SEC Petition Evaluation Report
Petition SEC-00126

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Site Expert(s):	N/A

Petition Administrative Summary			
Petition Under Evaluation			
Petition #	Petition Type	Petition Qualification Date	DOE/AWE Facility Name
SEC-00126	83.13	December 22, 2008	Piqua Organic Moderated Reactor (POMR)

Petitioner Class Definition
All employees associated with reactor activities who worked within and around the reactor dome at the Piqua Organic Moderated Reactor during the covered period from January 1, 1963 through December 31, 1966.

Class Evaluated by NIOSH
All employees associated with reactor activities who worked within and around the reactor dome at the Piqua Organic Moderated Reactor during the covered period from January 1, 1963 through May 1, 1966.

NIOSH-Proposed Class to be Added to the SEC
None

Related Petition Summary Information			
SEC Petition Tracking #(s)	Petition Type	DOE/AWE Facility Name	Petition Status
N/A	N/A	N/A	N/A

Related Evaluation Report Information	
Report Title	DOE/AWE Facility Name
N/A	N/A

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Peer Review Completed By:	[Signature on file] *Charles D. Nelson*	4/27/2009 *Date*
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SEC Evaluation Approved By:	[Signature on file] *Dave Sundin for Larry Elliott*	4/28/2009 *Date*

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Evaluation Report Summary: SEC-00126, Piqua Organic Moderated Reactor

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

Petitioner-Requested Class Definition

Petition SEC-00126, qualified on December 22, 2008, requested that NIOSH consider the following class: *All employees associated with reactor activities who worked within and around the reactor dome at the Piqua Organic Moderated Reactor during the covered period from January 1, 1963 through December 31, 1966.*

Class Evaluated by NIOSH

Based on its preliminary research, NIOSH reduced the petitioner-requested class. NIOSH evaluated the following class: *All employees associated with reactor activities who worked within and around the reactor dome at the Piqua Organic Moderated Reactor during the covered period from January 1, 1963 through May 1, 1966.* The petitioner-requested class was modified because the Piqua operations that began on May 2, 1966 (the start of the Recovery Program) were significantly different, perhaps with more potential exposures, than those occurring during the operational period from January 1, 1963 through May 1, 1966. NIOSH has identified information regarding the Piqua Recovery Program that warrants further research. During the Recovery Program the reactor facility was shutdown and a portion of the reactor and associated shielding were removed to inspect the reactor core and facilitate the decontamination of the coke-like mass located in the core of reactor. This activity was not associated with normal operational activities that began in 1963 and continued into 1966. Therefore, the review of the May 2, 1966 through December 31, 1966 timeframe has been reserved in this evaluation report, pending further review and research. In addition, NIOSH is awaiting a Department of Labor (DOL) decision regarding extending the covered period (currently defined by the DOE Office of Health, Safety and Security as starting in 1963 and ending in 1966) so that it can determine if the Decontamination and Decommissioning activities that were completed in February 1969 are covered activities.

NIOSH-Proposed Class to be Added to the SEC

Based on its full research of the class under evaluation, NIOSH has obtained monthly, semiannual, and annual reports, as well as information from former Piqua Organic Moderated Reactor (POMR) facility personnel that provide sufficient information to allow dose reconstructions to be performed with sufficient accuracy. Based on its analysis of these available resources, NIOSH found no part of the class under evaluation for which it cannot estimate radiation doses with sufficient accuracy.

Feasibility of Dose Reconstruction

Per EEOICPA and 42 C.F.R. § 83.13(c)(1), NIOSH has established that it has access to sufficient information to: (1) estimate the maximum radiation dose, for every type of cancer for which radiation doses are reconstructed, that could have been incurred in plausible circumstances by any member of the class; or (2) estimate radiation doses of members of the class more precisely than an estimate of maximum dose. Information available is sufficient to document or estimate the maximum internal and external potential exposure to members of the evaluated class under plausible circumstances during the specified period.

Health Endangerment Determination

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

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SEC Petition Evaluation Report for SEC-00126

1.0 Purpose and Scope

This report evaluates the feasibility of reconstructing doses for all employees associated with reactor activities who worked within and around the reactor dome at the Piqua Organic Moderated Reactor during the covered period from January 1, 1963 through May 1, 1966. It provides information and analyses germane to considering a petition for adding a class of employees to the congressionally-created SEC.

This report does not make any determinations concerning the feasibility of dose reconstruction that necessarily apply to any individual energy employee who might require a dose reconstruction from NIOSH. This report also does not contain the final determination as to whether the proposed class will be added to the SEC (see Section 2.0).

This evaluation was conducted in accordance with the requirements of EEOICPA, 42 C.F.R. pt. 83, and the guidance contained in the Office of Compensation Analysis and Support's (OCAS) *Internal Procedures for the Evaluation of Special Exposure Cohort Petitions*, OCAS-PR-004.

2.0 Introduction

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

42 C.F.R. § 83.13(c)(1) states: *Radiation doses can be estimated with sufficient accuracy if NIOSH has established that it has access to sufficient information to estimate the maximum radiation dose, for every type of cancer for which radiation doses are reconstructed, that could have been incurred in plausible circumstances by any member of the class, or if NIOSH has established that it has access to sufficient information to estimate the radiation doses of members of the class more precisely than an estimate of the maximum radiation dose.*

Under 42 C.F.R. § 83.13(c)(3), if it is not feasible to estimate with sufficient accuracy radiation doses for members of the class, then NIOSH must determine that there is a reasonable likelihood that such radiation doses may have endangered the health of members of the class The regulation requires 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

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

who were employed for at least 250 aggregated work days within the parameters established for the class or in combination with work days within the parameters established for other SEC classes (excluding aggregate work day requirements).

NIOSH is required to document its evaluation in a report, and to do so, relies upon both its own dose reconstruction expertise as well as technical support from its contractor, Oak Ridge Associated Universities (ORAU). Once completed, NIOSH provides the report to both the petitioner(s) and to the Advisory Board on Radiation and Worker Health (Board). The Board will consider the NIOSH evaluation report, together with the petition, petitioner(s) comments, and other information the Board considers appropriate, in order to make recommendations to the Secretary of HHS on whether or not to add one or more classes of employees to the SEC. Once NIOSH has received and considered the advice of the Board, the Director of NIOSH will propose a decision on behalf of HHS. The Secretary of HHS will make the final decision, taking into account the NIOSH evaluation, the advice of the Board, and the proposed decision issued by NIOSH. As part of this decision process, petitioners may seek a review of certain types of final decisions issued by the Secretary of HHS.[2]

3.0 SEC-00126, Piqua Organic Moderated Reactor (POMR) Class Definitions

The following subsections address the evolution of the class definition for SEC-00126, the Piqua Organic Moderated Reactor (POMR). When a petition is submitted, the requested class definition is reviewed as submitted. Based on its review of the available site information and data, NIOSH will make a determination whether to qualify for full evaluation all, some, or no part of the petitioner-proposed class. If some portion of the petitioner-proposed class is qualified, NIOSH will specify that class along with a justification for any modification of petitioner's class. After a full evaluation of the qualified class, NIOSH will determine whether to propose a class for addition to the SEC and will specify that proposed class definition.

3.1 Petitioner-Requested Class Definition and Basis

Petition SEC-00126, qualified on December 22, 2008, requested that NIOSH consider the following class for addition to the SEC: *All employees associated with reactor activities who worked within and around the reactor dome at the Piqua Organic Moderated Reactor during the covered period from January 1, 1963 through December 31, 1966.*

The petitioner provided information and affidavit statements in support of the petitioner's belief that accurate dose reconstruction over time is impossible for the POMR workers in question. NIOSH deemed the following information and affidavit statements sufficient to qualify SEC-00126 for evaluation:

> In support of the petition, the SEC-00126 petitioner claims that no records were kept on activities related to the Piqua site to include the dismantling of the facility and that the

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

petitioner's father was not trained in the hazards of the POMR. In addition, no monitoring devices were ever offered.

During the construction and operation of the reactor, [former POMR employee] *was employed by the city of Piqua as a material handler and subsequently a linesman for the power plant and helped out at the reactor site at various times even though he was primarily assigned to the original power plant adjacent to one another. He was a laborer primarily assigned any duty his supervisor would assign. This all done without any type of monitoring, training, or protective devices for handling nuclear material* [sic] *this was not explained but one has to surmise it was because of* [former POMR employee]'s *primary work was at the other building* [sic]. *It was during the second part of his career, decommissioning and dismantling of the Reactor, that* [former POMR employee] *had the most potential exposure to the harmful elements used at and remain at the Moderated Reactor located in Piqua Ohio.*

… At no time was [name of the former Energy employee] *trained in the hazards* [at the POMR site] *nor was any monitoring devices offered." "No records were kept on activities related to the Piqua site to include the dismantling of the facility and use of* [former POMR employee and survivor's father] *in such exposure.*

Based on its POMR research and data capture efforts, NIOSH determined that it has access to monthly, semiannual, and annual summary reports, reactor design, shielding material, and radiation source information for the time period under evaluation, but NIOSH has also determined that internal and external records are not complete for all time periods or for all radionuclides. The information and statements provided by the petitioner qualified the petition for further consideration by NIOSH, the Board, and HHS. The details of the petition basis are addressed in Section 7.4.

3.2 Class Evaluated by NIOSH

Based on its preliminary research, NIOSH reduced the petitioner-proposed class to include only the January 1, 1963 through May 1, 1966 timeframe, because the Piqua operations that began on May 2, 1966 (the start of the Recovery Program) were significantly different, perhaps with more potential exposures than those that occurred during the operational period from January 1, 1963 through May 1, 1966. NIOSH has identified information regarding the Piqua Recovery Program that warrants further research. During the Recovery Program, the reactor was shutdown and a portion of the reactor and associated shielding were removed to inspect the reactor core and facilitate the decontamination of the coke-like mass located in the core of reactor. This activity was not associated with normal operational activities that began in 1963 and continued through May 1, 1966. Therefore, the review of the May 2, 1966 through December 31, 1966 timeframe has been reserved in this evaluation report, pending further review and research. In addition, NIOSH is awaiting a Department of Labor (DOL) decision regarding extending the covered period (currently defined by the DOE Office of Health, Safety and Security as starting in 1963 and ending in 1966) so that it can determine if the Decontamination and Decommissioning activities that were completed in February 1969 are covered activities. NIOSH defined the following class for further evaluation: All employees associated with reactor activities who worked within and around the reactor dome at the Piqua Organic Moderated Reactor during the covered period from January 1, 1963 through May 1, 1966.

3.3 NIOSH-Proposed Class to be Added to the SEC

Based on its research, NIOSH has obtained monthly, semiannual, and annual reports, limited radiation exposure records, and information from former POMR facility personnel that allow dose reconstruction to be performed with sufficient accuracy. Based on its analysis of these available resources, NIOSH found no part of the class under evaluation for which it cannot estimate radiation doses with sufficient accuracy.

4.0 Data Sources Reviewed by NIOSH to Evaluate the Class

In addition to searching City of Piqua records, NIOSH completed an extensive database and Internet search for information regarding the Piqua Organic Moderated Reactor facility. The database search included the DOE Legacy Management Considered Sites database, the DOE Office of Scientific and Technical Information (OSTI) database, the Energy Citations database, the Atomic Energy Technical Report database, and the Hanford Declassified Document Retrieval System. In addition to general Internet searches, the NIOSH Internet search included OSTI OpenNet Advanced searches, OSTI Information Bridge Fielded searches, Nuclear Regulatory Commission (NRC) Agency-wide Documents Access and Management (ADAMS) web searches, the DOE Office of Human Radiation Experiments website, and the DOE-National Nuclear Security Administration-Nevada Site Office-search. Attachment Two contains a summary of Piqua Organic Moderated Reactor documents. The summary specifically identifies data capture details and general descriptions of the documents retrieved.

In addition to the database and Internet searches listed above, NIOSH identified and reviewed numerous data sources to determine information relevant to determining the feasibility of dose reconstruction for the class of employees under evaluation. This included determining the availability of information on personal monitoring, area monitoring, industrial processes, and radiation source materials. The following subsections summarize the data sources identified and reviewed by NIOSH.

4.1 ORAU Technical Information Bulletin (OTIB)

An ORAU Technical Information Bulletin (OTIB) is a general working document that provides guidance for preparing dose reconstructions at particular sites or categories of sites. NIOSH reviewed the following OTIB as part of its evaluation:

- *OTIB: Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures*, ORAUT-OTIB-0006; December 21, 2005; SRDB Ref ID: 20220

4.2 Facility Employees and Experts

To obtain additional information, NIOSH contacted seven former POMR facility personnel. One person contacted did not work at the POMR facility during the time period evaluated in this report; therefore, NIOSH did not conduct a complete interview with this person. NIOSH performed seven interviews with six former Piqua employees (one former employee was interviewed on two separate occasions), all were considered to be knowledgeable about the POMR facility. All interviews were conducted by phone. The purpose of the interviews was to gain additional first-hand information from people who worked at the POMR facility. A summary of the information obtained from the interviews can be found in Attachment One of this report.

- Personal Communication, 2009a, *Personal Communication with Former Health Physics Technician*; Telephone Interview by ORAU Team; January 20, 2009; SRDB Ref ID: 61683

- Personal Communication, 2009b, *Personal Communication with DOE Legacy Management Employee*; Telephone Interview by ORAU Team; January 29, 2009; SRDB Ref ID: 61681

- Personal Communication, 2009c, *Personal Communication with Former Shift Supervisor*; Telephone Interview by ORAU Team; February 19, 2009; SRDB Ref ID: 61677

- Personal Communication, 2009d, *Personal Communication with Former Construction Engineer, Instrumentation Engineer, and Electrical Engineer*; Telephone Interview by ORAU Team; February 19, 2009; SRDB Ref ID: 61684

- Personal Communication, 2009e, *Personal Communication with Former Reactor Operator and Maintenance Foreman*; Telephone Interview by ORAU Team; February 6, 2009; SRDB Ref ID: 61679

- Personal Communication, 2009f, *Personal Communication with Chief Health Physicist*; Telephone Interview by ORAU Team; February 23, 2009; SRDB Ref ID: 61680

- Personal Communication, 2009g, *Personal Communication with Former Health Physics Technician*, second interview; Telephone Interview by ORAU Team; March 18, 2009; SRDB Ref ID: 62597

- Personal Communication, 2009h, *Personal Communication with Former POMR Facility Employee*; documented telephone communication; March 23, 2009; SRDB Ref ID: 62596

4.3 Previous Dose Reconstructions

NIOSH reviewed its NIOSH OCAS Claims Tracking System (NOCTS) to locate EEOICPA-related dose reconstructions that might provide information relevant to the petition evaluation. Table 4-1 summarizes the results of this review. (NOCTS data available as of April 21, 2009)

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

Description	Totals
Total number of claims submitted for dose reconstruction	5
Total number of claims submitted for energy employees who meet the definition criteria for the class under evaluation (January 1, 1963 through May 1, 1966)	5
Number of dose reconstructions completed for energy employees who meet the definition criteria for the class under evaluation (i.e., the number of such claims completed by NIOSH and submitted to the Department of Labor for final approval).	3
Number of claims for which internal dosimetry records were obtained for the identified years in the evaluated class definition	0
Number of claims for which external dosimetry records were obtained for the identified years in the evaluated class definition	1

NIOSH reviewed each claim to determine whether internal and/or external personal monitoring records could be obtained for the employee. Five claims have been submitted for the POMR facility; three of the claims have been completed. NIOSH has located no claims with internal monitoring and only one claim with external monitoring for individuals that were employed during the period evaluated in this report.

4.4 NIOSH Site Research Database

NIOSH also examined its Site Research Database (SRDB) to locate documents supporting the evaluation of the proposed class. One hundred ninety-five documents in this database were identified as pertaining to the Piqua Organic Moderated Reactor facility. These documents were evaluated for their relevance to this petition. The documents include personnel data, historical background information on the Piqua facility, and monthly, semiannual, and annual reports. Through researching the records, NIOSH learned that R.S. Landauer Jr. and Company provided external dosimetry. Although R.S. Landauer Jr. and Company has stated that it cannot locate any POMR records, NIOSH is continuing its efforts to work with R.S. Landauer Jr. and Company regarding potential POMR data.

