufficient accuracy. NIOSH does not have access to sufficient personal monitoring data, or workplace monitoring data, to adequately determine the total potential intake of radioactive materials for workers in the proposed class.

Health Endangerment Determination

The NIOSH evaluation did not identify evidence from the petitioners or from other sources that would establish the class was exposed to radiation during a discrete incident likely to have involved exceptionally high-level exposures, such as nuclear criticality incidents or other events involving similarly high levels of exposures. However, the evidence reviewed in this evaluation indicates that some workers in the class may have accumulated chronic exposures through intake of radionuclides and from direct exposure to radioactive materials. Consequently, NIOSH has determined that health may have been 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-00064

1.0 Purpose and Scope

This report evaluates the feasibility of reconstructing doses for employees who worked at specific facilities during a specified time. It provides information and analysis germane to considering a petition for adding a class of employees to the Congressionally-created 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 NIOSH, with the exception of the employee whose dose reconstruction could not be completed, and whose claim consequently led to this petition evaluation. The finding in this report is not the final determination as to whether or not the proposed class will be added to the SEC (see Section 2.0). This report will be considered by the Advisory Board on Radiation and Worker Health (the Board) and by the Secretary of Health and Human Services (HHS). The Secretary of HHS will make final decisions concerning whether or not to add one or more classes to the SEC in response to the petition addressed by this report.

This evaluation, in which NIOSH provides its findings on both the feasibility of estimating radiation doses of members of this class with sufficient accuracy and on health endangerment, was conducted in accordance with the requirements of both EEOICPA and 42 C.F.R. pt. 83.

2.0 Introduction

Both EEOICPA and 42 C.F.R. pt. 83 require NIOSH to evaluate qualified petitions requesting that HHS add a class of employees to the SEC. The evaluation is intended to provide a fair, science-based determination of whether it is feasible to estimate, with sufficient accuracy, the radiation doses of the proposed class of employees through NIOSH dose reconstructions.[1]

NIOSH is required to document its evaluation in a report, and to do so, relies on its own dose reconstruction expertise as well as technical support from its contractor, Oak Ridge Associated Universities (ORAU). Once completed, NIOSH provides the report to both the 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 a decision on behalf of HHS. The Secretary of HHS will make the final decision, taking into account the NIOSH evaluation, the advice of the Board, and the proposed decision issued by NIOSH. As part of this final decision process, the petitioner(s) may seek a review of certain types of final decisions issued by the Secretary of HHS.[2]

[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.
[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.

3.0 NIOSH-Proposed Class Definition and Petition Basis

This NIOSH report provides a summary of the methods and findings of the NIOSH SEC evaluation for all AWE employees who were monitored or should have been monitored for exposure to ionizing radiation while working at the following General Atomics locations: Science Laboratories A, B, and C (Building 2); Experimental Building (Building 9); Maintenance (Building 10); Service Building (Building 11); Buildings 21 and 22; Hot Cell Facility (Building 23); Waste Yard (Buildings 25 and 26); Experimental Area (Buildings 27 and 27-1); LINAC Complex (Building 30); HTGR-TCF (Building 31); Fusion Building (Building 33); Fusion Doublet III (Building 34); SV-A (Building 37); SV-B (Building 39); and SV-D (no building number) for a number of work days aggregating at least 250 work days from January 1, 1960, through December 31, 1969, or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

The evaluation responds to Petition SEC-00064, which was submitted by an EEOICPA claimant who was employed as an electronic fabricator, lab technician, and senior lab technician at the facility during this period, and whose dose reconstruction could not be completed by NIOSH due to a lack of sufficient dosimetry-related information. The NIOSH determination that it is unable to complete a dose reconstruction for a EEOICPA claimant is a qualified basis for submitting an SEC petition pursuant to 42 C.F.R. § 83.9(b).

4.0 Radiological Operations Relevant to the Proposed Class

The following subsections summarize radiological operations at General Atomics from January 1960 to December 1969, 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 processes 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.

