DOE Review Release 08/31/2012

Document Title: **Paducah Gaseous Diffusion Plant – Introduction**	Document Number: ORAUT-TKBS-0019-1 Revision: 02 Effective Date: 08/23/2012 Type of Document: TBD Supersedes: Revision 01

Subject Expert(s): Jodie L. Phillips

Approval:	Signature on File Jodie L. Phillips, Document Owner	Approval Date:	08/20/2012
Concurrence:	Signature on File John M. Byrne, Objective 1 Manager	Concurrence Date:	08/21/2012
Concurrence:	Signature on File Edward F. Maher, Objective 3 Manager	Concurrence Date:	08/20/2012
Concurrence:	Vickie S. Short Signature on File for Kate Kimpan, Project Director	Concurrence Date:	08/20/2012
Approval:	Signature on File James W. Neton, Associate Director for Science	Approval Date:	08/23/2012

☐ New ☒ Total Rewrite ☐ Revision ☐ Page Change

FOR DOCUMENTS MARKED AS A TOTAL REWRITE, REVISION, OR PAGE CHANGE, REPLACE THE PRIOR REVISION AND DISCARD / DESTROY ALL COPIES OF THE PRIOR REVISION.

PUBLICATION RECORD

EFFECTIVE DATE	REVISION NUMBER	DESCRIPTION
09/09/2004	00	First approved issue. Initiated by Jay J. Maisler.
08/30/2006	00 PC-1	Approved page change revision to review against Worker Outreach comments and periodic revision. Updates required language on page 4 in Section 1.0. No sections were deleted. No further changes occurred as a result of internal formal review. This revision results in no change to the assigned dose and no PER is required. Training required: As determined by the Task Manager. Initiated by Paul A. Szalinski. Approval: Signature on File 08/16/2006 Daniel Mantooth, TBD Team Leader Richard Merrill Signature on File for 08/16/2006 John M. Byrne, Task 3 Manager Signature on File 08/16/2006 Edward F. Maher, Task 5 Manager Signature on File 08/17/2006 Kate Kimpan, Project Director Signature on File 08/30/2006 James W. Neton, Associate Director for Science
04/02/2007	01	Approved Rev 01 revised to incorporate Attributions and Annotations Section 1.3 and update the References section. Constitutes a total rewrite of the document. No further changes occurred as a result of internal formal review. Incorporates NIOSH formal review comments. This revision results in no change to the assigned dose and no PER is required. Training required: As determined by the Task Manager. Initiated by Daniel S. Mantooth.
08/23/2012	02	Added reference ORAUT-OTIB-0079. Revised the description of the Occupational Medical Dose technical basis document. Added information to indicate that coworker studies are now included in the Internal and External technical basis documents. No changes occurred as a result of formal internal and NIOSH review. Constitutes a total rewrite of the document. Training required: As determined by the Objective Manager. Initiated by Jodie L. Phillips.

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

DOE	U.S. Department of Energy
EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
kerma	kinetic energy released per unit mass
LAT	lateral
NIOSH	National Institute for Occupational Safety and Health
PA	posterior-anterior
PGDP	Paducah Gaseous Diffusion Plant
POC	probability of causation
TBD	technical basis document
U.S.C.	United States Code
§	section or sections

1.1 INTRODUCTION

Technical basis documents and site profile documents are not official determinations made by the National Institute for Occupational Safety and Health (NIOSH) but are rather general working documents that provide historic background information and guidance to assist in the preparation of dose reconstructions at particular sites or categories of sites. They will be revised in the event additional relevant information is obtained about the affected site(s). These documents may be used to assist NIOSH staff in the completion of the individual work required for each dose reconstruction.