4.5 Documentation and/or Affidavits Provided by Petitioners

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

- *Petition Form B*; August 21, 2008; OSA Ref ID: 106811

5.0 Radiological Operations Relevant to the Class Evaluated by NIOSH

The following subsections summarize both radiological operations at the POMR site from January 1, 1963 through May 1, 1966 and the information available to NIOSH to characterize particular processes and radioactive source materials. From available sources NIOSH has gathered monthly, semiannual, and annual summary reports, reactor design information, and shielding and radiation source materials. The information included within this evaluation report is intended only to be a summary of the available information. As previously discussed, NIOSH's review and evaluation of the May 2, 1966 through December 31, 1966 timeframe is reserved. Therefore, only the radiological operations performed January 1, 1963 through May 1, 1966 will be reviewed throughout this report.

5.1 POMR Plant and Process Descriptions

ATTRIBUTION: Section 5.1 was completed by Karin Jessen, Oak Ridge Associated Universities (ORAU). These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

The POMR site, also known as the Piqua Nuclear Power facility, was a nuclear power plant designed by Atomics International, that operated in Piqua, Ohio, about 34 miles north of Dayton, Ohio. The plant contained a 45.5-megawatt (thermal) organically cooled and moderated nuclear reactor that was originally built as a demonstration project by the AEC. The reactor was initially operated by Atomics International, who also trained employees from the City of Piqua to operate and maintain the plant. The City of Piqua eventually took over operation of the reactor, which operated between 1963 and 1966. Operations were terminated in 1966, due to technical difficulties such as control-rod problems and fouling of heat-transfer surfaces; in 1967, the AEC terminated its contract for reactor operation with the City of Piqua. The Piqua reactor was dismantled between 1967 and 1969, and the radioactive coolant and most other radioactive materials were removed. The remaining radioactive structural components of the reactor were entombed in the reactor vessel under sand and concrete (DOE, 2009).

The primary objective of the POMR facility was to demonstrate the feasibility of the organic reactor concept when operated as an integral part of a power generation system, and to provide information which ultimately was expected to lead to the design and construction of larger, more economically competitive nuclear power facilities (DOE, 2009). The plant was designed as a load-following system, meaning the reactor power level varied according to the steam demands. Superheated steam at constant pressure was supplied to the steam header in the Piqua Municipal Power Plant, located to the west across the Great Miami River. A summary of the POMR operating history is shown in Table 5-1.

Table 5-1: Summary of POMR Operating History	
Date	**Action**
June 1963	Initially criticality achieved.
July 1963	Fuel loading completed.
January 27, 1964	Full power achieved; reactor operated steadily but with one scram.
May 21, 1964	First scheduled shutdown for routine maintenance and inspection During this period of operation, POMR contributed ~ 40% of the energy generated by the City of Piqua.
December 7, 1964	Reactor was shut down to renew fifteen in-vessel filters and remove the fuel element in Core position F-13 for examination.
January 28, 1965	Reactor was shut down for complete replacement of in-vessel filters, maintenance, and for relocation of the instrumented fuel element from position E-12 to position D-5.
April 2, 1965	Several malfunctioning control rod drive units repaired. Concern over possible plugged condition of the inner process tube of the control rod-bearing elements led to the movement of the six inner ring control rod elements to peripheral positions. The core size was increased from 61- 67 fuel elements.
May 6 – 12, 1965	Scram occurred on May 6, 1965. During this time, the reactor coolant level had been lowered by operational error, which resulted in a temporary loss of circulation through three elements. Shutdown was extended until May 12 so the three fuel elements could be removed to spent-fuel storage.
May 13, 1965 (estimated date)	Immediately upon restart, excessive surface temperatures were noted, necessitating additional fuel element removal. Because of the fuel element removal, the system operated with only one coolant pump during the latter half of June and into July.
July 18, 1965	Reactor shut down for modifications, maintenance, and in-vessel filter replacement; performed extensive modifications of the in-core control rod circuitry.
September 6, 1965	Reactor operation resumed.
October 12, 1965	Reactor shut down, fuel rearrangements were made, increasing the core loading to 70 fuel elements.
October 23, 1965	Reactor restarted. Operation of the reactor continued at an average power level of about 24 MWt.
January 13, 1966	Reactor scrammed because of a spurious signal. At this time, there was no indication of any unusual condition in the reactor core. Prior to restarting the reactor, an abnormal in-core condition was identified during the performance of a rod-drop test. **Note: The reactor was shut down sometime after the abnormal in-core condition.**

Notes:
This document was created from information included in *Summary of Operating History* (Unknown author, unknown date-a) and from information included in *Piqua Recovery Program—Phase II-A Plan of Action* (Morgan, 1966).

Three pipelines, approximately 1,400 feet in length, connected the POMR facility on the east side of the Great Miami River and the Municipal Power Plant on the west side of the river. These three lines included: (1) a 12-inch diameter steam line for steam flow from the POMR steam generator to the conventional power plant steam header. This line also provided preheat and start-up steam from the conventional plant to the POMR facility, (2) a 6-inch diameter line for boiler feed-water supply from the conventional plant to the POMR facility, and (3) a 3-inch line for the return of process steam condensate from the POMR facility to the conventional plant.

POMR Components

Reactor Vessel

The reactor vessel was a pressure vessel made of low-carbon steel (SA-212-B) and had an internal diameter of 7.6 feet, an overall height of 27 feet, and an average wall thickness of 2 inches. It was designed to meet applicable American Society of Mechanical Engineers' codes for an internal pressure of 300 psia and 750°F. The vessel contained ten coolant inlet and outlet nozzle penetrations that were welded and flanged to the vessel. The penetrations consisted of a single 20-inch coolant inlet nozzle, two 14-inch coolant outlet nozzles, a single 6-inch auxiliary inlet nozzle, a 6-inch auxiliary outlet nozzle, two 14-inch sampling valve nozzles, two 8-inch control rod cable nozzles, and one 8-inch thermocouple lead-through nozzle (Atomics International, 1965a, p. 5).

Reactor Core

The core was positioned near the bottom of the reactor core tank. It consisted of a maximum of 85 fuel elements (the number of fuel elements varied during operations) of slightly enriched uranium and 13 control-safety rods and was surrounded by an annular thermal shield supported from a ledge inside the tank. Steel grid plates, located above and below the core, supported the fuel elements and control rods.

The core pressure was maintained by a control valve in the line to the degasifier. Regulated pressurizing pumps returned a constant flow from the degasifier into the primary loop. One pressurizing pump had to be running at all times; the second pump could be removed for service. In the event of loss of power to the main coolant pump, the pressurizing pumps maintained circulation through the core (Atomics International, 1965a, p. 8).

Shielding

Reactor radial shielding was achieved through the following: (1) inner thermal shield with 1.5 inch steel; (2) outer thermal shield with 4.0 inch steel; (3) reactor vessel wall with 1.125 inch steel; and (4) biological shield with 8 feet 4 inches of ordinary concrete (Atomics International, 1965a).

Shielding at the bottom of the reactor was achieved through the following: (1) the lower grid plate with 6-inch steel; (2) organic coolant, measuring 2.5 feet; (3) reactor vessel lower head with 1.125 inch steel; and (4) vessel support with 3 feet of concrete resting on the reactor building lower-floor level (Atomics International, 1965a).

Shielding above the reactor was achieved through the following: (1) the upper grid plate with 8 inch steel; (2) organic coolant, measuring 17.5 feet; and (3) reactor vessel head with 8.5 inch steel (Atomics International, 1965a).

Shielding was provided in other areas that contained process fluids; these areas included the purification room, the drain tank room, the waste fired boiler room, and the decay tank room (Atomics International, 1965a).

Control Rods

The control rod drives consisted of compact unitized assemblies located inside the core tank and immersed in the coolant above the core. The neutron absorber element consisted of an assembly of outside-diameter tubes filled with boron carbide, positioned to operate inside 13 selected circular fuel elements. The drive mechanism operated on the magnetic jack principle, wherein the rod is raised or lowered in discrete steps by energizing appropriate sets of electromagnetic coils.

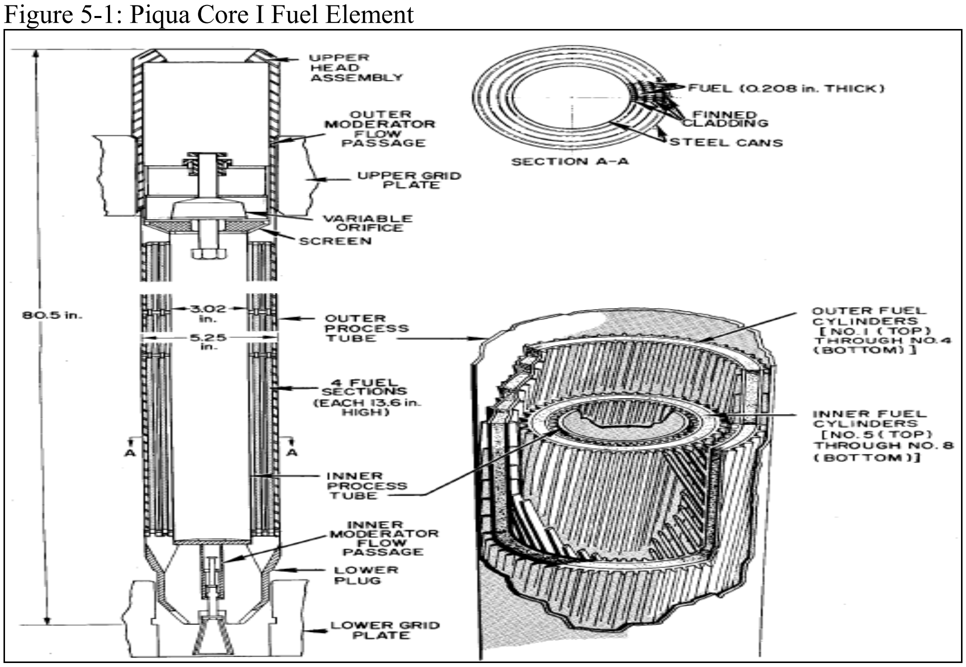
Fuel Elements

The fuel elements were circular in cross-section with an outside diameter of 5.25 inches and a length of approximately 80 inches (Unknown author, unknown date-b). The uranium inside the elements was in the form of two concentric tubes. To improve heat transfer, the inner and outer surfaces of each fuel tube were covered with finned aluminum cladding. To maintain physical separation of the fuel cylinders, the fins of the cladding were twisted into a slight spiral shape along their longitudinal axis. The finned fuel tubes were enclosed between two concentric stainless steel tubes. The ends of the steel tubes were fastened to upper and lower end pieces of the fuel elements. The upper end piece fit into the upper grid plate and supported the weight of the fuel element. The lower end piece guided the element in the lower grid plate and aligned it within the core.

Fuel elements consisted of uranium fuel, clad with aluminum. The fuel material was a metallic uranium alloy, enriched to approximately 1.9 weight percent uranium-235. The alloy was composed of uranium, approximately 3.5 weight-percent molybdenum and 0.1 weight-percent aluminum. The aluminum cladding had a finned surface to provide an extended heat transfer area. It was metallurgically bonded to the uranium fuel using a diffusion barrier of nickel approximately 0.001 inches thick. The maximum total mass of fuel in the core was 134 kg of uranium-235 and 6,776 kg of uranium-238. Figure 5-1 shows a Piqua fuel element.

An orifice was located in the inlet (upper) end of each fuel element that did not have a control rod associated with it. The orifices were adjustable during shutdown and were set to equalize the temperature rise across each fuel element.

Figure 5-1: Piqua Core I Fuel Element



Source: *Irradiation Performance of Piqua Core 1 Fuel Elements* (Arnold, 1966, p. 13)

Reactor Organic Coolant

The organic coolant used in the POMR was a commercially available hydrocarbon mixture of the three isomers of terphenyl[3]. After extensive testing of many hydrocarbons, this hydrocarbon mixture was selected as the moderator-coolant because terphenyls exhibit relatively high thermal and radiation stability, are noncorrosive, and have a relatively low vapor pressure at their expected operating temperatures (Unknown author, unknown date-b).

The organic coolant entered the tank above the core and flowed downward through the fuel elements into the lower plenum, below the lower grid plate. The coolant then flowed upward through the annulus between the core tank and the thermal shield into the outlet plenum of the core tank and back to the primary coolant loop. The organic coolant filled all of the available space in the tank and served as a moderator, coolant, reflector, and shield for the core.

During full-power operation, the coolant was heated in the core from 519°F to 575°F while transferring 155 x 10^6 Btu/hr from the core. The coolant was pumped by two main coolant pumps to the super heater and steam boiler where the heat was transferred to the steam system. A total of 150,000 lb/hr of superheated steam was produced at a pressure of 450 psia and a temperature of 550°F. The main coolant system consisted of a single loop in which two 6,000 gpm pumps operated in parallel, pumping 12,000 gpm to a single super heater and boiler. A flow bypass was utilized to divert coolant around the boiler for control purposes.

Radiation damage to the coolant, as well as exposure to heat, resulted in the formation of various gases and low molecular weight compounds, and at the same time produced some higher molecular weight compounds (referred to as high boilers). The higher molecular weight compounds consisted primarily of long-chained polymerization products and were removed from the coolant by vacuum distillation. The high boiler content was permitted to build up to about 30% in the coolant, which was thought to be the optimum concentration. The optimization was based on a balance of the decrease in radiation and thermal damage (decomposition) rate, and the decrease in the heat transfer characteristics of the coolant, as the high boiler content was increased (Unknown author, unknown date-b).

Reactor Systems

There were a number of auxiliary or supporting systems associated with the operation of the POMR facility. Three examples of auxiliary functions included (1) pressurization of the main coolant loop, including the reactor vessel, (2) dissipation of the residual or "decay" heat from the reactor core in the event the main coolant loop was inoperative, and (3) removal of water, gases, and other low-boiling materials formed in the core as a result of coolant decomposition. The schematics associated with the POMR systems are relayed in *Final Safeguards Summary Report for the Piqua Nuclear Power Facility*, Appendix K (Atomics International, 1961, pp. 59, 65, 69, 72, 76).

Containment Building

The reactor was housed within a containment building that consisted of a steel shell with an inner lining of concrete. The steel shell was approximately 73 feet in inside diameter and 123 feet in overall

[3] Terphenyls are aromatic hydrocarbons consisting of three benzene rings linked together with covalent bonds. Terphenyl is produced by a process that involves heating the benzene to about 600°C in the presence of a catalyst.

height. The shell was fabricated from A-201B steel and was 3/8 inch thick. Thicker plates were installed at the various penetrations points. The shell was lined with approximately 18 inches of concrete on the vertical sections above grade, and the dome was lined with concrete with a varying thickness from 18 inches at the lower edge to 6 inches at the top of the dome. The overall free volume within the building was approximately 300,000 cubic feet (Atomics International, 1965a, p. 3).

The containment building was designed to withstand an internal pressure of 5 psig. At this pressure, the maximum leakage rate was 1% of the free volume per day. Atmospheric pressure was normally maintained within the building by means of supply and exhaust fans (Atomics International, 1965a, p. 3). Airlocks were provided for access to the containment building.

Fuel Handling System

As described in the process and procedures defined in the *Final Safeguards Summary Report for the Piqua Nuclear Power Facility*, Appendix K, the specific fuel handling process was a remote process (Atomics International, 1961, pp. 302-305). The spent fuel rods, replaced during refueling operations, were transferred remotely to the fuel storage pool. The fuel storage pool was a separate storage system that contained an underwater rack for storing the spent fuel rods. Refueling was accomplished by working through the reactor top rotating shield, which contained a shield mounted on a circular bearing (to permit rotating around the vessel head flange) and a fuel removal port used during refueling operations. The fuel removal port could be located over any position in the reactor core. The fuel handling cask, which was a shielding device for transferring fuel into or out of the reactor, was equipped with a grappling and hoisting mechanism, a traveling bridge and carriage, and an emergency cooling system. Also involved in the fuel handling system was a fuel storage pool; the fuel storage pool was for the storage of spent fuel elements and consisted of a rack located at the bottom of the pool water. The storage holes in the rack were spaced to prevent fuel element criticalities (Atomics International, 1963).