4.1 General Atomics Plant Description

General Dynamics Corporation established the General Atomics Division in San Diego, California, to develop commercial applications for nuclear technology. General Atomics performed an array of radiological research and production activities at its Torrey Pines Mesa facility in La Jolla, California (General Atomics, 1998). General Atomics operated under licenses first issued by the Atomic Energy Commission (AEC) and later by the State of California. The General Atomics source term includes depleted, normal, and highly-enriched uranium [typically greater than 20% and up to 93.5% (SNM-696) U-235 by mass]. This uranium was in the form of scrap, fresh reactor fuel, and irradiated reactor fuel comprised of uranium, activation products, and fission products. Thorium was used in fuel fabrication work. Plutonium work was also done on site. Four linear accelerators (LINACs) and several nuclear reactors were employed. Sealed sources were used for instrument calibrations and other work. By-product materials (Atomic Numbers 3-83) and tritium were also used.

General Atomics performed irradiation and time-of-flight studies with four LINACs; developed and fabricated reactor fuels; operated three on-site TRIGA reactors (Training/Research/Isotopes General Atomics); performed fusion research (since the mid-1960s); ran experimental criticality test facilities; used an “experimental” facility that is understood to have conducted a diverse set of tests with radioactive materials; and worked with special nuclear material (SNM) and radioactive tracers in its laboratory facilities. Hot Cells were used for handling radioactive materials associated with high radiation fields or very large quantities of radioactive materials that might be subject to processes resulting in dispersion. Operations conducted in these hot cells included post-irradiation examinations of DOE fuels, structural materials, and reactor dosimetry materials; and mechanical inspection of irradiated fuel. Development and manufacture of Experimental Beryllium Oxide Reactor (EBOR) fuel, tritium extraction, and experiments to test plutonium transport using plutonium oxide were also performed in hot cells.

Fuel fabrication involved working with uranium (up to 93.5% U-235 by mass) and thorium. Radioactive materials were coated, blended, compounded, heated, rolled, extruded, machined, compacted, and eventually made into fuel elements. There were many tasks required for fuel fabrication whereby raw materials were converted to usable fuel assemblies.

General Atomics reclaimed highly-enriched uranium (HEU) from non-irradiated NERVA (Nuclear Engines for Rocket Vehicle Applications) scrap fuel. The scrap was identified as being in Scrap Groups III (uranium compounds such as oxides) and IV (combustibles such as paper, tissue wipes, filters, etc.). The scrap materials were to be shipped from the Westinghouse Electric Corporation’s Astrofuel Facility in Cheswick, Pennsylvania, to General Atomics for processing into uranium oxides (Type III recovered uranium: UO_2, UO_3, and U_3O_8). SNM in the form of uranium-bearing impure scrap materials (e.g., oxides or carbides) was processed to recover and purify the contained uranium. The material was accumulated from several sources (both on-site and off-site), including out-of-specification SNM product, process equipment, scrap, waste, and solid residue from liquid evaporation. Some of the materials came from the facility recovery operations.

The steps used for uranium material extraction and purification are described in SNM License 696 (SNM-96). In addition to the production, research, and recovery activities conducted with uranium and SNM, General Atomics also worked with thorium materials. Thorium was one of the radionuclides used in the initial stages of operation; such use continued through the operational period. Thorium was used in Building 2 (Science Laboratories) for testing mixtures and components of fuel assemblies. The thorium operations conducted in Building 2 included grinding of thorium, high-temperature heating under vacuum, and fabrication of thorium-uranium gel. Undetermined amounts of thorium were used in Building 9 (Experimental Building); operations included extrusion, rolling, cutting, milling, lathing, and casting of metal. Research and development of reactor fuel pellets using uranium and thorium was one of the activities conducted in Building 23 (Hot Cell Facility). When work was performed in hot cells, there was the potential for exposure during the transport of radioactive materials to and from the Hot Cells and during maintenance of equipment.

Radioactive materials containing thorium and other radionuclides were volume-reduced at, stored at, and shipped from the Waste Yard (Buildings 25 and 26). Information regarding the total quantities and activities of individual radionuclides handled at the Waste Yard has not been identified.