In this document the word "facility" is used as a general term for an area, building, or group of buildings that served a specific purpose at a site. It does not necessarily connote an "atomic weapons employer facility" or a "Department of Energy [DOE] facility" as defined in the Energy Employees Occupational Illness Compensation Program Act [EEOICPA; 42 U.S.C. § 7384l(5) and (12)]. EEOICPA defines a DOE facility as "any building, structure, or premise, including the grounds upon which such building, structure, or premise is located … in which operations are, or have been, conducted by, or on behalf of, the Department of Energy (except for buildings, structures, premises, grounds, or operations … pertaining to the Naval Nuclear Propulsion Program)" [42 U.S.C. § 7384l(12)]. Accordingly, except for the exclusion for the Naval Nuclear Propulsion Program noted above, any facility that performs or performed DOE operations of any nature whatsoever is a DOE facility encompassed by EEOICPA.

For employees of DOE or its contractors with cancer, the DOE facility definition only determines eligibility for a dose reconstruction, which is a prerequisite to a compensation decision (except for members of the Special Exposure Cohort). The compensation decision for cancer claimants is based on a section of the statute entitled "Exposure in the Performance of Duty." That provision [42 U.S.C. § 7384n(b)] says that an individual with cancer "shall be determined to have sustained that cancer in the performance of duty for purposes of the compensation program if, and only if, the cancer … was at least as likely as not related to employment at the facility [where the employee worked], as determined in accordance with the POC [probability of causation[1]] guidelines established under subsection (c) …" [42 U.S.C. § 7384n(b)]. Neither the statute nor the probability of causation guidelines (nor the dose reconstruction regulation, 42 C.F.R. Pt. 82) restrict the "performance of duty" referred to in 42 U S. C. § 7384n(b) to nuclear weapons work (NIOSH 2010).

The statute also includes a definition of a DOE facility that excludes "buildings, structures, premises, grounds, or operations covered by Executive Order No. 12344, dated February 1, 1982 (42 U.S.C. 7158 note), pertaining to the Naval Nuclear Propulsion Program" [42 U.S.C. § 7384l(12)]. While this definition excludes Naval Nuclear Propulsion Facilities from being covered under the Act, the section of EEOICPA that deals with the compensation decision for covered employees with cancer [i.e., 42 U.S.C. § 7384n(b), entitled "Exposure in the Performance of Duty"] does not contain such an exclusion. Therefore, the statute requires NIOSH to include all occupationally-derived radiation exposures at covered facilities in its dose reconstructions for employees at DOE facilities, including radiation exposures related to the Naval Nuclear Propulsion Program. As a result, all internal and external occupational radiation exposures are considered valid for inclusion in a dose reconstruction. No efforts are made to determine the eligibility of any fraction of total measured exposure for inclusion in dose reconstruction. NIOSH, however, does not consider the following exposures to be occupationally derived (NIOSH 2010):

- Background radiation, including radiation from naturally occurring radon present in conventional structures
- Radiation from X-rays received in the diagnosis of injuries or illnesses or for therapeutic reasons

[1] The U.S. Department of Labor (DOL) is ultimately responsible under the EEOICPA for determining the POC.

1.2 PURPOSE

The purpose of this technical basis document (TBD) is to provide a summary of the contents of the five TBDs that, along with this Introduction, constitute the Paducah Gaseous Diffusion Plant (PGDP) Site Profile.

1.3 SCOPE

The PGDP Site Profile is divided into six major parts – this Introduction, Site Description, Occupational Medical Dose, Occupational Environmental Dose, Occupational Internal Dose, and Occupational External Dose. Some parts include an attachment that provides critical data for the specialists reconstructing the doses.

PGDP is one of the original sites that was designated by Congress as part of the Special Exposure Cohort (SEC) under EEOICPA [42 U.S.C. § 7384l(14)]. This designation is as follows:

> *(A) The employee was so employed for a number of work days aggregating at least 250 work days before February 1, 1992, at a gaseous diffusion plant located in Paducah, Kentucky, Portsmouth, Ohio, or Oak Ridge, Tennessee, and, during such employment—*
>
> > *(i) was monitored through the use of dosimetry badges for exposure at the plant of the external parts of employee's body to radiation; or*
> >
> > *(ii) worked in a job that had exposures comparable to a job that is or was monitored through the use of dosimetry badges.*

Dose reconstruction guidance in this site profile provides a technical basis for dose reconstructions for nonpresumptive cancers that are not covered in the SEC class through January 31, 1992. Dose reconstructions for individuals employed at PGDP before February 1, 1992, but who do not qualify for inclusion in the SEC, can be performed using this guidance as appropriate.