Heat Transfer System

The main heat transfer system consisted of a single coolant loop which contained two main coolant pumps, a superheater, a boiler, a surge tank, and the reactor vessel. Coolant flowed from the reactor vessel through the parallel connected main pumps, to the superheater and boiler, and back to the reactor vessel. The nominal flow rate through the system with a single pump in operation was about 7,000 gpm, and with two pumps it was about 12,000 gpm. The flow rate was not less 220 gpm per megawatt of thermal power. The heat generated in the reactor core was removed by the circulation of the coolant in one downward pass through the core (Atomics International, 1965a, p. 5).

Degasification System

The degasification system was designed to remove waste gases and 8 pounds of water vapor per hour from the coolant. This system consisted of a degasifier tank which was designed to operate at a partial vacuum. The associated piping was provided to supply a sidestream of coolant from the main heat transfer system to the degasifier. There was a pressure reducing valve, located upstream of the degasifier, that controlled the main heat transfer system pressure and provided accessory control for maintaining vacuum in the degasifier.

Purification System

The radiolytic decomposition of the coolant produced high-molecular-weight compounds (known as high boilers) which had to be removed from the coolant to maintain a fixed percentage of high boiler content. The coolant purification system continuously removed these compounds (which were subsequently transferred and treated/burned in the waste disposal system); thus, maintaining the desired high boiler content in the coolant in the main heat transfer system. The purification system also decontaminated the coolant, since most of the radioactivity in the coolant was removed with the high boilers (Atomics International, 1961, pp. 66-331).

As described in *Final Safeguards Summary Report for the Piqua Nuclear Power Facility*, the purification system consisted of a distillation column, column feed heaters, condensers and still bottoms, and product receiver tanks. Purification system piping provided a sidestream of coolant from the coolant storage system and pressurization system into the column feed heaters. The purification system separated high boilers from the coolant and maintained the main heat transfer system coolant at a high boiler concentration of approximately 30% or less. The purification system was designed to process coolant at a flow rate of up to 1,000 pounds/hour.

Aqueous Waste System

The aqueous waste system consisted of a settling basin, waste holdup tanks, demineralizers, and interconnecting piping and sumps serving various process areas. The system was designed to gather and separate organic and particulate material from the aqueous wastes. Discharge from the settling basin could be stored in holdup tanks prior to disposal. Provisions were made for decontaminating the water, using an ion exchange technique, if radioactivity levels were above permissible levels.

Waste Gas System

The waste gas system consisted of a steam ejector, condensers, and holdup decay tanks. The system allowed gases to flow from the purification and degasification systems. The waste gases were processed through one of two decay tank banks; each bank contained eleven decay tanks, each having a diameter of 10 inches and a length of 15 feet. Four of the decay tanks in each bank were filled with activated carbon for processing waste gas prior to the gas being discharged through the stack. The decay tanks had a sufficient total capacity to delay the gases for 48 hours, giving ample time for radioactive decay of the process gases before exhausting into the atmosphere. The waste gas system provided storage and monitoring of all process gases prior to their release into the atmosphere through the stack.

Organic Waste Disposal System

The organic waste disposal system consisted of holdup tanks serving the purification system and a waste fired boiler designed to burn organic waste from the plant. Still bottoms from the purification system column were pumped into the decay tank and stored. The decay tank consisted of a compartmentalized vessel with seven compartments, each compartment having a capacity of 3,000 gallons. The contents of each compartment were sampled prior to processing through the waste fired boiler. Organic wastes were burned subsequent to analysis.

Heating and Cooling System

The heating and ventilation system provided for air circulation and heating or cooling in all buildings. It also provided for maintaining pressure differentials between various areas of the buildings, to ensure that air flow was always from non-contaminated areas into those areas having a higher potential for contamination. All ventilation air was filtered and monitored before being exhausted into the atmosphere. In the event of high radioactivity in the exhaust system, the reactor building had the ability to be automatically isolated, and the air would have been recirculated in a closed loop within the building.

POMR Safety Features

The POMR included many safety features that helped to ensure safe operation of the reactor and POMR personnel safety. Notable safety features included concrete for shielding, below-ground level components, process gases and waste monitoring, and automatic shutdown and air recirculation. Specific safety features include the following:

- Concrete surrounded the reactor vessel (8'4" of concrete shielded or absorbed radiation emitted from the reactor core);
- Continuous stack effluent monitors (including a particulate monitor and a gaseous activity monitor. Detection of airborne radioactivity levels above specified instrument radiation levels activated an alarm in the control room, and reactor building isolation devices would be activated upon detection of particulate activity);
- Personnel Monitors (Portal Monitor);
- Exhaust Gas prefilter and absolute filter before going out of the 125 foot exhaust stack;
- Below-ground-level components (including the core, associated piping, and organic auxiliary systems);
- Solid concrete walls and partitions in the auxiliary building (to protect the environs from radiation from the piping and vessels in the building);
- Sealed openings surrounding the reactor;
- Containment shell (dome) was maintained at a negative pressure (with respect to the atmosphere) and retained any radioactive material released from the reactor vessel or process piping;
- Airlocks used for containment shell
- Noncorrosive properties of the organic coolant (corrosion of the fuel, piping, or other reactor equipment was unlikely);
- Process gases were monitored (prior to entry into the train of decay tanks);
- Potentially contaminated waste water was stored and monitored for safety determination (prior to being discharged from the plant);
- Radiation monitors located at the exhaust stack (if excessive radioactivity was detected, the reactor building was automatically isolated and the air was recirculated within the building);
- Automatic shutdown actions incorporated throughout the plant (in the event of off-normal conditions, the reactor would be shut down and/or isolated);
- Fifteen remote area monitors (each detector operated a corresponding relay meter and a recorder in the control room to continuously indicate the radiation level from the area or equipment being monitored);

- Continuous monitoring of cooling water (via sample stream from the cooling water effluent taken prior to the effluent entering and mixing with industrial wastes);
- Failed element location system (helped determine the presence of a failed fuel element in the core by monitoring the delayed neutron activity of the bulk outlet coolant);
- Annunciator point system (provided audio and visual indication of off-normal conditions);
- Fuel handling system (used cameras and periscopes to remotely view the operational areas); and
- Continuous air monitors (CAMs) (located throughout the plant).

Post-Operational Period

In January 1966, when the reactor shut down due to a scram, several control rod drive problems were discovered; in particular, control rod 10 would not drop into place (Atomics International, 1966b). The reactor was opened and repairs were made to the control rods. In February, the investigation continued; some fuel elements were pulled (or were attempted to be pulled) in an effort to return them to their correct positions. However, many of the fuel elements failed to seat properly. On February 4, 1966, one fuel element was removed and transferred to the fuel storage pool. This fuel element was found, using underwater television and photographs, to have buckles at three elevations and to have a "carbonaceous material" and a "fouling film" on its surface (Atomics International, 1966b). On February 24, 1966, after this fuel element was sent offsite for destructive analysis, the POMR facility suspended onsite recovery efforts and began to develop a plan for core unloading (Atomics International, 1966b). After discovering the buckled fuel element, operations were secured (through May 1, 1966) while the situation was evaluated by Atomics International and a plan for a path forward was developed. It should be noted that the buckling that was reported was observed in the outer process tube that formed the outer support surface of the fuel element and enclosed the fuel assemblies. A detailed report of the visual inspection of each fuel element included descriptions of each buckle and the surface appearance and location of the carbonaceous material (McCurnin, 1966). Nowhere in the documents reviewed was there a reference to a fuel cladding failure.

5.2 Radiological Exposure Sources from POMR Operations

The following subsections provide an overview of the internal and external exposure sources for the POMR class under evaluation.

5.2.1 Internal Radiological Exposure Sources from POMR Operations

<u>ATTRIBUTION</u>: Section 5.2.1 and its related subsections were completed by Daniel Mantooth, Dade Moeller and Associates, Inc. These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

The potential sources of alpha-emitting radionuclides at the POMR site included the uranium fuel itself, as well as transuranic radionuclides produced during the fission process while the reactor was running. However, in either case, these alpha-emitters would not be available for personnel exposures unless the aluminum cladding on the fuel was breached, allowing these radionuclides to contaminate the coolant and other parts of the system. The pre-demolition radiological survey performed in 1968, reported alpha contamination levels as "…non detectable during operation and less than 1 dpm/100 cm^2 in final survey in all locations" (Wheelock, 1970, Appendix B).

The possibility of a cladding breach was discussed in one document (Ashley, 1964, p. 173) as being the cause of low levels of Xe-133 (a uranium fission product) detected in the process gas. However, the fact that the failed Fuel Element Location System (FELS) did not indicate such a failure led POMR site engineers to conclude that the xenon-133 was most likely a result of uranium contamination in the aluminum cladding. In any case, the amount of uranium involved would not have resulted in measureable exposures to POMR personnel. The absence of alpha emitting radionuclides was confirmed by radiological surveys conducted prior to the facility retirement (Wheelock, 1970, Appendix B, Table B-4).

The primary sources of internal exposure at the POMR facility consisted of beta/gamma-emitting radionuclides from four sources: (1) activated impurities in the coolant, (2) activated corrosion products, (3) neutron recoil reactions with the aluminum cladding, and (4) tritium produced by ternary fission.[4]

5.2.1.1 Activated Impurities in the Coolant

The radionuclides that arise from activation of impurities in the coolant, as specified in Table 5-2, include sodium-24, phosphorus-32, sulfur-35, chlorine-38, manganese-56, arsenic-76, argon-41, and nitrogen-13 (Atomics International, 1961; Atomics International, 1965a; Atomics International, 1964a), although argon-41 was believed to result from air in-leakage to the reactor vessel. The presence of nitrogen-13 was explained in the documentation as "...from the nitrogen cover gas" (Atomics International, 1965a). However, it is more likely that the carbon-14 was created from the carbon in the organic coolant from the carbon-12 (p, γ) ^{13N} reaction. The gaseous species argon-41 and nitrogen-13 were removed by the coolant purification system, and after sufficient decay were exhausted via the main stack. Personnel had little opportunity for exposure to these gases during maintenance activities. Due to their short half-life, the majority of the activity in the system would have decayed prior to breaching coolant or other systems. POMR personnel outside the facility may have been exposed to low levels of these radionuclides during reactor plant operation.

Ninety-six to ninety-eight percent of the non-gaseous radionuclides sodium-24, phosphorus-32, manganese-56, and arsenic-76 were thought to be collected along with the high-boiling organics from the coolant purification system. Seventy-eight percent of the sulfur-35 and chlorine-38 were collected in the same manner (Atomics International, 1961). Other systems where particulate activity could have been encountered include the in-vessel filters, coolant purification system, and the fuel storage pool purification filters. Operations that involved system maintenance or filter material replacement would have carried the potential for exposing personnel to these radionuclides. These radionuclides were present throughout the operational history of the reactor, but due to radioactive decay, the relative contributions would shift to longer-lived species during an outage period. Activated impurities were estimated to comprise 48% of the particulate radioactive species in the coolant (Atomics International, 1961).

5.2.1.2 Activated Corrosion Products

[4] Attribution: The percentage reported for each source was calculated by *Daniel Mantooth, Dade Moeller and Associates, Inc.* from estimated concentration values found on page V-4 of Atomics International, 1961.

The primary radionuclide arising from the activation of corrosion products in the coolant is Mn-56. Since this radionuclide is a particulate, the discussion pertaining to locations in the reactor and mechanisms of exposure are identical to that presented for activated coolant impurities in Section 5.2.1.1, above. Activated corrosion products (i.e., Mn-56) were estimated to comprise 13% of the total particulate activity (Atomics International, 1961). The radiological data for Mn-56 and potential sources are listed in Table 5-2.

The reported method for radionuclide identification in the reactor coolant and effluents was by pulse-height analysis (gamma spectroscopy). This method would not have detected non-gamma emitting species such as tritium or carbon-14. The presence of these species was suggested in *Final Safeguards Summary Report for the Piqua Nuclear Power Facility* with calculated concentrations in coolant of 5.3E-04 μCi/cc and 1.4E-04 μCi/cc for tritium and carbon-14, respectively (Atomics International, 1961). Analytical results for tritium and carbon-14 in the coolant have not been found. Analyses of various process residues and water (Wheelock, 1970 Appendix B, Table B-2) in the fuel storage pool indicated tritium levels ranging from 7.5E-04 μCi/cc to 2.1E-02 μCi/cc. Results for carbon-14 ranged from 9E-05 μCi/cc to 2.1E-02 μCi/cc. *Piqua Nuclear Power Facility Monthly Operating Report No. 24* reported that "bioassay performed for personnel working over the open reactor for tritium and net beta activity showed no positive result" (Atomics International, 1965b); these actual bioassay data have not been located.

5.2.1.3 Neutron Recoil Reaction Products

Several particulate nuclides were thought to be produced by neutron recoil reactions with materials present in the aluminum fuel cladding (Atomics International, 1961; Atomics International, 1964c; Atomics International, 1965a; Atomics International, 1964a; Atomics International, 1965d). These include sodium-24 (also arises from impurities), magnesium-27, cobalt-58, and cobalt-60. [Note: Mg-27 has a half-life of 9.5 minutes. Isotopes with half-lives less than 10 minutes provide negligible contribution to internal dose. Thus, magnesium-27 will not be included as a radionuclide of concern.][5] Since these radionuclides are particulates, the discussion pertaining to locations in the reactor and mechanisms of exposure is identical to that previously presented for activated coolant impurities in Section 5.2.1.1. Radionuclides arising from recoil reactions were estimated to comprise 39% of the total particulate activity (Atomics International, 1961).

5.2.1.4 Fission Products

Potential fission products such as xenon-133m, xenon -135, krypton-85m, krypton-85, and krypton-87 were detected in the process gas, but only at levels on the order of a few disintegrations per minute per gram (dpm/g). Considering the low activity levels and the fact that these isotopes are noble gases and are only significant from an external exposure standpoint, they will not be considered further as a source of internal dose.

The *Final Safeguards Summary Report for the Piqua Nuclear Power Facility* proposed that the presence of tritium in the coolant was primarily a result of the ternary fission in the fuel (Atomics International, 1961, p. V-6). Twenty-five percent of the tritium created was assumed to enter the

[5] Attribution: This decision was based on comments from the ORAU Team's DOE Site Principal Internal Dosimetrist, Elizabeth Brackett, MJW Corporation.

coolant by diffusion or recoil processes, which would have resulted in an estimated equilibrium concentration of 0.21 µCi/cm^3 at full power. This concentration is 10 times greater than the maximum value measured in process residues reported above in Section 5.2.1.2. which were analyses of various process residues in systems and water in the fuel storage pool. Analytical results for tritium in the coolant nor environmental monitoring data been located. However, an analysis for tritium in the carbonaceous material discovered in the coolant resulted in a level of 3.9 µCi/g (Atomics International, 1966b). *Piqua Nuclear Power Facility Monthly Operating Report No. 24* mentioned that "bioassay performed for personnel working over the open reactor for tritium and net beta activity showed no positive result" (Atomics International, 1965b). However, no bioassay data have been located.