Coated thorium fuel pellets were irradiated in the linear accelerator building (LINAC Complex or Building 30). Other research activities involving thorium were also conducted at the LINAC Complex. Criticality testing of fuel elements containing thorium was routinely conducted at the Critical Assembly Facility (Building 31); thorium compaction also occurred in this facility. Fabrication and testing of HTGR (High Temperature Gas Cooled Reactor) fuel was performed in Buildings 37 (SV-A) and 39 (SV-B). One of the primary uses of thorium at General Atomics was in the fabrication of Th-U fuel. Potential exposure to thorium in these Sorrento Valley areas resulted in part from the transport and handling of materials, maintenance of fabrication equipment, and airborne leaks from the thorium conversion furnace (SNM-696).

Records suggest that thorium was routinely used in the aforementioned buildings. However, based on available documentation (General Atomics, 1964; SNM-696), the transfer, storage, and use of thorium in other radiological buildings was also likely. NIOSH has not located documentation on the amount of thorium used and processes employed in these remaining buildings or on the level of thorium activity in any specific locations of the facility.

4.2 General Atomics Functional Areas

Some of the larger radiological operations involved the Fuel Fabrication Facility, the Hot Cell Facility (Building 23), the reactors, and the linear accelerator. In addition, there were a number of research and development and small-scale manufacturing projects on going in the General Atomics research and experimental buildings. Although many of the facilities were operational by 1960, some were moved or constructed during the 1960s. This evaluation report identifies the functional areas and facilities where thorium was handled, used, or processed. A list of these facilities is shown in Table 4-1; these thorium facilities are discussed in the successive report sub-sections.

Table 4-1: General Atomics Facilities That Conducted Radiological Work	
Building	**Process**
Building 2 Science Laboratories A, B, and C	Radiological and chemical laboratories
Building 9 Experimental Building (E Building)	Many radiological operations, including fuel element development and Pu storage
Building 10 Maintenance Building	Radioanalytical laboratory and Health Physics
Building 11 Service Building	Shipping and receiving of radioactive materials
Building 21 (TRIGA)	Housed three TRIGA reactors
Building 22	TRIGA Fuel Fabrication
Building 23 (Hot Cell Facility)	Multiple radiological operations
Buildings 25 and 26	Waste handling, minimization, processing, and storage; SNM storage; and a gamma counting facility
Building 27 (Experimental Area Building #1)	Preparation of target samples for neutron irradiation; post-irradiation radiochemical separations
Building 27-1 (Experimental Area Building #1 – Bunker; also contained 'Strontium Facility')	Neutron activation; yttrium production; and research and development
Building 30 (LINAC Complex)	High-energy electron accelerators
Building 31 (HTGR-TCF) Also called the Critical Assembly Facility	Testing of fuel elements
Building 33 (Fusion Building)	Study of controlled thermonuclear reactions
Building 34 (Fusion Doublet III)	Research in magnetic fusion technologies (involving short-lived radiation sources)
Building 37 (SV-A)	Fabrication of fuel elements; SNM
Building 39 (SV-B)	Fabrication and testing of fuel assemblies for HTGR; SNM
SV-D (no building number)	Assembled thermionic and thermoelectric fuel elements; SNM

4.2.1 LINAC Facility

The LINAC facility began operating in 1962 and was used for a variety of research activities. Early experiments investigated the intensity of delayed radiations from the fission of uranium-238, uranium-235, plutonium-239, and thorium-232 (General Atomics, 1964).

Administrative controls coupled with physical interlocks were used to ensure the safety and protection of LINAC personnel. Any material registering over twice background on an alpha, beta, or gamma detector was considered radioactive (SNM-69).