The Site Description TBD (ORAUT 2012a) is a description of the facilities and processes that PGDP used to process and enrich uranium. The purpose of the gaseous diffusion plant has been and continues to be the enrichment of uranium, initially for military applications and subsequently for commercial nuclear reactor fuel. PGDP enriches feed material in the form of uranium hexafluoride gas (UF_6) from approximately 0.711% ^{235}U up to about 2.5% ^{235}U. The enriched product from PGDP has been sent to other DOE gaseous diffusion plants at Piketon, Ohio, and Oak Ridge, Tennessee, for further enrichment. Some feed material was recycled uranium from spent reactor fuel.

The Occupational Medical Dose TBD (ORAUT 2012b) provides information about the doses individual workers received from X-rays that were required as a condition of employment. The PGDP occupational medicine program required preemployment, periodic, and termination screening chest X-ray examinations. The chest examinations usually consisted of one posterior-anterior (PA) in the early years, and both a PA and a lateral (LAT) starting in the mid-1970s and continuing into the 1980s and 1990s. While there are some LAT chest projections in the claim file records before the mid-1970s, they were much more commonly performed after that time. Occupational exposures from medical X-rays were conducted on site; therefore, the dose from such procedures should be evaluated during the dose estimate (ORAUT 2011). In addition to parts of the body exposed in the primary beam of an X-ray machine, other tissues received some dose from secondary radiation. Secondary radiation consists of X-rays that are scattered from surrounding materials or that escape from the source assembly. This TBD provides tables that list estimated dose equivalents to organs of the body for male and female PGDP employees; these estimates are favorable to claimants. The

tables are derived from an assessment of the air kerma at the source-to-skin distance based on specific operating parameters for the facility, insofar as these are known.

The Occupational Environmental Dose TBD (ORAUT 2012c) applies to workers who were not monitored for external or internal radiation exposure. The environmental dose is the dose workers received when working on the site but outside the buildings from inhalation of radioactive materials in the air and direct radiation exposure from sources such as the depleted uranium hexafluoride cylinders in storage.

Inhalation of environmental radionuclides results in internal dose to the whole body or body organs. The internal dose for workers outside the facilities was determined from the air concentrations that were a result of the releases from stacks, individual buildings, and the purge cascade and other operations at PGDP. Unmonitored workers might have incurred occupational doses internally from onsite releases to the air. Air concentrations of radionuclides were determined using annual environmental reports for 1952 through 2001. Values for airborne concentrations and annual intakes are provided for total uranium and ^{99}Tc.

Site annual environmental reports, health physics surveys, and other reports were reviewed for data that would be useful in reconstructing ambient radiation levels. Ambient radiation dose rates include natural background radiation and sources on the site.

PGDP personnel have annually compared these data with thermoluminescent dosimeter data from offsite locations and literature values for State of Kentucky and regional exposure levels. The determination has always been that onsite ambient radiological conditions measured at the security fence are not significantly different from offsite, State, and regional annual exposure levels. This is attributed to the geology of the region around PGDP. Exceptions to this observation have been monitoring locations near depleted uranium cylinder storage yards in recent years. These locations have shown increases in external exposure as the inventory of depleted uranium has increased. The approach for estimating external dose using this information is provided in the TBD.

The Occupational Internal Dosimetry TBD (ORAUT 2012d) describes the internal dosimetry program at PGDP. The primary method for monitoring employees for intakes of radionuclides at PGDP was urine bioassay, which was instituted at the start of enrichment operations and has continued to the present day. However, the focus of the monitoring program in the early years was the detection of excreted soluble uranium. When monitoring for less soluble isotopes of uranium and transuranic elements was necessary, *in vivo* methodologies were implemented to supplement the excretion data. These methods were primarily whole-body counting and chest (lung) counting.

Until the mid-1980s, action levels were set based on the amount of uranium excreted. Later, intakes and doses were assessed based on both *in vivo* and *in vitro* monitoring results. Data are available from 1952 to the present for *in vivo* and *in vitro* analysis records and associated interpretations.