Table 5-2: Radionuclides of Concern for Internal Exposure

Radionuclide	Half-life*	Primary Radiations and Energies (Mev)*	Potential Source Reactions	
Na-24	15 hr	β^- 4.17 γ 1.369	Coolant Impurities: Recoil:	$^{23}Na(n,\gamma)^{24}Na$* $^{27}Al(n,\alpha)^{24}Na$**
P-32	14.28 d	β^- 1.71	Coolant Impurities:	$^{32}S(n,p)^{32}P$*
S-35	87.9 d	β^- 0.167	Coolant Impurities: Coolant Impurities:	$^{37}Cl(d,a)^{35}S$* $^{34}S(n,\gamma)^{35}S$*
Cl-38	37.29 min	β^- 4.91 γ 1.60	Coolant Impurities:	$^{37}Cl(n,\gamma)^{38}Cl$*
Mn-56	2.58 hr	β^- 2.85 γ 0.847	Corrosion/Impurities:	$^{55}Mn(n,\gamma)^{56}Mn$*
Co-58	70.88 d	β^+ 0.474 γ 0.810 (99%)	Recoil:	$^{58}Ni(n, p)^{58}Co$**
Co-60	5.26 yr	β^- 0.314 (99%) γ 1.173 (100%) 1.133 (100%)	Recoil:	$^{60}Ni (n,p)^{60}Co$*
As-76	26.4 hr	β^- 2.97 γ 0.559 (43%) 0.957(6%) 1.22 (5%) ≤2.1 (2%)	Coolant Impurities:	$^{75}As(n,\gamma)^{76}As$*
Tritium	12.3 yr	β^- 0.0186	Coolant Activation	$^{2}H(n,\gamma)^{3}H$*
C-14	5730 yr	β^- 0.156	Coolant Activation	$^{13}C(n,\gamma)^{14}C$*

Notes:
* Data are from *Radiological Health Handbook* (Radiological Health Handbook, 1970).
** Data are from *Final Safeguards Summary Report for the Piqua Nuclear Power Facility* (Atomics International, 1961).

5.2.2 External Radiological Exposure Sources from POMR Operations

ATTRIBUTION: Section 5.2.2 and its related subsections were completed by Louise Buker, Oak Ridge Associated Universities (ORAU) and Roger Halsey, Oak Ridge Associated Universities (ORAU). These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

Workers at the POMR facility were potentially exposed to external photon, beta, and/or neutron radiation from activities associated with maintaining and operating the reactor. Potential exposure sources included radioactive materials from the operation and maintenance of the nuclear reactor and radioactive materials in the form of calibration sources.

5.2.2.1 Photon

Some POMR radiological operations potentially involved gamma and X-ray photon radiation fields. The potential photon exposure sources would have included the following:

- Gamma-emitting fission and/or activation products resulting from the reactor operations,
- Bremsstrahlung radiation from various beta-emitting radionuclides, and
- Calibration sources of cobalt, cesium, and other miscellaneous radionuclides (Geiger, 1969).

During operations, the radiation levels from the coolant lines and filters would have resulted from activation of corrosion products and other impurities in the coolant, as well as from recoil products from the core. The short lived gamma-emitting isotopes that have a half-life of 10 minutes or less (magnesium-27 and nitrogen-13) would be responsible for the majority of the radiation from the coolant lines (Atomics International, 1965a, p. 265). During reactor operations, the highest radiation levels in the plant were at the degasifier filters, F 2A and F 2B (Atomics International, 1965a, pp. 265 -270).

5.2.2.2 Beta

There was a potential for beta particle-emitting source term during shutdowns, maintenance, refueling, and when fuel was removed. Beta radiation could have resulted from activation and fission products. During normal operations, fission and activation products would have been located within the core and within the various shielding surrounding the core.

NIOSH located documentation explaining the beta radiation levels during maintenance activities. The documentation stated that "beta radiation is the primary type of activity encountered when systems are opened." It further stated that through the entire test program, as a result of the low dose rates present, it was unnecessary to establish work time limits for personnel performing maintenance work on exposed system components (Atomics International, 1965a, p. 275).

The potential for beta exposure from fission and activation products was known and documented prior to plant startup (Atomics International, 1963, p. 83).

5.2.2.3 Neutron

There was a low potential for neutron radiation exposure associated with POMR operations. Neutron exposures could have occurred, as a result of the fission process, from operating the reactor from 1963 to 1966. In addition, there was some potential for neutron exposures from a plutonium-beryllium (PuBe) neutron source for those personnel who calibrated the neutron survey instruments (Personal Communication, 2009g). The potential personnel exposures from this type of check source is considered to be encompassed in the assessment of reactor-related neutron exposures included in this evaluation. The rate of neutron generation from reactor operations was based on the rate of fission which would have been directly proportional to the reactor power level. An interviewee mentioned that there was a plutonium-beryllium neutron calibration source used for checking the long counter[6], which was an energy-independent neutron measuring instrument (Personal Communication, 2009g).

The source of the neutron emissions and potential worker exposures was minimized as a result of the design of the POMR, which controlled the operationally-related neutron exposure sources. The POMR was well-shielded by concrete that surrounded the reactor vessel, below-ground-level components, and sealed openings that surrounded the reactor (Unknown author, unknown date-b).

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

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

6.1 Available POMR Internal Monitoring Data

ATTRIBUTION: Section 6.1 was completed by Daniel Mantooth, Dade Moeller and Associates, Inc. These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

No primary source bioassay monitoring data (e.g., original dosimetry records) were located for POMR personnel for the NIOSH-evaluated period. One report, *Piqua Nuclear Power Facility Monthly Operating Report No. 24* mentions that urine samples were collected for personnel "…working over the open reactor," but the bioassay showed no positive result tritium and net beta activity. One former employee reported that bioassays were performed annually (Personal Communication, 2009h).

Maximum and occasionally average stack effluent activity concentrations were reported in monthly, quarterly, and semiannual reports (Atomics International, 1964b; Atomics International, unknown date; Atomics International, 1965b; Atomics International, 1965d; Atomics International, 1964c). The concentrations reported in the reports are consistent with the calculated estimates provided in the *Final Safeguards Summary Report for the Piqua Nuclear Power Facility* (Atomics International, 1961, Table V-3).

Maximum and average air activity concentrations for environmental and onsite samples are provided in three reports—*Piqua Nuclear Power Facility Monthly Operating Report No. 24*; *Piqua Nuclear Power Facility Monthly Operating Report No. 26*; and *Piqua Nuclear Power Facility Monthly Operating Report No. 19*. The location of these samples could not be determined from the available information. The concentrations reported are substantially less than the maximum permissible

[6] A long counter is a neutron detector that is designed to measure all neutrons accurately. It has a flat response over a broad range of neutron energies. At its core, it has a BF_3 proportional counter, able to discriminate neutrons against gamma activity by use of the neutron-alpha reaction on boron-10. This core is surrounded by a cylinder of paraffin. Fast neutrons are moderated by the paraffin and are then captured by the boron-10 in the BF_3 gas. Discriminators are used to accept only the signals from the alpha and lithium-7 recoil products. The detectors are energy independent, typically in the range from 10 keV to 5 MeV and are shielded to provide a highly directional response (Cember, 1969).

concentration values shown in Table V-3 of *Final Safeguards Summary Report for the Piqua Nuclear Power Facility* (Atomics International, 1961).

No primary source workplace air or breathing zone air sample data (e.g., original records) were located. However, there were instances in which levels were discussed in relative terms, (e.g., "…no personal contaminations or inhalations" (Atomics International, 1965b); "Airborne activity in the containment building has not exceeded that normally observed from natural background" (Atomics International, unknown date))

6.2 Available POMR External Monitoring Data

ATTRIBUTION: Section 6.2 was completed by Louise Buker, Oak Ridge Associated Universities (ORAU) and Roger Halsey, Oak Ridge Associated Universities (ORAU). These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

NIOSH has not located any primary source external dosimetry records (e.g., original dosimetry records) for the Piqua workers. External data for the POMR facility that have been found are in the form of exposure summary reports and monthly and semiannual operational progress reports for the years 1963 through 1966. The historical Piqua documentation demonstrates knowledge of potential workplace external radiation hazards, applicable radiation exposure guidelines, methods for limiting worker exposure, and radiation monitoring and dosimetry capabilities.

Photon

The most complete, available data consist of summary dosimetry data reported annually to the AEC offices for Chicago Operations and Idaho Operations. These summary data provide evidence that external monitoring was performed for the Piqua site. Table 6-1 summarizes the dosimeter results that were sent annually to the AEC Chicago Operations Office.

Table 6-1: Piqua Summary Annual Whole-Body Penetrating Exposures

Year	No. Identified as NOT Monitored	No. Identified as Monitored	No. Identified with 0-1 rem	No. Identified with 1-2 rem
1963	0	42	42	-
1964	0	46	46	-
1965	0	47	47	-
1966	0	50	42	8

Notes:
- indicates that no exposures were reported in this range.
Information for 1963 is from *Summary of Whole Body Radiation Exposures to External Penetrating Radiation Accumulated During the Year-1963* (AEC, 1963, p. 34).
Information for 1964 is from *Summary of Whole Body Radiation Exposures to External Penetrating Radiation Accumulated During the Year-1964* (AEC, 1964, p. 18).
Information for 1965 is from *Summary of Whole Body Radiation Exposures to External Penetrating Radiation Accumulated During the Year-1965* (AEC, 1965a, p. 27).
Information for 1966 is from *Summary of Whole Body Radiation Exposures to External Penetrating Radiation Accumulated During the Year-1966* (AEC, 1966, p. 23).

The summary data that were reported to the AEC Idaho Operations Office for the year 1963 indicated that 31 Atomics International employees worked at the Piqua facility with the City of Piqua workers, performing the same types of jobs. The Atomic International employees' dosimeters indicated that they received 0 gamma, 0 beta, and 0 neutron dose for the year 1963 (City of Piqua, 1964). One worker did have detectable gamma of 60 mrem for the year. Individual data for the City of Piqua workers are unavailable at this time.

Monthly and semiannual operational reports indicate that R. S. Landauer Jr. and Company was the dosimetry provider. However, individual dosimetry records are not currently available; thus, the information that NIOSH has available to supplement the data provided in Table 6-1 consists of operational progress reports from 1963 through 1966. These reports include references to ambient radiation levels and routine survey results. Table 6-2 provides a summary of the available data from semiannual and monthly reports that were sent to the Chicago AEC Operations Office.

Table 6-2: Piqua Semiannual and Monthly Report Results

Table 6-2 and its corresponding notes span two pages.

	Timeframe		Results		
Report Type and Number	**Begin**	**End**	**Number of Positive Results**	**Maximum Result**	**Notes from the Radiation Monitoring Section of the reports**
Semiannual-2 (Atomics International, 1963)	01/01/63	06/30/63	Unknown	Unknown	No radiation measurement mentioned (Atomics International, 1963)
Semiannual-3 (Atomics International, 1964d)	07/01/63	12/31/63	Unknown	Unknown	No radiation measurement mentioned (Atomics International, 1964d)
Semiannual-4 (Atomics International, 1964a)	01/01/64	06/30/64	Unknown	Unknown	Radiation levels measured at eighteen locations while operating at full power (45.5 MWt.) No neutrons detected from the biological shield or above the reactor at the 100' level (Atomics International, 1964a, p. 82) Location OC-104 <0.5 mrem/hr neutrons Location OC-101, 14" line in the P-1A room <0.5 mrem/hr neutrons (Atomics International, 1964a, p. 83) During shutdown in June, the following measurements were taken: • 1 R/hr measured at in-core filter that had been removed (Atomics International, 1964a, p. 17)

Table 6-2: Piqua Semiannual and Monthly Report Results *Table 6-2 and its corresponding notes span two pages.*					
	Timeframe		**Results**		
Report Type and Number	**Begin**	**End**	**Number of Positive Results**	**Maximum Result**	**Notes from the Radiation Monitoring Section of the reports**
					• Filter media measured < 20 mrad/hr beta - gamma, including 5 mR/h gamma (Atomics International, 1964a, p. 17)
Semiannual-5 (Atomics International, 1965e)	07/01/64	12/31/64	Unknown	Unknown	2-4 mR/h surface of main coolant piping (Atomics International, 1965e, pp. 61-63)
Monthly-19 Atomics International, 1964c)	10/01/64	10/31/64	10	30 mrem	N/A
Semiannual-6 (Atomics International, 1965c)	01/01/65	06/30/65	Unknown	120 mrem	During the month of April, this max estimated dose was received during inspection from non-routine removal of fuel elements (Atomics International, 1965c, pp. 76-77) 700mR/h degasification filter, attributed to Mg-27 and Na-24 from the 6 new fuel elements (Atomics International, 1965c, pp. 76-77)
Monthly-24 Atomics International, 1965b)	03/01/65	03/31/65	4	80 mrem	N/A
Simiannual-7 (Atomics International, 1966a)	07/01/65	01/13/66	Unknown	Unknown	No section for plant radiation levels; some discussion of dose rates for a degasifier (Atomics International, 1966a, p. 66)
Monthly-26 (Atomics International, 1965d)	05/01/65	05/31/65	2	290 mrem	Dose received by HP personnel during reactor shutdown monitoring and calibration of HP instruments (Atomics International, 1965d, p. 20)
Semiannual-8 (Atomics International, 1966b)	01/01/66	06/30/66	Unknown	Unknown	5 mR/h beta and gamma; sample of coke surface (Atomics International, 1966b, p. 103)

Notes:
"Unknown" indicates that information was not provided or available.

For 1963, the available operational reports—*Piqua Nuclear Power Facility Operations Analysis Program Progress Report No. 2 (Fiscal Year 1963)* and *Piqua Nuclear Power Facility Operations Analysis Program Progress Report No. 3 (July 1, 1963-December 31, 1963)*—did not discuss the highest dose for POMR personnel (Atomics International, 1963; Atomics International, 1964d). However, there is a 1963 report from the City of Piqua for 31 Atomics International workers that worked at the site; this report lists 0 gamma, 0 beta, and 0 neutron dose for thirty of the employees. For one employee, the report lists 60 mrem gamma (City of Piqua, 1964). In addition, there is a summary of quarterly cycle data that was submitted to the AEC for one Piqua employee for the years 1963 through 1965, where it was reported that he received 0 photon, 0 beta, and 0 neutron dose for each of those years (AEC, 1965b).

For 1964, *Piqua Nuclear Power Facility Monthly Operating Report No. 19* reported only one maximum exposure of 30 mrem for the month of October, and 10 readings that were greater than detectable levels for deep dose (Atomics International, 1964c). The semiannual operational reports did not mention the highest exposure for the period. The reports include summaries of survey monitoring data that provide dose rates at certain areas of the plant for beta, gamma, and neutrons. Additionally, *Piqua Nuclear Power Facility Operations Analysis Program Progress Report No. 4 (January 1, 1964-June 30, 1964)* provides a summary of the radiation levels associated with the megawatt thermal energy of the reactor from January through May of 1964 for survey monitoring dose rates at the "waste gas activity" location, the "out of core bypass filter activity" location, and the "main coolant superheater outlet line" location. The highest level was approximately 400 mR/hr at the "out of core bypass filter" location; the "waste gas activity" and the "main coolant superheater outlet line" measurements were less than 30 mR/hr (Atomics International, 1964a, p. 80).

For 1965, the available operational reports— *Piqua Nuclear Power Facility Reactor Operations Analysis Program Semiannual Progress Report No. 6 (January 1-June 30, 1965)* and *Piqua Nuclear Power Facility Monthly Operating Report No. 24*—report that there were maximum doses reported of 80 mrem in March; 120 mrem in April during a non-routine inspection of fuel elements; and 290 mrem in May, received during calibration activities during a reactor shutdown period (Atomics International, 1965c; Atomics International, 1965b).

For 1966, *Piqua Nuclear Power Facility Reactor Operations Analysis Program Semiannual Progress Report No. 8 (January 1-June 30, 1966)* did not report the maximum external exposure at the site (Atomics International, 1966b). However, the Site Summary reports identified in Table 6-1 did report findings that exceeded the 1 rem value (but less than the 2 rem value) for eight workers.

Beta

NIOSH has not located a complete set of data covering beta or shallow measurements. The monthly and semiannual reports have reported beta or shallow measurements occasionally with gamma measurements. The annual summary reports to the AEC Chicago Operations (the whole-body penetrating exposures are provided in Table 6-1) do not provide a beta dose because only whole-body penetrating exposure ranges were being reported.

However, the external dosimetry for plant workers (film badges provided by R. S. Landauer Jr. and Company) included a shallow dose component (Atomics International, 1965b, p. 23). In the summary data that were reported to the AEC Idaho Operations Office for 1963, the Atomic International employees' dosimeters indicated that 30 of the 31 individuals monitored received 0 beta dose for the year. One individual had a reported dose of 20 mrem beta (City of Piqua, 1964).