4.2.2 Experimental Building (E Building)

The Experimental Building was involved in much of the initial fuel development work conducted onsite. The first major operation conducted within the facility was the fabrication of TRIGA reactor fuel elements (UZrH, a uranium-zirconium hydride alloy). There were two radiologically-controlled areas within the structure, designated as Zones A (South Control Zone: A-1, A-2, and A-3) and B (Hot Suite: B-1, B-2, and B-3). All operations with the potential to generate particulate matter were conducted in hoods or glove boxes, or were serviced by portable ductwork attached to an exhaust system. Procedural and administrative controls were in place to minimize exposure; these controls typically helped the health physics group to protect personnel. There were two SNM storage vaults located adjacent to the east wall of the facility and a security storage area designed to store materials in Zone A for short periods of time.

Undetermined amounts of thorium were used in the Experimental Building in fuel fabrication experiments involving extrusion, rolling, cutting, milling, lathing, and casting of metal.

4.2.3 Critical Assembly Facility

This facility consisted of two buildings contained in a fenced area between the LINAC Complex and TRIGA / Experimental Area Building #1. The facility was used to conduct many critical and sub-critical assembly experiments. These buildings, also referred to as Building 31, were collectively referred to as the Critical Assembly Facility. The buildings were used to support the Marine Gas-Cooled Reactor (MGCR) and HTGR programs (General Atomics, 1961). In addition to these two buildings, a fuel assembly building was located in the area. Fuel assemblies were irradiated with accelerator-produced neutrons or with neutron triggers (e.g., PoBe or PuBe sources). The design of the fuel and assembly was such that if an undesired criticality were to occur, the fuel would either rapidly expand (Russell, 1967) or the sub-critical fuel beds would separate (Pound, 1974), inducing the neutron excursion to terminate. Criticality testing of fuel elements containing thorium was conducted at this facility.

4.2.4 Science Laboratories

The Science Laboratories were composed of three two-story, arc-shaped buildings forming an annular ring around the central library and cafeteria buildings. The Science Laboratories contained 150 individual laboratories and associated offices. Much of General Atomics work in chemistry, experimental physics, electronics, metallurgical research, reactor physics, and thermoelectricity was performed in these buildings. Thorium was used in the Science Laboratories for testing mixtures and components of fuel assemblies. Operations included grinding of thorium, high-temperature heating under vacuum, and fabrication of thorium-uranium gel.

4.2.5 Hot Cell Facility

The Hot Cell Facility (HCF) was constructed in 1959 and used primarily to facilitate remote inspection of irradiated, highly-radioactive HTGR and TRIGA fuel (General Atomics, 1960). Approximately 12% of the building footprint was taken up by the hot cell (SNM-69). A hot cell was made up of 3 sections: the high-level cell (HLC), low-level cell (LLC), and the metallurgy cell (MC). The HLC was used as a remotely operated “hot” machine shop to cut open and section irradiated fuel samples for inspection. The MC was used for analytical inspection and research activities, including the sample preparation that entailed grinding, polishing, and mounting. The LLC was used as an interface between the other “hot” cells and other areas of the building, and housed all shipping cask off-loading and packaging operations. Thick (up to 42-inch), high-density concrete walls were in place to minimize personnel exposure to penetrating radiation. In addition to uranium and other fuel constituents, thorium materials were handled in the hot cell facility.

4.2.6 Waste Yard/Incinerator

The waste processing facility includes several buildings, collectively referred to as Building 25. The facility was used for waste handling, minimization, processing, and storage; SNM and by-product material storage; and as a gamma-counting facility. Liquid wastes generated on the site were treated by placing them in evaporation pools. Only authorized personnel were allowed into the fenced-off incinerator area; they were required to wear a film badge and a self-reading dosimeter, and to submit bioassay samples for analysis (SNM-69). Several locations were used within the waste processing facility area to store radioactive materials, including TRIGA Hot Storage, a temporary storage yard, the Butler Building, and the By-Products Vault. Radioactive materials containing thorium were volume-reduced at, stored at, and shipped from the Waste Yard. Information regarding the total quantities and activities of individual radionuclides handled at the Waste Yard has not been identified.