A review of in-house procedures used to assess the concentration of uranium in urine indicates that a variety of quality control steps were an integral part of the process. Therefore, the *in vitro* results from in-house processing, typically reported in units of micrograms of uranium per liter, are considered to be generally reliable. However, interpretation of those results can be difficult, primarily because of uncertainties about enrichment and solubility and the contribution of environmental uranium, and because samples were collected at work and during the middle of the work week, which could include cross-contamination and the inability to separate soluble and insoluble intake fractions.

Guidance on selection of source terms is provided in the TBD. Input parameters for the interpretation of *in vivo* and *in vitro* measurement results are presented and include instructions for assessing dose for monitored and unmonitored employees. The detection limits of the *in* vivo and *in* vitro

methodologies and potential missed dose are discussed. Existing data analysis is summarized, and significant incidents with internal dose potential are identified.

Additional data are provided for the evaluation of unmonitored workers. Attachment B to ORAUT (2012d) contains the coworker analyses.

The Occupational External Dosimetry TBD (ORAUT 2012e) describes the program for measuring skin and whole-body doses to the workers from sources that were external to the body. The methods used at PGDP have evolved over the years as new techniques and equipment have been developed. In addition, concepts in radiation protection have changed. Dose reconstruction, PGDP practices and policies, and dosimeter types and technology for measuring the dose from the different types of radiation are discussed in this section. Attention is given to the evaluation of doses measured from exposure to beta, gamma, and neutron radiation.

Sources of bias, workplace radiation field characteristics, responses of different beta/gamma and neutron dosimeters in the workplace fields, and the adjustments to the recorded dose measured by these dosimeters during specific years are presented in detail. In addition, the sources of potential dose that could be missed because of the limitations of dosimetry systems and the methods of reporting low doses are presented as a function of dosimeter type, year, and type of radiation.

Additional data are provided for the evaluation of shallow dose and the assignment of dose to unmonitored workers. Attachment A to ORAUT (2012e) contains the coworker dose assignment. Attachment B to ORAUT (2012e) contains the skin dose assignment.

1.4 ATTRIBUTIONS AND ANNOTATIONS

All information requiring identification was addressed via references integrated into the reference section of this document.

REFERENCES

NIOSH (National Institute for Occupational Safety and Health), 2010, *Radiation Exposures Covered for Dose Reconstructions Under Part B of the Energy Employees Occupational Illness Compensation Program Act*, DCAS-IG-003, Rev. 01, Division of Compensation Analysis and Support, Cincinnati, Ohio, October 5.

ORAUT (Oak Ridge Associated Universities Team), 2011, *Guidance on Assigning Occupational X-ray Dose Under EEOICPA for X-rays Administered Off-Site*, ORAUT-OTIB-0079, Rev. 00, Oak Ridge, Tennessee, January 3.

ORAUT (Oak Ridge Associated Universities Team), 2012a, *Paducah Gaseous Diffusion Plant – Site Description*, ORAUT-TKBS-0019-2, Rev. 03, Oak Ridge, Tennessee, August 22.

ORAUT (Oak Ridge Associated Universities Team), 2012b, *Paducah Gaseous Diffusion Plant – Occupational Medical Dose*, ORAUT-TKBS-0019-3, Rev. 03, Oak Ridge, Tennessee, August 23.

ORAUT (Oak Ridge Associated Universities Team), 2012c, *Paducah Gaseous Diffusion Plant – Occupational Environmental Dose*, ORAUT-TKBS-0019-4, Rev. 03, Oak Ridge, August 24.

ORAUT (Oak Ridge Associated Universities Team), 2012d, *Paducah Gaseous Diffusion Plant – Occupational Internal Dose*, ORAUT-TKBS-0019-5, Rev. 03, August 24.

ORAUT (Oak Ridge Associated Universities Team), 2012e, *Paducah Gaseous Diffusion Plant – Occupational External Dose*, ORAUT-TKBS-0019-6, Rev. 04, Oak Ridge, August 24.