Survey data reported in the annual and semiannual reports typically were reported as β-γ (beta-gamma). There were couple of instances where the gamma exposure rate was distinguished from the beta-gamma total. These instances described scenarios with the potential for personnel exposure. The first instance described a measurement of an in-core filter that had been removed. It had a reading of 20 mrad/hr beta-gamma including 5 mr/hr gamma (Atomics International, 1964a, p. 17). The second instance described a survey that was taken inside the purification column and overheads cooler that had been opened for maintenance. The highest reading found at this location was 10 mrads/hr beta-gamma, including 0.5 mrad/hr gamma at 1" from the contaminated surface (Atomics International, 1964c, p. 19).

Neutron

There is no complete set of data that explicitly covers neutron dose. However, based on the available summary data, the individual data reports (reported to the AEC as whole-body radiation exposures to penetrating radiation) (AEC, 1963; AEC, 1964; AEC, 1965a; AEC, 1966) would likely have included neutron dose, had any been detected. In the summary data that were reported to the AEC Idaho Operations Office for 1963, the 31 Atomic International employees' dosimeters indicated that they received 0 neutron dose that year (City of Piqua, 1964).

During an interview, a former POMR health physics technician stated that neutron surveys were routine and performed initially each time the power level was raised (Personal Communication, 2009g). One set of neutron results collected in 1964 was reported in a semiannual report (Atomics International, 1964a p. 83). Three locations were listed as having no neutrons, while two others were listed as having <0.5 mrem/hr neutrons and had a corresponding gamma dose rate. The survey was taken while the plant was operating at full power (45.5 MWt).

7.0 Feasibility of Dose Reconstruction for the Class Evaluated by NIOSH

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

In determining feasibility, NIOSH begins by evaluating whether current or completed NIOSH dose reconstructions demonstrate the feasibility of estimating with sufficient accuracy the potential radiation exposures of the class. If the conclusion is one of infeasibility, NIOSH systematically evaluates the sufficiency of different types of monitoring data, process and source or source term data, which together or individually might assure that NIOSH can estimate either the maximum doses that members of the class might have incurred, or more precise quantities that reflect the variability of exposures experienced by groups or individual members of the class. This approach is discussed in OCAS's SEC Petition Evaluation Internal Procedures, which are available at http://www.cdc.gov/niosh/ocas. The next four major subsections of this Evaluation Report examine:

- The sufficiency and reliability of the available data. (Section 7.1)
- The feasibility of reconstructing internal radiation doses. (Section 7.2)
- The feasibility of reconstructing external radiation doses. (Section 7.3)
- The bases for petition SEC-00126 as submitted by the petitioner. (Section 7.4)

7.1 Pedigree of POMR Data

This subsection answers questions that need to be asked before performing a feasibility evaluation. Data Pedigree addresses the background, history, and origin of the data. It requires looking at site methodologies that may have changed over time; primary versus secondary data sources and whether they match; and whether data are internally consistent. All these issues form the bedrock of the researcher's confidence and later conclusions about the data's quality, credibility, reliability, representativeness, and sufficiency for determining the feasibility of dose reconstruction.

Available data for the POMR facility are in the form of summary reports, including monthly, semiannual, and annual reports for the years 1963 through 1966. The types of monitoring data reported in the monthly and semiannual reports are inconsistent from report to report. If we were to only use these reports, there would be some information gaps for all years of operation, and NIOSH does not have access to the individual, hardcopy monitoring data.

7.1.1 Internal Monitoring Data Pedigree Review

<u>ATTRIBUTION</u>: Section 7.1.1 was completed by Daniel Mantooth, Dade Moeller and Associates, Inc. These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

No original records for bioassay or area air samples, or (surface contamination) data records have been located. There are several cases where air sampling results (reported as maximum, minimum, and average) for stack effluent and environmental activity levels are reported in summary documents. Other documents report these parameters and workplace air levels subjectively (i.e., < MPC). A data quality review cannot be performed on the summary data that was reported to the AEC without the actual data records. The summary documents reviewed consist of various monthly, quarterly, and semiannual reports of reactor plant conditions that collectively cover the entire thirty-two month period in which the reactor operated. Although this information is not the original data, the information contained within these documents, when taken together, indicates that POMR radiological conditions were benign with respect to internal dose; an indication supported by the reports of former POMR personnel interviewed during the course of this evaluation report (Personal Communication, 2009a; Personal Communication, 2009e; Personal Communication, 2009g). Collectively, every source reviewed and interview conducted leads to the conclusion that surface and airborne contamination levels and radionuclides present during POMR operations were unlikely to have resulted in measurable internal dose.

7.1.2 External Monitoring Data Pedigree Review

ATTRIBUTION: Section 7.1.2 was completed by Louise Buker, Oak Ridge Associated Universities (ORAU). These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

Although external monitoring did occur at POMR, NIOSH has not yet been able to locate the original data records. The only external monitoring data available to NIOSH consist of summary dosimetry data reported annually to the AEC offices of Chicago Operations and Idaho Operations. Without the actual data records, a data quality review cannot be performed on the summary data that were reported to the AEC.

However, there is corroborating evidence that supports NIOSH's ability to bound the external dose for the class evaluated in this report. A 1963 summary report to the AEC Idaho Operations Office indicates that 30 Atomics International workers who worked at the POMR facility received 0 gamma, 0 beta, and 0 neutron dose for the year 1963, and one Atomics International worker received 60 mrem gamma, 20 mrem beta and 0 mrem neutron (City of Piqua, 1964). In addition, former POMR personnel interviewed during the course of this evaluation report provided information about the POMR facility's radiation protection practices that coincides with the available summary data. Information obtained from interviews with former POMR facility personnel indicates that (1) personnel working at the site were issued monthly or quarterly film badges, and (2) area surveys were conducted on a routine and/or as-needed basis. Also, the monitoring was conducted for beta, gamma, and neutron radiation. NIOSH has compared the actual result information (as relayed in Section 6.2, and contained in Table 6-2, of this report) to the maximum values in the ranges of doses listed in the summary data reports for the respective operational years. This comparison supports NIOSH's conclusion that the summary report data provided in Table 6-1 can be used as a bounding estimate for the external doses for the evaluated class.

7.2 Evaluation of Bounding Internal Radiation Doses at POMR

ATTRIBUTION: Section 7.2 and its related subsections were completed by Daniel Mantooth, Dade Moeller and Associates, Inc. These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

The principal source of internal radiation doses for members of the class under evaluation was exposure to beta/gamma emitting radionuclides from four sources: (1) activated impurities in the coolant, (2) activated corrosion products, (3) neutron recoil reactions with the aluminum cladding, and (4) tritium produced by ternary fission. The following subsections address the ability to bound internal doses, methods for bounding doses, and the feasibility of internal dose reconstruction.

7.2.1 Evaluation of Bounding Process-Related Internal Doses

NIOSH was unable to locate any urinalysis data, lung-count data, or any other type of bioassay data. Detailed below is a summary of the particulate airborne activity information available for reconstructing the process-related internal doses of members of the class under evaluation.

As discussed previously, particulate radionuclides consisting of sodium-24, phosphorus-32, sulfur-35, chlorine-38, manganese-56, arsenic-76, magnesium-27, cobalt-58, and cobalt-60 were detected in the organic coolant, in in-vessel filters, and in filters associated with the coolant purifications system, the degasifications system, the fuel storage pool-purification system, and the waste fired boiler. It was proposed that tritium and carbon-14 would be present in the coolant at levels up to 0.21 µCi/cc and 1.4e-04 µCi/cc, respectively (Atomics International, 1961). Airborne activity, if present, would have been generated by maintenance activities on these systems. As mentioned previously, no work area air sampling data have been located that could be used to support establishing bounding estimates of the airborne activity.

The *Final Safeguards Summary Report for the Piqua Nuclear Power Facility* (Atomics International, 1961) provides calculations demonstrating that airborne levels would be less than the MPC specified in the 1960 regulations (current at the time) (10 C.F.R. pt. 20). Summary documents reported air sampling results in relative terms (i.e., "…no personal contaminations or inhalations" and "…airborne levels in containment building were less than background") (Atomics International, 1964a; Atomics International, 1965a; Atomics International, unknown date; Atomics International, 1965b) that corroborate the safety analysis estimation. Because the reactor was a closed-loop primary system, and the coolant became a solid at room temperature, it was unlikely that personal contamination and inhalation was a factor.[7] Air monitoring capability is described in *Compilation of Piqua Nuclear Power Facility Operating Limits and Controls and Post-Critical Operational Tests*, and confirms that the air sampling equipment (with the exception of tritium and carbon-14) could detect total beta-gamma activity at the MPC level for cobalt-60 (9E-9µCi/cm^3) for restricted areas and would alarm before activity approached hazardous levels (Atomics International, 1965a). The reported sensitivity for workplace air monitors for particulate activity was 1E-12 µCi/cm^3 (Atomics International, 1965a), or nearly 3 orders of magnitude less than the MPC. The presence of workplace air samplers, their capabilities, and consistently low airborne activity levels were also confirmed by former Piqua personnel (Personal Communication, 2009a; Personal Communication, 2009e; Personal Communication, 2009g).

There were no incidents reported that led to significant personnel contamination. As an example, *Piqua Nuclear Power Facility Reactor Operations Analysis Program Semiannual Progress Report No. 6 (January 1-June 30, 1965)* mentioned that the soot collection bag from the waste fired boiler came loose and released contaminated soot into the auxiliary building. Total surface contamination levels of 1,000 dpm/44 in^2 (~400 dpm/100 cm^2) were measured (Atomics International 1965c, p. 77).

[7] Attribution: This conclusion was made by Daniel Mantooth, Dade Moeller and Associates, Inc. and is based on five interviews that referenced a solid coolant (Personal Communication, 2009a; Personal Communication, 2009c; Personal Communication, 2009d; Personal Communication, 2009f; Personal Communication, 2009g)

No personnel contaminations or inhalations occurred during this event. The radioisotopes involved were not specified, but it can be assumed that they were comprised of those described above and listed in Table 5-2. Based on its research to date, NIOSH has not located air sampling data sufficient by themselves to support bounding process-related internal dose. However, the information discussed above and further evaluated below, supports the conclusion that airborne particulate activity in process areas was not likely to exceed the MPCs. The bounding process-related internal doses from the particulate radionuclides can be obtained using the MPC values. Intakes of tritium and carbon-14 are calculated using the maximum ratio of the reported or measured activities in the coolant or process residues, respectively (see Section 5.2.1.2) to the total reported particulate activity. The resulting ratio is then applied to the expected process airborne level (i.e., MPC) to derive the bounding value for tritium and carbon-14.

7.2.2 Evaluation of Bounding Ambient Environmental Internal Doses

Ambient environmental internal doses could have resulted from the inhalation of radionuclides exhausted from the reactor plant. Ambient air particulate levels were monitored in stack effluents at both on- and off-site (so-called "environmental samples") locations. Data for stack particulates have not been located, but several reports indicate that stack effluents were consistently "…less than the MPC" (Atomics International, unknown date; Atomics International, 1964a; Atomics International, 1964b; Atomics International, 1964c; Atomics International, 1965c). In addition, the stack monitoring system was reported to have sufficient sensitivity to detect particulate activity equal to 3E-10 $\mu Ci/cm^3$ of iodine-131 (Atomics International, 1965a), which is equivalent to the unrestricted MPC for cobalt-60, the limiting radionuclide of concern at the POMR facility. Since the maximum beta energies for iodine-131 and cobalt-60 are on the same order (i.e., 0.606 and 0.318), it can be assumed that the monitoring instrument sensitivity would be similar. Alarms would sound in the control room when activity exceeded the MPC level. The information regarding stack effluent values and monitoring coincides with the estimated values provided in the *Final Safeguards Summary Report for the Piqua Nuclear Power Facility* (Atomics International, 1961). In the case of onsite and offsite monitoring, several monthly reports provide results of this sampling (Atomics International, 1964c; Atomics International, 1965b; Atomics International, 1965d), with all indicating a total particulate activity well below the outside operational (unrestricted area) MPC values.

Based on its research to date, NIOSH has located limited air sampling data to support bounding ambient environmental internal dose. However, the information discussed previously supports NIOSH's conclusion that airborne activity levels outside the process areas and the plant grounds can be bounded by application of operational internal dose assessment methods.

7.2.3 Methods for Bounding Internal Dose at POMR

7.2.3.1 Methods for Bounding Operational Period Internal Dose

The method for bounding the operational period internal dose is based on the conclusion that the airborne activity in operational areas would not have exceeded the lowest applicable MPC without being detected by the existing monitoring system and noted in the routine summary reports. This conclusion is based on information in the SRDB and interviews with former POMR facility personnel indicating that the POMR facility had, and used, workplace alarming airborne monitoring equipment capable of detecting airborne particulate activity to the MPC levels in effect at the time (as noted in 10 C.F.R. pt. 20, Appendix B Table II). Typically, the alarm on air monitors is set at some percentage of the applicable limit for the most restrictive radionuclide (i.e., lowest MPC). For the purposes of bounding the operational period internal dose, it will be assumed that the alarms were set to trip at the MPC for the most restrictive radionuclide. The radionuclide with the lowest MPC listed in Table 5-2 is chlorine-38 (3E-09 $\mu Ci/cm^3$). However, due to its short half-life (37.3 min), it is likely that chlorine-38 levels could have largely decayed away before sufficient activity would be collected by the air monitor to cause an alarm. The radionuclide with the next lowest MPC is cobalt-60 (9E-09 $\mu Ci/cm^3$); with a half-life of over 5 years, sufficient activity would collect to reach alarm levels if elevated airborne activity was present. If the total beta/gamma airborne activity did not exceed the MPC for cobalt-60 (9E-09 $\mu Ci/cm^3$), and the total particulate activity consisted of 48% impurities, 13% corrosion products, and 39% recoil products (as noted in Section 5.2.1), the total air activity would be comprised of 4E-09 µCi/cc impurities, 1E-09 µCi/cc corrosion products, and 4E-09 µCi/cc recoil products. These concentrations can be used to assess the radionuclide exposures in each applicable category (Table 7-1). The radionuclide that represents the maximum internal dose contributor in each category can be evaluated on a case-by-case basis, and the categories combined to establish a composite dose estimate. The application of this method supports NIOSH's ability to bound the internal dose from exposure to these radionuclides for the evaluated class.

To calculate the airborne levels of tritium and carbon-14 in process areas, ratios were calculated between the maximum expected or reported activity of these two radionuclides to the total activity in the coolant and residues from other radionuclides (activation, corrosion, and recoil), as described previously. Information obtained from several documents (Atomics International, 1964b; Atomics International, 1964a; Atomics International, 1965d; Atomics International, 1965b) provide data indicating an average coolant activity over a wide range of conditions of 1.1e-02 $\mu Ci/cm^3$. The greatest tritium activity discovered in the available on the SRDB documentation is the estimate provided by *Final Safeguards Summary Report for the Piqua Nuclear Power Facility*, or 0.21 $\mu Ci/cm^3$. The ratio of this tritium activity to the total activity would be 19.1 (0.21 $\mu Ci/cm^3$ ÷ 1.1e-02 $\mu Ci/cm^3$ = 19.1). Since the maximum airborne activity is not expected to exceed the MPC for cobalt-60 (9E-09 $\mu Ci/cm^3$), the tritium airborne concentration should not exceed 1.7E-07 $\mu Ci/cm^3$ (19.1 x 9E-09 $\mu Ci/cm^3$). The maximum activity value found for carbon-14 was reported in the analyses of soot from the flue gas collector (Wheelock, 1970 Appendix B, Table B-2), which is equal to 2.1E-02 $\mu Ci/cm^3$. The ratio of this activity to the total activity is 1.9(2.1E-02 $\mu Ci/cm^3$ ÷ 1.1E-02 $\mu Ci/cm^3$ = 1.9), which would result in a process airborne concentration of 1.7E-08 $\mu Ci/cm^3$ (1.9 X 9E-09 $\mu Ci/cm^3$ = 1.7E-08 $\mu Ci/cm^3$). These concentrations can be used to assess the respective radionuclide exposures. The application of this method supports NIOSH's ability to bound the internal dose from exposure to these radionuclides for the evaluated class.