4.2.7 Reactor Facilities

Three separate TRIGA reactors (Mark I, Mark F, and Mark III) were operated within Building 21; each reactor was individually licensed (R-38, R-67, and R-100, respectively). The original building, constructed in 1957, housed the Mark I reactor. The building was later expanded to the east and then to the north (1966) to house the Mark F and III reactors, respectively. The Mark I, F, and III reactors were all below-ground pool reactors (General Atomics, 1969). They were designed to: provide university training; provide a source of neutrons and/or gamma radiation for research; aid investigations of the effects of radiation on materials; and produce radioisotopes.

The Mark I, which was graphite-reflected, was operated routinely at steady-state thermal levels up to 250 kW; it could also be operated in pulsed mode. The Mark F reactor (also known as the Advanced TRIGA Prototype and the FLAIR [Flash Irradiation Reactor]), which was water-reflected, operated routinely at steady-state thermal power levels up to 1500 kW and also could be operated in pulsed mode. The Mark III reactor, also water-reflected, operated routinely at steady-state thermal levels up to 1500 kW.

The core of the TRIGA reactor contained reactor fuel, dummy fuel assemblies, and one or more neutron source holders. Workers may have been exposed to external and internal radiation during fuel loading and maintenance. Thorium was a fuel mixture constituent during some of these operations.

4.2.8 Other Locations

Due to the diversity of General Atomics operations, there was a significant potential for thorium storage, handling, or use in any of the buildings or work areas associated with radiological activities. For instance, thorium was likely handled in a radiochemistry laboratory located in the Maintenance Building, and the Service Building was used for receiving and shipping radioactive materials and components. Based on available information, NIOSH cannot rule out the possible existence of thorium contamination in any General Atomics radiological work area. Consequently, all General Atomics radiological work areas are included in the proposed SEC class.

5.0 Summary of Available Monitoring Data for the Proposed Class

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

This same hierarchy is used for determining external exposures to the cancer site. Personal monitoring data from film badges or thermoluminescent dosimeters (TLD) comprise the primary data used to determine such external exposures. If there are no personal monitoring data, then exposure rate surveys, process knowledge, and source term modeling can sometimes be used to reconstruct the potential exposure.

A more detailed discussion of the information required for dose reconstruction can be found in OCAS-IG-001, *Internal Dose Reconstruction Implementation Guide*, and OCAS-IG-002, *External Dose Reconstruction Implementation Guide*. These documents are available at: http://www.cdc.gov/niosh/ocas/ocasdose.html.

5.1 General Atomics Internal Monitoring Data

During the AWE operational period for General Atomics (1960 through 1969), some workers were monitored by bioassay; however, bioassays were not routine at General Atomics until October 1963. NIOSH has reviewed available data, which appear to be from random sampling, and identified 1,188 bioassay results through September 1963 (ORAUT, 2006). NIOSH has identified 1,577 bioassay records for the period October through December 1963. These results are gross activity results. NIOSH has identified 17,188 results from October 1963 through December 1969. According to the data available to NIOSH, most results were for *in vitro* sampling. A majority of the samples collected from 1960 through 1963 were analyzed for gross beta, gross alpha, and U-235. Most of the *in vitro* bioassay data available for the period October 1963 through December 1969 show that samples were analyzed for gross alpha or for uranium activity. The bioassay program incorporated gross counting methods to determine exposure to uranium, and the analytical methods used were not well documented. Determination of the specific internal exposures to other radionuclides, including thorium-232, thorium-238, plutonium, and americium, did not occur within the AWE operational period (ending December 31, 1969). NIOSH has located no *in vitro* results for exposure to thorium. Further, NIOSH has not found any evidence to suggest that *in vitro* bioassay for thorium exposure was ever performed at General Atomics.

General Atomics began monitoring for tritium exposure by bioassay in September 1965. NIOSH has identified 194 tritium bioassay records for the period November 1965 through December 1969.

General Atomics implemented an *in vivo* analysis program in 1966. The Helgeson mobile counter was brought to the site a few times each year. The perceived potential for internal exposure was the early basis for including a worker in the *in vivo* bioassay program. Many individual measurement spectra are included with results identifying the radionuclide and quantity measured. Background and calibration measurements were also observed in the records provided by Helgeson (Helgeson, 1966). The first U-235 lung counting results (~1966 through 1967) were considered "experimental" by Helgeson, and were either associated with some large uncertainty or assumed to be invalid. Workers were chosen for lung counts based on their potential for U-235 exposure and the results of their uranium urinalyses (Helgeson, 1969). The early General Atomics U-235 *in vivo* measurements are indicators that a worker had the potential for U-235 exposure.