Table 7-1: Radionuclides of Concern by Category

Coolant Impurities/ Components	Corrosion Product	Recoil Products
Na-24	Mn-56	Na-24
P-32	-	Co-58
S-35	-	Co-60
Cl-38	-	-
Mn-56	-	-

As-76	-	-
Tritium	-	-
C-14	-	-

The assessment methods presented here define the methods by which a maximum internal dose estimate can be determined for the evaluated worker class, which supports NIOSH's conclusion that the operationally-related internal dose for the evaluated worker class can be bounded.

7.2.3.2 Methods for Bounding Ambient Environmental Internal Dose

The method for bounding the ambient environmental internal dose is based on the conclusion that the total airborne activity in non-process areas would not have exceeded the lowest applicable non-process MPC without being detected by the existing monitoring system and noted in the routine summary reports. This conclusion is based on information in the SRDB and interviews with former POMR facility personnel, which indicated that the POMR facility had, and used, environmental and onsite sampling and analysis procedures with sufficient sensitivity to detect airborne particulate activity to the MPC levels in effect at the time (as noted in 10 C.F.R. pt. 20, Appendix B Table II). Typically, action levels for environmental monitoring are established at some percentage of the applicable limit for the most restrictive radionuclide (i.e., lowest MPC). For the purpose of bounding the ambient environmental dose, it will be assumed that the action level is equal to the MPC for the most restrictive radionuclide; the radionuclide with the lowest MPC listed in Table 5-2 is cobalt-60 (3E-10 µCi/cm^3 *[10 CFR pt 20, 1961])*. If the total beta/gamma airborne activity did not exceed 3E-10 µCi/cm^3, and the total particulate activity consisted of 48% impurities, 13% corrosion products, and 39% recoil products (as noted in Section 5.2.1), the total air activity would be comprised of 1E-10 µCi/cc impurities, 4E-11 µCi/cc corrosion products, and 1E-10 µCi/cc recoil products.

The ratios calculated above (between the expected activity of tritium and carbon-14 and the total measured coolant activity) are used to determine ambient environmental airborne levels. For tritium, the expected airborne activity would be 5.7E-09 µCi/cm^3 (19.1 x 3E-10 µCi/cm^3). For carbon-14, the expected ambient airborne level would be 5.7E-10 µCi/cm^3 (1.9 x 3E-10 µCi/cm^3 = 5.7E-10 µCi/cm^3).

As discussed in Section 7.2.2 and presented in this assessment of the ambient environmental airborne concentrations (as compared to the operationally-related values), the ambient environmental dose, based on the airborne activity levels outside the process areas and the plant grounds (and associated internal doses), can be bounded by the operationally-related values/levels and internal dose assessment methods.

7.2.4 Internal Dose Reconstruction Feasibility Conclusion

An extensive review of the data available on the SRDB, as well as interviews with former POMR facility personnel, have revealed no evidence of a radiological condition, transient or otherwise, that would lead to significant internal dose for the class evaluated in this report. In addition, information was located that leads to the conclusion that workplace monitoring, with the exception of tritium and carbon-14, was sufficiently sensitive to detect airborne radioactivity at levels lower than the MPC values in effect during the operational period for the facility. The tritium and carbon-14 concentrations were evaluated through the determination of coolant concentration ratios, based on what would be considered worst-case calculated conditions as defined in the *Final Safeguards Summary Report for the Piqua Nuclear Power Facility* (Atomics International, 1961). Based on this information and the assessment as presented in Section 7.2 of this report, NIOSH has concluded that it is feasible to bound the internal dose (reconstruct dose with sufficient accuracy) for the class evaluated in this report.

7.3 Evaluation of Bounding External Radiation Doses at POMR

ATTRIBUTION: Section 7.3 and its related subsections were completed by Louise Buker, Oak Ridge Associated Universities (ORAU) and Roger Halsey, Oak Ridge Associated Universities (ORAU). These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

The principal sources of external radiation doses for members of the proposed class were the Piqua Organic Moderated Reactor and the calibration sources used to calibrate the radiation monitoring equipment.

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

7.3.1 Evaluation of Bounding Process-Related External Doses

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

7.3.1.1 Personnel Dosimetry Data

The available external dosimetry data for the site is in the form of summary data reported to the AEC Chicago Operations office for the City of Piqua workers and to the AEC Idaho Operations for the Atomics International workers who worked at the POMR facility. This summary data cover the complete timeframe and are based on film badge data. For the purpose of bounding the possible external doses, the external data appear to be reliable in summary form. The data are presented in Table 6-1 above. According to the references reviewed and an interview with a former Piqua health physics technician, the film badge exchange frequency was monthly for operation and maintenance personnel, and quarterly for administrative personnel (Personal Communication, 2009g).

In addition to the summary data, there are three monthly reports that state the maximum exposure for the month, and a complete set of semiannual reports that make reference to employee external radiation exposures. Although the data are not fully comprehensive, whenever the maximum levels are mentioned, the maximum levels are much lower than the values in the AEC summary reports for the same time period.

Photon

The data are sufficient to support bounding photon dose estimates for the years 1963 through 1966 from the upper bound of 1 rem for the years 1963 through 1965, and 2 rem for the year 1966; see Table 6-1 of this report.

Beta

There is evidence that film badge beta monitoring was performed during the operational period, as indicated in the summary data. External dosimetry for plant workers were film badges provided by R. S. Landauer Jr. and Company (Atomics International, 1965b, p. 23), which included a shallow dose component.

Documentation of shallow dosimetry results is incomplete for the operational lifetime of the POMR. In all of the documents that have been reviewed (City of Piqua, 1964), there is only one report of beta dose where gamma exposure is discussed (i.e., 60 mrem gamma and 20 mrem beta).

Neutron

There is evidence that POMR facility personnel were monitored for neutron exposure with film badges (City of Piqua, 1964). During an interview, a former plant health physics technician said that he did not remember any positive neutron results from the Nuclear Track Emulsion (NTA), Type A film badges (Personal Communication, 2009g). Although there are no complete sets of neutron film badge results available, it is assumed that the complete set of summary data (reported to the AEC as whole-body radiation exposures from penetrating radiation) would have included neutron dose if it had been detected (AEC, 1963; AEC, 1964; AEC, 1965a; AEC, 1966).

The limitation of using this penetrating external exposure summary data as bounding is due to the lack of sensitivity of NTA film dosimeters at lower energies (Fix, 1997); NTA film has a lower energy threshold (~500 keV, below which the measured dose rapidly decreases). The threshold of ~500 keV could cause the dosimeter to miss much of the neutron dose in highly shielded workplace radiation fields, including those in a reactor facility. The shielding significantly reduces the neutron energy, altering the exposure spectrum. In general, if the calibration spectra is the same as the workplace spectra then an accurate neutron dose can be measured (i.e., the same fraction of the neutron spectra is missed in the calibration and in the workplace). However, in highly shielded facilities, the workplace neutron spectra is much more degraded than the calibration spectra (Fix, 1997, pp. 39-45).

Since the sensitivity of the NTA film is regarded as likely underestimating the neutron dose, the paired measurements of neutron and photon dose will be used to establish a neutron-to-photon ratio. Survey measurements reported in *Piqua Nuclear Power Facility Operations Analysis Program Progress Report No. 4 (January 1, 1964-June 30, 1964)* showed no detectable neutrons in normally-accessible areas. In areas where neutrons were detected, the levels were low when compared to the potential for gamma exposure. Two measured values, each indicated as <0.5 mrem/hr, were found. These <0.5 mrem/hr readings were taken at the “OC-104, 14” line in the P-1B room location with a concurrent gamma reading of 13.5 mR/hr, and at the “OC-101, 14” line in the P-1A room location with a concurrent gamma reading 11 mR/hr (Atomics International, 1964a, p. 83).

The survey (reported in *Piqua Nuclear Power Facility Operations Analysis Program Progress Report No. 4 (January 1, 1964-June 30, 1964*) was conducted when the plant was operating at full power. The first detectable reading was associated with a gamma level of 13.5 mR/hr, assuming a worst case neutron reading of 0.5 mrem/hr, with a resulting neutron-to-photon ratio of 3.7% (or 0.037 to 1). The second detectable reading was associated with a gamma level of 11 mR/hr, with a worst case neutron reading of 0.5 mrem/hr, with a resulting neutron-to-photon ratio of 4.5% (or 0.045 to 1). Based on this information, a neutron-to-photon ratio of 10% (or 0.10 to 1) can be applied as a bounding ratio (in round numbers) to assess neutron dose given a photon dose (which would be assigned based on the bounding photon dose approach already discussed). Since these measurements were made with a long counter (Personal Communication, 2009g), which is known for being neutron energy independent (Fix, 1997; Cember, 1969), this approach avoids any energy dependence issues related to the NTA badges.

7.3.1.2 Area Monitoring Data

Area monitoring data were available from progress reports, monthly reports, and semiannual reports.

Photon

In the monthly, semiannual, and annual reports, there are references to ambient gamma levels, primarily presented as example levels. For example, *Piqua Nuclear Power Facility Operations Analysis Program Progress Report No. 4 (January 1, 1964-June 30, 1964)* indicated that "Gamma radiation which penetrated the biological shield was less than 1 mr/hr" (Atomics International, 1964a, p. 78). However, there are no consistent surveys or summary data available.

The most complete set of monitoring data available is in a table summarizing a survey taken in 1964 (during the first year of operation), described as a "typical survey." The table includes readings from eighteen locations that ranged from 0.1 mr/hr at the "FELS Tank" location to 250 mr/hr at the "F-2A Degasifier filter" location (Atomics International, 1964a, p. 83). The report indicated that with the exception of the degasifier filter, radiation levels remained low enough to permit operator access for contact maintenance on the primary coolant system without time limits (Atomics International, 1964a, p. 82).

Beta

There are several discrete cases mentioned in the reviewed documents where beta-gamma radiation levels were measured (Atomics International, 1967, p. 15; Atomics International, 1965c, p. 76; Atomics International, 1964a, p. 17). NIOSH discovered only a couple of instances where the beta-gamma reading was distinguished from the gamma activity (Atomics International, 1964a, p. 17; Atomics International, 1964c, pp. 19-20).

Neutron

In an interview with a former POMR plant health physicist technician, the former employee stated that neutron surveys were routinely performed and were performed at every power level, and that the type of detector used at the plant was a long counter (Personal Communication, 2009a; Personal Communication, 2009g)

One of these surveys, conducted while the plant was operating at full power, was reported in *Piqua Nuclear Power Facility Operations Analysis Program Progress Report No. 4 (January 1, 1964-June 30, 1964)*; this report included a summary table listing the results of a "typical radiation survey" of the plant when it was operating at 45.4 MWt (Atomics International, 1964a). The neutron radiation surveys of the "Reactor 100-ft level" location, the "East Reactor Biological Shield at the 78' level" location, and the "East Reactor Shield at the 72' level" location were indicated as having "no neutrons" and were recorded as < 0.5 mrem/hr neutrons (Atomics International, 1964a).

Although neither the instrument nor the methodology is mentioned, an inference may be made about the detection level by the two non-zero values. The minimum detection level of the process would be a value greater than zero, but at most, 0.5 mrem per hour.

7.3.2 Evaluation of Bounding Ambient Environmental External Doses

The ambient environmental external dose is accounted for, and therefore bounded, by the operational dose. Therefore, further discussion and analysis of the external ambient environmental dose will not be included in this report.

7.3.3 POMR Occupational X-Ray Examinations

NIOSH has found no records indicating that employees at Piqua Organic Moderated Reactor Facility were required to complete medical examinations, including chest X-rays prior to beginning work, on a periodic basis (e.g., annually), or following termination. However, a former Piqua shift supervisor indicated that chest X-rays were included in the annual physical (Personal Communication, 2009c). Although no records have been identified that indicate that occupational medical X-rays were required, the dose associated with X-ray exams can be assessed using the methodology defined in ORAUT-OTIB-0006. NIOSH believes that this methodology supports its ability to bound the occupational medical X-ray doses for the evaluated class.

7.3.4 Methods for Bounding External Dose at POMR

There is an established protocol for assessing external exposure when performing dose reconstructions (these protocol steps are discussed in the following subsections):

- Photon Dose
- Beta Dose
- Neutron Dose
- Medical X-ray Dose

7.3.4.1 Methods for Bounding Operational Period External Dose

Photon Dose

The photon dose can be assessed based on bounding assumptions from the site summary data for external dose (based on information provided in Table 6-1, above). The photon information, as discussed in the personal dosimetry and area monitoring data sections above, supports applying the bounding dose of 1 rem for the years 1963 through 1965 and 2 rem for the year 1966. The upper bound for a particular year would be assigned to individuals who worked at the POMR site.

Beta Dose

Survey data reported in the annual and semiannual reports were typically reported as beta-gamma (i.e., β-γ). There were a couple of instances where the gamma exposure rate was distinguished from the beta-gamma total. These instances described scenarios with the potential for personnel exposure. The first instance described a measurement on an in-core filter that had been removed. It had a reading of 20 mrad/hr beta-gamma and 5 mR/hr gamma (Atomics International, 1964a, p. 17). The second instance was measured as 10 mrads/hr beta-gamma, including 0.5 mR/hr gamma at 1 inch (Atomics International, 1964c, pp. 19-20).

The Varskin 3 software application was also used to assess bounding beta-to-gamma ratios for direct contact (for hands-on) dose to the extremities, based on the evaluation of source term information. Gamma spectroscopy results from three coolant filter media were used as the basis of the analysis; cobalt-58, cobalt -60, iron-59, manganese-54, and zinc-65 were identified in the gamma spectroscopy results (Atomics International, 1964a, p. 102). The Varskin 3 analysis determined a ratio of 40:1 for direct contact with the skin (0 cm air gap) and a 20:1 ratio for a 5 cm air gap (the largest gap allowed by Varskin 3). A bounding beta-to-gamma ratio of 40:1 can be applied when calculating direct contact dose to the hand. This is a bounding value because this assumes direct material contact (i.e., coolant) and that no personal protective equipment (e.g., gloves) was worn. Furthermore, a bounding beta-to-gamma ratio of 20:1 can be applied to the upper extremities (e.g., elbow to hand) or lower extremities (e.g., legs, below the knee), in cases of direct contact. The beta-to-gamma ratio of 20:1 for the extremities (excluding the hand) is considered bounding because the material would need to be within 5 cm of the body. Furthermore, the extra shielding from personal protective equipment is not taken into account; thus, the potential beta fractions would be overestimated for the shallow dose calculation.

Neutron Dose

The potential for neutron dose existed only when the reactor was operating. The potential for neutron exposure is not independent of the potential for gamma exposure; that is, there was no place around the reactor where personnel could be exposed to neutrons that didn't also have gamma exposure.

Measurements reported in *Piqua Nuclear Power Facility Operations Analysis Program Progress Report No. 4 (January 1, 1964-June 30, 1964)* showed no detectable neutrons in normally-accessible areas. In areas where neutrons were detected, the levels were low when compared to the potential for gamma exposure. Two values, each indicated as <0.5 mrem/hr, were found. These <0.5 mrem/hr readings were taken at the "OC-104, 14" line in the P-1B room" location with a concurrent gamma reading of 13.5 mR/hr and at the "OC-101, 14" line in the P-1A room" location with a concurrent gamma reading of 11 mR/hr (Atomics International, 1964a, p. 83).

This survey reported in *Piqua Nuclear Power Facility Operations Analysis Program Progress Report No. 4 (January 1, 1964-June 30, 1964)* was conducted when the plant was operating at full power, and should represent the maximum neutron flux. The first detectable reading was associated with a gamma level of 13.5 mR/hr, giving a neutron-to-photon ratio of 3.7% (or 0.037 to 1). The second was associated with a gamma level of 11 mR/hr, giving a neutron-to-photon ratio of 4.5% (or 0.045 to 1). Based on this information, a neutron-to-photon ration of 10% (or 0.10 to 1) can be applied as a bounding ratio to assess neutron dose given a photon dose (which would be assigned based the bounding photon dose approach section above).

This value is conservative as (1) the actual reported value was "<0.5 mrem/hr", (2) the survey showed no measureable results in the normally occupied areas of the plant, (3) the plant was operating at full power, and (4) the ratio is more than twice the value of the measured ratios. In addition, this is corroborated by a statement in an interview with a former plant health physics technician who stated that he did not recall a positive neutron result on any film badge report and that the only time he observed detectable neutron exposure was when calibrating the neutron survey instrument. (Personal Communication, 2009g).

7.3.5 External Dose Reconstruction Feasibility Conclusion

Although no personal dosimetry data were available, NIOSH has access to sufficient information to support assessing the external dose for the class evaluated in this report. The method for bounding the operational period external dose is based on bounding the doses with the upper limit of the summary data for photon dose and through the application of bounding beta-to-gamma and neutron-to-photon ratios, which were based on surveys that represent maximum exposure scenarios and source term information. Based on this information and the assessment as presented in Section 7.3, NIOSH has concluded that it is feasible to bound the external dose (reconstruct dose with sufficient accuracy) for the class evaluated in this report.

7.4 Evaluation of Petition Basis for SEC-00126

ATTRIBUTION: Section 7.4 and its related subsections were completed by Karin Jessen, Oak Ridge Associated Universities (ORAU). These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

The following subsections evaluate the assertions made on behalf of petition SEC-00126 for the POMR site.

7.4.1 Covered Period of Employment

ISSUE: The petitioner stated that he had received a letter from DOL indicating to him that the covered period of employment would be expanded through 1969.

RESPONSE: NIOSH was unable to confirm any letter from DOL about expanding the covered period. However, NIOSH submitted a letter to DOL requesting that the covered period include the D&D period. As of April 13, 2009, NIOSH has not received any additional DOL direction regarding a change in the covered employment period for the POMR facility.

7.4.2 Monitoring

ISSUE: *…He was a laborer primarily assigned any duty his supervisor would assign. This all done without any type of monitoring, training, or protective devices for handling nuclear material this was not explained but one has to surmise it was because of* [Name Redacted] *primary work was at the other building.*

RESPONSE: Although NIOSH has not located individual data, NIOSH is aware that radiological monitoring was performed at the POMR facility. This is evident in the monthly and semiannual reports where exposures were reported and summarized in the reports. In addition, the people interviewed for this report stated that they remember wearing monitoring devices, including pencil dosimeters and film badges (Personal Communication, 2009a; Personal Communication, 2009c; Personal Communication, 2009d; Personal Communication, 2009e). For any potential unmonitored Piqua personnel, it is assumed that exposures calculated or measured for monitored Piqua personnel would exceed any potential exposures to unmonitored personnel.

7.5 Summary of Feasibility Findings for Petition SEC-00126

This report evaluates the feasibility for completing dose reconstructions for employees at the POMR facility from January 1, 1963 through May 1, 1966. NIOSH found that the available summary records, process descriptions, and source term data available are sufficient to complete dose reconstructions for the evaluated class of employees.

Table 7-2 summarizes the results of the feasibility findings at POMR for each exposure source during the time period from January 1, 1963 through May 1, 1966.

Table 7-2: Summary of Feasibility Findings for SEC-00126 January 1, 1963 through May 1, 1966		
Source of Exposure	**Reconstruction Feasible**	**Reconstruction Not Feasible**
Internal	**X**	
Process Related	X	
Ambient/ Environmental	X	
External	**X**	
- Gamma	X	
- Beta	X	
- Neutron	X	
- Occupational Medical X-ray	X	

8.0 Evaluation of Health Endangerment for Petition SEC-00126

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

Based on POMR process information, summary report information, source term information, and interviews with former POMR facility personnel, NIOSH's evaluation determined that it is feasible to estimate radiation dose for members of the NIOSH-evaluated class with sufficient accuracy based on the sum of information available from available resources. Modification of the class definition regarding health endangerment and minimum required employment periods, therefore, is not required.

9.0 Class Conclusion for Petition SEC-00126

Based on its full research of the class under evaluation, NIOSH found no part of said class for which it cannot estimate radiation doses with sufficient accuracy. This class includes all employees associated with reactor activities who worked within and around the reactor dome at the Piqua Organic Moderated Reactor during the covered period from January 1, 1963 through May 1, 1966.

NIOSH has carefully reviewed all material sent in by the petitioner, including the specific assertions stated in the petition, and has responded herein (see Section 7.4). NIOSH has also reviewed available technical resources and many other references, including the Site Research Database (SRDB), for information relevant to SEC-00126. In addition, NIOSH reviewed its NOCTS dose reconstruction database to identify EEOICPA-related dose reconstructions that might provide information relevant to the petition evaluation.

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

10.0 References

10 C.F.R. pt. 20, *Standards for Protection Against Radiation*, Cumulative Supplement of the Federal Register; January 1, 1961; SRDB Ref ID: 62588

42 C.F.R. pt. 81, *Guidelines for Determining the Probability of Causation Under the Energy Employees Occupational Illness Compensation Program Act of 2000;* Final Rule, Federal Register/Vol. 67, No. 85/Thursday, p 22,296; May 2, 2002; SRDB Ref ID: 19391

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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Atomics International, 1965b, *Piqua Nuclear Power Facility Monthly Operating Report No. 24*; Atomics International; April 1965; SRDB Ref ID: 55943

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Attachment One: Information from Interviews with Former Piqua Personnel

	Dosimetry	Survey	Neutron	General Radiation	CAMs	Incidents	Bioassay	Other
Shift Supervisor, City of Piqua, July 1960-February 1969 (PC, 2009c)	Pencil dosimeters were used during normal operations (Stored in rack when not in use). Film badges were used when fuel came on the site to load the core (until the fuel was put in storage in 1969).	Routinely	No neutrons to be concerned about.	Beta-gamma was the only concern.	CAMS were not used; the only air monitoring done was in the ventilation system.	Moderator temperature kept increasing during power operation. **[Note: Interviewee thought this was kept hidden, but NIOSH found an entire write up dedicated to this.]**	Possibly done occasionally.	Spill when coolant pump removed, coolant set up like wax, no radiation problem, blue coveralls worn (standard plant clothing)
HP Technician, City of Piqua, Fall 1961-Spring 1966 (PC, 2009a & PC, 2009g)	When operations began, all workers wore film badges that were exchanged monthly. Admin workers badges were eventually exchanged quarterly. Of the ~45 workers who were routinely monitored, only 1 or 2 workers would have a positive reading (20-30 mR) above MDL. Control badges were used to determine background levels. Thinks NTA badges used for neutron exposures. Visitors were assigned film badges. As many as 31 workers from Atomics International, Inc. (AI) worked at Piqua because they were responsible for reactor startup. Some of	Daily, weekly, and monthly surveys, depending on type of survey. All surveys were documented. Neutron surveys were done routinely, at least monthly. When the power level was raised, extensive neutron surveys were done initially. Afterwards, the surveys were less extensive.	No neutron issues; the greatest neutron dose came from calibrating the neutron survey instrument using a PuBe source. There was a potential for neutron exposure at the primary coolant line (P1B). The levels were less than 0.5 mrem/hr.	They could do all maintenance work at any time because there was not a dose issue. The only measurable exposure occurred when they were working with the instrument thimbles on top of the reactor in the high-bay area. When tubular fuel rods were pulled, they were about 200 mR/hr. HPs left them on ground, took a coffee break to allow for radioactive decay. Filter change out comment: It was a hot (thermal) and dirty (non-radioactive) job, but the exposure rate was low. The highest gamma dose rate (10-15 mR/h)	CAMs operating at all times. Rotating filter media was changed hourly and was read continuously using an end window GM tube. It was all recorded on a strip chart recorder. One sample was taken every month and sent away for outside analysis. A portion of the filter was sent out monthly for analysis and then sent to AEC Chicago.	No unusual events that led to either contamination or exposure.	Does not recall any bioassays or WBC being performed.	Only remembers one time when decon had to be done. The coolant coked up and turned black…all contaminates were trapped in black substance. There was a beta window on the badges and this dose was reported. The badges were worn outside the coveralls so that the beta dose could be measured.

	Dosimetry	Survey	Neutron	General Radiation	CAMs	Incidents	Bioassay	Other
	these workers wore both AI and Piqua film badges, but Piqua was responsible for tracking their doses. Dosimetry records first went to the City of Piqua, and then were sent to AEC Chicago Operations Office on a monthly basis. All badges were shipped to Landauer in Chicago.			was around the primary coolant pump coming out of the core. The gamma dose was very small and there was usually nothing to report. No worker had a monthly dose exceeding 50 mR. Cannot remember the highest annual dose, but it was so minimal that it was not a concern.				
Construction Engineer, Atomics International, 1961-1966 (PC, 2009d)	All reactor operators and maintenance workers wore film badges all the time, and they also had pencil dosimeters. Recalled that administrative workers had to go to an HP to get a film badge if they were going into the Reactor Building. Years after he left, he received information from the AEC that told him how much radiation dose he received. He said that the AEC would send exposure records to AI.	Contamination surveys were routinely performed; it was a very clean plant. HPs would tell workers where rad levels were.	Neutrons in core, but no leaks of neutrons from reactor vessel. Containment tight and 6' of shielding around reactor.	Was a very, very low-radiation-level place.	Does not recall any area sampling being performed, but the exhaust air from the stack was monitored.	Around 1964, in the Reactor Building, a seal on a pump failed and began spewing out organic material coolant. When the seal let loose and the coolant spilled out, supposedly there was a fire, but no one saw it.	-	Instrumentation in containment vessel. If instrumentation had to be pulled, they did not shut down reactor, they minimized the number of workers doing the job.
Reactor Operator & Maintenance	Does not recall film badge exchange frequency; it may have	Radiation and contamination surveys were	No neutron radiation.	The beta and gamma radiation were from	Air monitoring was done inside and	-	Does not recall giving urine samples. However,	Piqua was the cleanest plant he ever worked at.

	Dosimetry	Survey	Neutron	General Radiation	CAMs	Incidents	Bioassay	Other
Foreman, DOE, 1960-1969 (PC, 2009e)	been done monthly. Never saw the results of film badge measurements, but he received a yearly letter telling him what his exposure was for that year. Does not recall getting any exposure. The pencil dosimeters were used for a whole day and registered a maximum reading of 200 mR. The workers turned the dosimeters over to the HP every day and the HP checked the reading, but he does not know if the readings were recorded. Does not recall ever getting a reading on his dosimeter. Although, he might have gotten a reading on one job when he cleaned up the residue on the absolute filters from the coolant on a big boiler.	routinely performed.		activation of the impurities in the coolant.	outside the POMR plant.		he was not saying it did not happen, just that he does not remember giving urine samples.	
Health Physicist, City of Piqua (PC, 2009f)	-	Only smear surveys of the floors.	No neutron exposures.	The highest doses at the site were about 100 mrem in a month. Doses could have also been in the 30-40 mrem/month range.	No air contamination.	-	-	Does not recall any particular contamination event at the Piqua site; no contamination events.

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Attachment Two: Data Capture Synopsis

Table A2-1: Data Capture Synopsis for POMR			
Data Capture Information	**Data Capture Description**	**Completed**	**Uploaded into SRDB**
Primary Site/Company Name: Piqua Organic Moderated Reactor; DOE 1963-1966 Other company names: Piqua Nuclear Power Facility PNPF Atomics International, now Boeing at Santa Field Laboratory, 1963-1964, see below for data capture results	See below.	See below	See below
State Contacted: Ohio Department of Health, David Lipp	No relevant documents not already in the SRDB identified.	11/03/2008	0
American Municipal Power-Ohio, Kent Carson, Sr.	No relevant documents identified.	02/02/2009	0
Cincinnati Public Library	An operational report from the first criticality to the first scheduled shutdown.	11/06/2008	1
Claimant	Documented communications, monthly report #69, and a final survey report.	02/25/2009	4
Comprehensive Epidemiologic Data Resource (CEDR)	No relevant documents identified.	10/10/2008	0
Department of Labor (Paragon)	Testing and operation reports at 50% and 100% power, core unloading and inspection report and drawings, facility photos, failure analyses, and cathodic protection of the containment shell.	12/05/2008	22
DOE Hanford Declassified Document Retrieval System (DDRS)	No relevant documents identified.	10/10/2008	0
DOE Legacy Management Considered Sites	All Considered Sites documents are contained in the Grand Junction Office DVD's. No search was necessary.	N/A	0
DOE Legacy Management - Grand Junction Office	Annual site radiological surveys, FUSRAP documents, total residual radioactivity in the reactor, building drawings, and remediation planning documents.	11/24/2008	33
DOE OpenNet	No relevant documents identified.	10/10/2008	0
DOE OSTI Energy Citations	Reports on shipping casks and waste treatment, and an Energy Research and Development Administration Decontamination and Decommissioning conference.	01/14/2009	8

Table A2-1: Data Capture Synopsis for POMR			
Data Capture Information	**Data Capture Description**	**Completed**	**Uploaded into SRDB**
DOE OSTI Information Bridge	A 1991 annual site inspection and radiological survey, reports on the performance and metallurgy of organic moderated reactor fuel elements, and a study of military applications.	01/14/2009	14
Google	FUSRAP site fact sheet, a discussion of entombment as a decommissioning technology, AEC and DOE reports, and a 2008 annual site inspection and radiological survey.	10/25/2008	9
Interlibrary Loan	Facility engineering design and a status report.	12/19/2008	2
National Academies Press (NAP)	No relevant documents identified.	10/10/2008	0
National Nuclear Security Administration (NNSA) - Nevada Site Office	No relevant documents identified.	10/10/2008	0
NRC Agencywide Document Access and Management (ADAMS)	No relevant documents identified.	10/10/2008	0
Office of Scientific & Technical Information (OSTI)	Operations analysis progress reports, engineering studies of organic moderation, and information on preparation and shipping of fuel elements.	12/16/2008	22
Piqua Public Library	No relevant documents identified.	01/27/2009	0
Science Applications International Corporation (SAIC)	Complex-wide exposure records for 1960 and 1961.	09/02/2004	2
San Bruno Federal Records Center	Quality assurance documentation and weekly reports, all relating to the de-activation of the facility.	02/02/2006	14
Santa Susanna Field Laboratory (Boeing)	Fuel element safety analysis, fuel shipment reports, criticality controls, radiological surveillance program, recovery plans, weekly highlights reports, studies of organic contaminant formation, 1967 recovery program plans, coolant surveillance reports, reactor operations analysis program reports, control rod studies, modification studies, coolant chemistry reports, coolant filtration studies, core examination reports, and facility retirement reports.	12/05/2008	51
Unknown	Personnel exposure information for 1963 and film badge records for 2 employees.	07/31/2003	1
Washington State University (U.S. Transuranium and Uranium Registries)	No relevant documents identified.	10/10/2008	0
Total			**183**

Table A2-2: Database Searches for POMR			
Database/Source	**Keywords**	**Hits**	**Uploaded into SRDB**
DOE OpenNet http://www.osti.gov/opennet/advancedsearch.jsp COMPLETED 10/10/2008	"Piqua" + 01/01/1960 - 08/10/2008	9	0
DOE Hanford DDRS http://www2.hanford.gov/declass/ COMPLETED 10/10/2008	"Piqua" + 01/01/1960 - 08/10/2008	0	0
DOE OSTI Energy Citations http://www.osti.gov/energycitations/ COMPLETED 01/14/2009	"Piqua" + Reactor + 01/01/1960 - 08/10/2008	194	8
DOE OSTI Information Bridge http://www.osti.gov/bridge/advancedsearch.jsp COMPLETED 01/14/2009	"Piqua" + 01/01/1960 - 08/05/2008	118	14
DOE CEDR http://cedr.lbl.gov/ COMPLETED 10/10/2008	"Piqua"	0	0
NNSA - Nevada Site Office www.nv.doe.gov/main/search.htm COMPLETED 10/10/2008	"Piqua"	0	0
U.S. Transuranium & Uranium Registries http://www.ustur.wsu.edu/ COMPLETED 10/10/2008	"Piqua"	0	0
National Academies Press http://www.nap.edu/ COMPLETED 10/10/2008	"Piqua"	0	0
NRC ADAMS Reading Room http://www.nrc.gov/reading-rm/adams/web-based.html COMPLETED 10/10/2008	"Piqua" + 01/01/1960 - 08/10/2008	73	0
Google http://www.google.com COMPLETED 10/25/2008	americium OR Am241 OR Am-241 OR "AM 241" OR 241Am OR 241-Am OR "241 Am" AND "Piqua" ionium OR Th230 OR Th-230 OR "Th 230" OR 230Th OR 230-Th OR "230 Th" AND "Piqua" neptunium OR Np237 OR Np-237 OR "Np 237" OR 237Np OR 237-Np OR "237 Np" AND "Piqua"	7,435	9