In addition to the Helgeson *in vivo* analysis, General Atomics conducted its own in-house *in vivo* measurements beginning in 1966. The subject sat in an office chair lined with 0.25-inch thick lead and a 4” x 4” NaI(Tl) detector operated in a lap geometry.

The *in vivo* bioassay program was not used in 1966 to routinely monitor for exposures to thorium, although twelve workers were analyzed for thorium in March of that year. These results were reported to be experimental and final results were not provided by Helgeson (Helgeson, 1966). Available records indicate that a thorium *in vivo* result was reported for only one worker in 1969, who was reported to have no thorium activity (Helgeson, 1969).

5.2 General Atomics External Monitoring Data

External whole body dosimetry results are available for monitored General Atomics workers for the entire AWE operational period (January 1960 through December 1969). NIOSH has 27,661 external monitoring records available for that period. Initially, external dosimetry services using film badges were provided by R. S. Landauer, Jr. and Company. In July 1961, those services were transferred to Radiation Detection Company; however, in 1965 they were transferred back to R. S. Landauer, Jr. and Company. Personnel working in areas where potential neutron exposure could occur were issued film badges sensitive to beta, gamma, and neutron radiation. Otherwise, personnel were issued film badges sensitive to only beta and gamma radiation.

No details on the Radiation Detection Company dosimeter design or film type are currently available, but site documentation suggests that the film badge was comparable to the Landauer design. Film badge detection thresholds for R.S. Landauer, Jr. and Company badges were reported in January 1961 as 10 mrem from gamma, 40 mrem from beta, and 20 mrem from fast neutrons. Other documentation indicates that film badge detection thresholds in the early days were assumed to be as high as 50 mrem for gamma and 60-80 mrem for beta.

In addition to the badge dosimeters, personnel used direct- or indirect-reading dosimeters, such as personal ion chambers. It is unclear whether these additional dosimeters detected low-energy X-rays. (Currently available pocket dosimeters designed for low-energy X-ray detection report the lower end of the energy range as 20 to 40 keV. Dosimeters not specifically designed for low-energy X-ray detection have thresholds of about 80 keV.) Extremity dosimeters were used in some operations, such as during removal of irradiated samples from the TRIGA reactors (Gurren, 1966). Results from the pocket dosimeters were logged by staff on a routine basis. Some on-site readings are included in the available individual dosimetry records.

Site documentation indicates that during the 1960 to 1961 timeframe, film badges, fast and thermal neutron detection equipment, and direct- and indirect-reading pocket dosimeters were irradiated to evaluate the radiation recorded on each device. Beginning in early 1960, indium foils were incorporated into personnel security badges in case of a criticality event (Ray, 1960). By July 1961, all personnel film holders were equipped with a built-in threshold detector for neutron dose evaluations in the event of a criticality (Bold, 1961). Badges were exchanged on a bi-monthly frequency at General Atomics in 1960 and 1961 (Bold, 1962). In 1962, badges were exchanged monthly (Bold, 1968); this frequency was likely used until 1996 when quarterly exchanges were begun.

According to 1961 correspondence, “Special Tests for Employees Working Around BeO,” special radiation tests, X-rays, and spirograms were conducted for employees working in the vicinity of BeO (Bethard 1961a, 1961b, 1961c, and 1961d). No additional documentation detailing occupationally-required medical X-ray examinations has been identified. NIOSH’s review of data for EEOICPA claimants who worked at General Atomics suggests that X-rays were given annually. To date, no information regarding equipment and techniques specific to General Atomics has been located.

5.3 General Atomics Workplace Monitoring Data

Engineering controls to reduce radiation/radioactivity exposure appear to have been present throughout the site. General Atomics conducted routine air monitoring, but noted inadequacies in the frequency and quality of its program in the early years. NIOSH has no documentation that suggests thorium was specifically monitored by air sampling.