Table A2-2: Database Searches for POMR			
Database/Source	**Keywords**	**Hits**	**Uploaded into SRDB**
	polonium OR Po210 OR Po-210 OR "Po 210" OR 210Po OR 210-Po OR "210 Po" AND "Piqua" thorium OR Th232 OR Th-232 OR "Th 232" OR 232Th OR 232-Th AND "Piqua" AND Reactor "232 Th" OR "Z metal" OR myrnalloy OR "chemical 10-66" OR "chemical 10-12" AND "Piqua" ionium OR UX1 OR UX2 OR Th-230 OR Th230 OR "Th 230" OR 230-Th OR "230 Th" AND "Piqua" 230Th OR Th-234 OR Th234 OR "Th 234" OR 234-Th OR 234Th OR "234 Th" AND "Piqua" tritium OR H3 OR H-3 OR mint OR HTO AND "Piqua" AND Reactor uranium OR U233 OR U-233 OR "U 233" OR 233U OR 233-U OR "233 U" AND "Piqua" AND Reactor U234 OR "U 234" OR U-234 OR 234U OR 234-U OR "234 U" AND "Piqua" U235 OR "U 235" OR U-235 OR 235-U OR 235U OR "235 U" OR U238 AND "Piqua" "U 238" OR U-238 OR 238-U OR 238U OR "238 U" AND "Piqua" U308 OR "U 308" OR U-308 OR 308-U OR 308U OR "308 U" OR "uranium extraction" OR "black oxide" OR "brown oxide" AND "Piqua" "green salt" OR "orange oxide" OR "yellow cake" OR UO2 OR UO3 AND "Piqua" UF4 OR UF6 OR C-216 OR C-616 OR C-65 OR C-211 OR U3O8 AND "Piqua" AND Reactor		

Table A2-2: Database Searches for POMR			
Database/Source	**Keywords**	**Hits**	**Uploaded into SRDB**
	plutonium OR Pu-238 OR Pu238 OR "Pu 238" OR 238Pu OR 238-Pu OR "238 Pu" AND "Piqua" AND Reactor Pu-239 OR Pu239 OR "Pu 239" OR 239Pu OR 239-Pu OR "239 Pu" AND "Piqua" Pu-240 OR Pu240 OR "Pu 240" OR 240Pu OR 240-Pu OR "240 Pu" AND "Piqua" Pu-241 OR Pu241 OR "Pu 241" OR 241Pu OR 241-Pu OR "241 Pu" AND "Piqua" radium OR Ra-226 OR Ra226 OR "Ra 226" OR 226-Ra OR 226Ra OR 226-Ra AND "Piqua" AND Reactor Ra-228 OR Ra228 OR "Ra 228" OR 228Ra OR 228-Ra OR "228 Ra" AND "Piqua" radon OR Rn-222 OR Rn222 OR "Rn 222" OR 222Rn OR 222-Rn OR "222 Rn" AND "Piqua" AND Reactor thoron OR Rn-220 OR Rn220 OR "Rn 220" OR 220Rn OR 220-Rn OR "220 Rn" AND "Piqua" AND Reactor protactinium OR Pa-234m OR Pa234m OR "Pa 234m" OR 234mPa OR 234m-Pa OR "234m Pa" AND "Piqua" AND Reactor strontium OR Sr-90 OR Sr90 OR "Sr 90" OR 90-Sr OR 90Sr OR "90 Sr" AND "Piqua" AND Reactor oralloy OR postum OR tuballoy OR "uranyl nitrate hexahydrate" OR UNH OR K-65 OR "sump cake" AND "Piqua" AND Reactor "uranium dioxide" OR "uranium tetrafluoride" OR "uranium trioxide" AND "Piqua"		

Table A2-2: Database Searches for POMR			
Database/Source	**Keywords**	**Hits**	**Uploaded into SRDB**
	"uranium hexafluoride" OR "air count" AND "Piqua" accident AND "Piqua" AND Reactor "air dust" OR "air filter" OR "airborne test" AND "Piqua" AND Reactor "alpha particle" OR "belgian congo ore" OR bioassay OR bio-assay AND "Piqua" AND Reactor breath OR "breathing zone" OR BZ OR calibration OR "chest count" OR collimation OR columnation AND "Piqua" AND Reactor contamination OR curie OR denitration OR "denitration pot" AND "Piqua" AND Reactor derby OR regulus OR dose OR dosimeter AND "Piqua" AND Reactor dosimetric OR dosimetry OR electron OR environment AND "Piqua" AND Reactor "Ether-Water Project" OR exposure OR "exposure investigation" OR "radiation exposure" AND "Piqua" AND Reactor external OR "F machine" OR fecal OR "feed material" OR femptocurie OR film OR fission OR fluoroscopy AND "Piqua" AND Reactor "Formerly Utilized Sites Remedial Action Program" OR FUSRAP OR gamma-ray OR "gas proportional" OR "gaseous diffusion" AND "Piqua" AND Reactor health OR "health instrument" OR "health physics" OR "H.I." OR HI OR HP OR "highly enriched uranium" OR HEU AND "Piqua" AND Reactor hydrofluorination OR "in vitro" OR "in vivo" OR incident OR ingestion OR inhalation OR internal AND "Piqua" AND Reactor investigation OR isotope OR isotopic OR "isotopic enrichment" OR "JS		

Table A2-2: Database Searches for POMR			
Database/Source	**Keywords**	**Hits**	**Uploaded into SRDB**
	Project" OR Landauer OR "liquid scintillation" AND "Piqua" AND Reactor log OR "log sheet" OR "log book" OR "low enriched uranium" OR LEU AND "Piqua" AND Reactor "maximum permissible concentration" OR MPC OR metallurgy OR microcurie OR millicurie AND "Piqua" AND Reactor "mixed fission product" OR MFP OR monitor OR "air monitoring" OR nanocurie OR "nasal wipe" OR neutron OR "nose wipe" AND "Piqua" AND Reactor nuclear OR Chicago-Nuclear OR "nuclear fuels" OR "nuclear track emulsion" OR "type A" AND "Piqua" AND Reactor NTA OR "occupational radiation exposure" OR occurrence OR "ore concentrate" OR "PC Project" AND "Piqua" AND Reactor permit OR "radiation work permit" OR "safe work permit" OR "special work permit" OR RWP OR SWP AND "Piqua" AND Reactor "phosphate research" OR photofluorography OR photon OR picocurie OR pitchblende OR "pocket ion chamber" OR PIC OR problem OR procedure AND "Piqua" AND Reactor radeco OR radiation OR radioactive OR radioactivity OR radiograph OR radiological AND "Piqua" AND Reactor "Radiological Survey Data Sheet" OR RSDS OR radionuclide OR raffinate OR reactor AND "Piqua" AND Reactor respiratory OR "retention schedules" OR roentgen AND "Piqua" AND Reactor sample OR "air sample" OR "dust sample" OR "general area air sample" AND "Piqua" AND Reactor		

Table A2-2: Database Searches for POMR			
Database/Source	**Keywords**	**Hits**	**Uploaded into SRDB**
	"solvent extraction" OR source OR "sealed source" OR spectra OR spectrograph OR spectroscopy AND "Piqua" AND Reactor spectrum OR standard OR "operating standard" OR "processing standard" AND "Piqua" AND Reactor survey OR "building survey" OR "routine survey" OR "special survey" OR "technical basis" AND "Piqua" AND Reactor "thermal diffusion" OR "thermoluminescent dosimeter" OR TLD OR "Tiger Team" AND "Piqua" AND Reactor "tolerance dose" OR urinalysis OR urine OR "whole body count" OR WBC AND "Piqua" AND Reactor "working level" OR WL OR X-ray OR "X ray" OR Xray OR "x-ray screening" AND "Piqua" AND Reactor "Atomics International" AND "Piqua" DOE/CH-9111 OR DOE/CH-9225		

Table A2-3: OSTI Documents Ordered for POMR			
Document Number	**Document Title**	**Requested Data**	**Date Received**
N/A OSTI ID: 5179961 SRDB: 54696	Piqua Nuclear Power Facility Radiological Surveillance Program	10/29/2008	11/25/2008
N/A OSTI ID: 4666935 SRDB: 55945	Piqua Nuclear Power Facility Monthly Operating Report No. 19	10/29/2008	12/05/2008
N/A OSTI ID: 4614403 SRDB: 55944	Piqua Nuclear Power Facility Monthly Operating Report No. 26	10/29/2008	12/05/2008

Table A2-3: OSTI Documents Ordered for POMR			
Document Number	**Document Title**	**Requested Data**	**Date Received**
N/A OSTI ID: 4592064 SRDB: 55943	Piqua Nuclear Power Facility Monthly Operating Report No. 24	10/29/2008	12/05/2008
N/A OSTI ID: 4181116 SRDB: 55942	Piqua Nuclear Power Facility Monthly Operating Report No. 53	10/29/2008	12/05/2008
NAA-SR-12561 OSTI ID: 4501434 SRDB: 55892	Piqua Nuclear Power Facility Reactor Operations Analysis Program Semiannual Progress Report No. 10, January 1--June 30, 1967.	10/29/2008	12/08/2008
NAA-SR-12445 OSTI ID: 4799966 SRDB: 55883	Piqua Nuclear Power Facility Reactor Operations Analysis Program Semiannual Progress Report No. 9, July 1--December 31, 1966.	10/29/2008	12/08/2008
NAA-SR-MEMO-12540 OSTI ID: 4496873 SRDB: 55938	Piqua Nuclear Power Facility Reactor Operations Analysis Program Report 55, June 1967.	10/29/2008	12/08/2008
NAA-SR-4576 OSTI ID: 4143395 SRDB: 55904	Piqua OMR Waste Gas Disposal	10/29/2008	12/08/2008
NAA-SR-8722 OSTI ID: 4123254 SRDB: 55926	Piqua Nuclear Power Facility Operations Analysis Program Progress Report No. 2, Fiscal Year 1963	10/29/2008	12/08/2008
NAA-SR-5688 OSTI ID: 4080480 SRDB: 55906	Proceedings of the Organic Cooled Reactor Forum, October 6-7, 1960	10/29/2008	12/08/2008
NAA-SR-11628 OSTI ID: 4565167 SRDB: 55817	Piqua Nuclear Power Facility Reactor Operations Analysis Program Semiannual Progress Report No. 6, January 1-June 30, 1965	10/29/2008	12/08/2008
NAA-SR-9473 OSTI ID: 4031136 SRDB: 55932	Piqua Nuclear Power Facility Operations Analysis Program Progress Report No. 3, July 1, 1963-December 31, 1963	10/29/2008	12/08/2008
NAA-SR-MEMO-10529 OSTI ID: 4639851 SRDB: 55934	Preparation and Transportation of Piqua Fuel Elements. Summary Report	10/29/2008	12/08/2008
NAA-SR-11142 OSTI ID: 4583353 SRDB: 55815	Piqua Nuclear Power Facility Reactor Operations Analysis Program Semiannual Progress Report No. 5, July 1-December 31, 1964	10/29/2008	12/08/2008
NAA-SR-11650 Sect 3	Hallam Nuclear Power Facility and Piqua Nuclear Power	10/29/2008	12/08/2008

Table A2-3: OSTI Documents Ordered for POMR			
Document Number	**Document Title**	**Requested Data**	**Date Received**
OSTI ID: 4582815 SRDB: 55818	Facility		
NAA-SR-10307 OSTI ID: 4683534 SRDB: 55814	Piqua Nuclear Power Facility Operations Analysis Program Progress Report No. 4, January 1-June 30, 1964	10/29/2008	12/08/2008
NAA-SR-MEMO-12071 OSTI ID: 4468274 SRDB: 55935	Piqua Nuclear Power Facility Reactor Operations Analysis Program Report No. 41, January--April 1966	10/29/2008	12/08/2008
NAA-SR-11995 OSTI ID: 4465693 SRDB: 55880	Piqua Nuclear Power Facility Reactor Operations Analysis Program Semiannual Progress Report No. 7, July 1, 1965--January 13, 1966	10/29/2008	12/08/2008
NAA-SR-12148 OSTI ID: 4440848 SRDB: 55881	Piqua Nuclear Power Facility Reactor Operations Analysis Program Semiannual Progress Report No. 8, January 1--June 30, 1966	10/29/2008	12/08/2008
NAA-SR-11200 OSTI ID: 4571317 SRDB: 55816	Aec Unclassified Programs. Quarterly Technical Progress Report, January-March 1965	10/29/2008	12/08/2008
NAA-SR-3575 NAA-SR-MEMO-4048 OSTI ID: 4182273 SRDB: 55896 & 55940	Preliminary Safeguards Report for the Piqua Organic Moderated Reactor (revised) Supplement I to the Preliminary Safeguards Report for the Piqua Organic Moderated Reactor (revised)	10/29/2008	12/08/2008
NAA-SR-6893 OSTI ID: 4781060 SRDB: 55921	Energy Absorption Rates in OMR Coolants	10/29/2008	12/08/2008
NAA-SR-MEMO-6581 OSTI ID: 4803723 SRDB: 55941	Re-evaluation of Energy Absorption Rate in OMR`s	10/29/2008	12/08/2008
NAA-SR-12516 OSTI ID: 4799937 SRDB: 55890	Safety Evaluation of PNPF Modifications	10/29/2008	12/08/2008
NAA-SR-3635 OSTI ID: 4221122 SRDB: 55901	Preliminary Design Description for the Piqua Organic Moderated Reactor Plant, Piqua, Ohio (revised)	10/29/2008	12/08/2008
N/A OSTI ID: 4343710 SRDB: 56036	Recovery of Uranium from Piqua Cold Scrap Fuel Elements	10/29/2008	12/16/2008
DPSPU-72-124-5	Safety Analysis Report: Piqua--Elk River Shipping Cask	10/29/2008	12/17/2008

Table A2-3: OSTI Documents Ordered for POMR			
Document Number	**Document Title**	**Requested Data**	**Date Received**
OSTI ID: 4602683 SRDB: 55811	(packaging of radioactive and fissile materials). Final Report.		
N/A OSTI ID: 4498453	Piqua Nuclear Power Facility Surveillance and Recovery Program. Final Report	10/29/2008	01/14/2009
N/A OSTI ID: 4683116	Piqua Elk River Reactors Spent Fuel Shipping Cask Design Report	10/29/2008	01/14/2009
N/A OSTI ID: 5446994	Annual Survey of the Retired Piqua Nuclear Power Facility	10/29/2008	01/14/2009
DOE/CH/10370-1 OSTI ID: 6355044	Annual Survey of the Retired Piqua Nuclear Power Facility	10/29/2008	01/14/2009
TID-18813 OSTI ID: 4702649	Piqua-Elk River Reactors Spent Fuel Shipping Cask. Final Design Report	10/29/2008	01/29/2009
NAA-SR-Memo-7676 OSTI ID: 4728186	Piqua Operations Analysis Program. Annual Technical Progress Report, Fiscal Year 1962	10/29/2008	N/A - OSTI doesn't have this one

Table A2-4: Cincinnati Public Library Documents Ordered for POMR			
Document Number	**Document Title**	**Requested Data**	**Date Received**
N/A OSTI ID: 4815595 SRDB: 56595	Piqua Nuclear Power Facility. 1. Status Report 2. General Description of the Piqua Reactor	10/29/2008	12/19/2008
N/A OSTI ID: 4196389 SRDB: 56588	Engineering Design of Piqua OMR	10/29/2008	12/19/2008
N/A OSTI ID: 4676966 SRDB: 53465	Operating of Piqua Nuclear Power Facility from Criticality to First Scheduled Shutdown	10/29/2008	11/06/2008
N/A OSTI ID: 4147910	Safety Considerations for the Organic Moderated Reactor in Piqua, Ohio	10/29/2008	N/A - OSTI cannot provide; article is in German