Surface area wipe-testing was performed periodically at General Atomics, but it is unclear whether direct contamination surveys were routinely performed. Several incidents involving radioactivity releases and occurrences of contamination were documented (Hughes, 1964; Hughes, 1967; Hughes, 1969; Kesting, 1964; Kesting, 1969; Lepper, 1963). At least one incident, in 1968, involved the LINACs whereby both long- and short-lived radionuclides were potentially released. Because thorium was irradiated at the accelerators, it is plausible that thorium was released during one or more incidents.

6.0 Feasibility of Dose Reconstruction for the Proposed Class

42 C.F.R. § 83.14(b) states that HHS will consider a NIOSH determination that there was insufficient information to complete a dose reconstruction, as indicated in this present case, to be sufficient, without further consideration, to conclude that it is not feasible to estimate the levels of radiation doses of individual members of the class with sufficient accuracy.

In the case of a petition submitted to NIOSH under 42 C.F.R. § 83.9(b), NIOSH has already completed research to determine that a dose reconstruction cannot be completed for an employee at the DOE or AWE facility. This determination by NIOSH provides the basis for the petition by the affected claimant. NIOSH has further considered defining the extent of the class of employees who are similarly affected, as indicated by the completed research, and hence, as a class of employees, dose reconstruction is similarly not feasible.

This section of the report summarizes research findings by which NIOSH determined that it lacked sufficient information to complete the relevant dose reconstruction and on which basis it has defined the class of employees for which dose reconstruction is not feasible. NIOSH's determination relies on the same statutory and regulatory criteria that govern consideration of all SEC petitions.

6.1 Feasibility of Estimating Internal Exposures

As indicated in Section 5.1, NIOSH has identified no evidence to suggest that a bioassay monitoring program for thorium exposure existed at General Atomics during the AWE operational period from January 1, 1960 through December 31, 1969. As indicated in Section 4.0, potential for thorium intakes existed throughout the radiological areas of the General Atomics facility, with no identifiable correlation between thorium activity levels and the uranium activity levels found in the workplace. Concentrated thorium was commonly produced or used during radiological operations and experiments. Consequently, although a uranium bioassay monitoring program existed during portions of the defined period, the uranium bioassay results are not adequate to allow the bounding of worker doses due to potential thorium intakes.

NIOSH does not have air monitoring program documentation or air monitoring data relative to the worker breathing zones or for the work areas containing concentrated thorium activities at General Atomics. Given the lack of evidence of any thorium-specific monitoring program, NIOSH has determined that there are insufficient air monitoring data available to support reconstruction of thorium-specific internal doses with sufficient accuracy. Further, NIOSH lacks sufficient process and source term information to adequately assess potential thorium doses that may have occurred due to the diverse radiological operations at General Atomics.

Given the data currently available to NIOSH, it is not possible to adequately reconstruct the internal doses that would have resulted from intake of thorium at General Atomics from January 1960 through December 1969. Consequently, NIOSH is unable to adequately estimate total internal exposures for the General Atomics AWE operational period. Prior to the start of routine bioassay in October 1963, NIOSH is unable to reconstruct any internal doses from any radionuclide. Internal dose due to intake of uranium can be reconstructed for exposures starting in October 1963, and tritium doses can be estimated after September 1965.

Some limited documentation is currently available to match radiological workers to specific locations; however, many of these workers were likely assigned to multiple locations. Therefore, the proposed class cannot be restricted to a specific job title or occupation. Thorium was used or potentially used, handled, or stored in the locations included in the class definition.

6.2 Feasibility of Estimating External Exposures

This evaluation responds to a petition based on NIOSH determining that internal radiation exposures to thorium could not be reconstructed for a dose reconstruction referred to NIOSH by the Department of Labor. As noted above, HHS will consider this determination to be sufficient without further consideration to determine that it is not feasible to estimate the levels of radiation doses of individual members of the class with sufficient accuracy. Consequently, it is not necessary for NIOSH to evaluate the feasibility of reconstructing external radiation exposures for the class covered by this report.

However, for the record, NIOSH considers the adequate reconstruction of occupational external radiation doses for General Atomics workers feasible. Available records indicate that General Atomics workers were monitored for external whole-body exposures. Adequate reconstruction of external dose is considered possible by using claimant-favorable assumptions as well as applicable protocols specified in various complex-wide Technical Information Bulletins (TIBs).

In addition, NIOSH considers the adequate reconstruction of medical dose for General Atomics workers feasible by using claimant-favorable assumptions as well as applicable protocols specified in the complex-wide TIB ORAUT-OTIB-0006, *Technical Information Bulletin: Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures*.

7.0 Summary of Feasibility Findings for Petition SEC-00064

This report evaluated the feasibility for estimating the dose, with sufficient accuracy, for General Atomics employees from January 1, 1960, through December 31, 1969. NIOSH determined that it lacks bioassay data and air monitoring results necessary to reconstruct the internal exposures at the facility during this time period. Consequently, NIOSH finds that it is not feasible to estimate with sufficient accuracy the radiation doses resulting from internal exposures received by members of this class of employees.

NIOSH has documented herein that it cannot complete the dose reconstruction(s) related to this petition. The basis of this finding is specified in this report, which demonstrates that NIOSH 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. Members of this class at General Atomics may have received internal intakes from exposure to thorium at the plant. NIOSH lacks sufficient information, including biological monitoring data, air monitoring information, and process and radiological source information that would allow it to estimate the potential intake(s) of thorium, and the resulting dose to which the proposed class may have been exposed.

8.0 Evaluation of Health Endangerment for Petition SEC-00064

The health endangerment determination for the class of employees covered by this evaluation report is governed by EEOICPA and 42 C.F.R. § 83.14(c) and § 83.13(c)(3). Pursuant to these requirements, if it is not feasible to estimate with sufficient accuracy radiation doses for members of the class, NIOSH must determine that there is a reasonable likelihood that such radiation doses may have endangered the health of members of the class. The regulations require NIOSH to assume that any duration of unprotected exposure may have endangered the health of members of a class when it has been established that the class may have been exposed to radiation during a discrete incident likely to have involved levels of exposure similarly high to those occurring during nuclear criticality incidents. If the occurrence of such an exceptionally high-level exposure has not been established, then NIOSH is required to specify that health was endangered for those workers who were employed for a number of work days aggregating at least 250 work days within the parameters established for the class or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

NIOSH has determined that members of the class were not exposed to radiation during a discrete incident likely to have involved levels of exposure similarly high to those occurring during nuclear criticality incidents. However, the evidence reviewed in this evaluation indicates that some workers in the class may have accumulated chronic radiation exposures through intake of radionuclides and from direct exposure to radioactive materials. Consequently, NIOSH is specifying that health may have been 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-00064

The evaluation defines a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. The NIOSH-proposed class includes all AWE employees who were monitored or should have been monitored for exposure to ionizing radiation while working at the following General Atomics locations: Science Laboratories A, B, and C (Building 2); Experimental Building (Building 9); Maintenance (Building 10); Service Building (Building 11); Buildings 21 and 22; Hot Cell Facility (Building 23); Waste Yard (Buildings 25 and 26); Experimental Area (Buildings 27 and 27-1); LINAC Complex (Building 30); HTGR-TCF (Building 31); Fusion Building (Building 33); Fusion Doublet III (Building 34); SV-A (Building 37); SV-B (Building 39); and SV-D (no building number) for a number of work days aggregating at least 250 work days from January 1, 1960, through December 31, 1969, or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

10.0 References

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42 C.F.R. pt. 82, *Methods for Radiation Dose Reconstruction Under the Energy Employees Occupational Illness Compensation Program Act of 2000*; Final Rule; May 2, 2002; SRDB Ref ID: 19392

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; SRDB Ref ID: 22001

42 U.S.C. §§ 7384-7385 [EEOICPA], *Energy Employees Occupational Illness Compensation Program Act of 2000*; as amended

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