ORAU Team **Dose Reconstruction Project for NIOSH** Technical Basis Document for Paducah Gaseous Diffusion Plant - Introduction	Document Number: ORAUT-TKBS-0019-1 Effective Date: 08/30/2006 Revision No.: 00 PC-1 Controlled Copy No.: _____ Page 1 of 6
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RECORD OF ISSUE/REVISIONS

ISSUE AUTHORIZATION DATE	EFFECTIVE DATE	REV. NO.	DESCRIPTION
Draft	05/17/2004	00-A	New technical basis document for the Paducah Gaseous Diffusion Plant – Site Profile. Initiated by Jay J. Maisler.
Draft	06/08/2004	00-B	Addressed OCAS comments. Initiated by Jay J. Maisler.
Draft	07/07/2004	00-C	Addressed additional OCAS comments. Initiated by Jay J. Maisler.
09/09/2004	09/09/2004	00	First approved issue. Initiated by Jay J. Maisler.
09/09/2004	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

ACRONYMS AND ABBREVIATIONS

EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
DOE	Department of Energy
DOL	Department of Labor
GM	Geiger-Muller
HHS	Department of Health and Human Services
ICPMS	Inductively Coupled Plasma Mass Spectrometry
kerma	kinetic energy released per unit mass
NIOSH	National Institute for Occupational Safety and Health
ORAU	Oak Ridge Associated Universities
OWCP	Office of Worker Compensation
PGDP	Paducah Gaseous Diffusion Plant
TBD	technical basis document
TLD	thermoluminescent dosimeter
TRU	transuranic

1.1 PURPOSE

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 historical background information and guidance to assist in the preparation of dose reconstructions for particular sites or categories of sites. The documents 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 POC guidelines (nor the dose reconstruction regulation) define "performance of duty" for DOE employees with a covered cancer or restrict the "duty" to nuclear weapons work.

As noted above, the statute 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 contains an exclusion with respect to the Naval Nuclear Propulsion Program, 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 dosimetry monitoring results are considered valid for use in 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:

- Radiation from naturally occurring radon present in conventional structures
- Radiation from diagnostic X-rays received in the treatment of work-related injuries

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

1.2 SCOPE

The Paducah Site Profile is divided into six major sections: this Introduction, Site Description, Occupational Medical Dose, Occupational Environmental Dose, Occupational Internal Dose, and Occupational External Dose. Some sections are accompanied by an attachment that provides the critical data for the specialists reconstructing the doses.

The Site Description TBD (ORAUT-TKBS-0019-2) is a brief description of the facilities and processes used in processing and enriching 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 (UF_6) gas from approximately 0.711% ^{235}U up to about 2.5% ^{235}U. The enriched product from PGDP was sent to other U. S. Department of Energy (DOE) gaseous diffusion plants at Portsmouth, Ohio, and Oak Ridge, Tennessee, for further enrichment. Some feed material was recycled uranium obtained from spent reactor fuel.

The Occupational Medical Dose TBD (ORAUT-TKBS-0019-3) provides information about the dose individual workers received from X-rays required as a condition of employment. The PGDP occupational medicine program required pre-employment and regular diagnostic chest X-ray examinations. The examinations consisted of one posterior-anterior and one lateral chest projection. In addition to parts of the body exposed in the primary beam of an X-ray machine, other tissues receive some dose from secondary radiation. Secondary radiation consists of X-rays that are scattered from surrounding materials or that escape from the source assembly. In this TBD, tables are provided that list favorable to claimant estimated dose equivalents to organs of the body that result from single and combined posterior-anterior and lateral chest X-rays for male and female PGDP employees. 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-TKBS-0019-4) applies to workers who were not monitored for external or internal radiation exposure. The environmental dose is the dose workers received when working outside the buildings on the site 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 of the facilities was determined from the air concentrations resulting from the releases from stacks, individual building releases, and from the purge cascade and other operations at PGDP. Unmonitored workers may have been exposed to occupational doses internally from on-site releases into the air. Air concentrations of radionuclides were determined using annual environmental reports and are provided from 1952 through 1996. 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 includes natural background radiation and from sources within the facility.

PGDP personnel have annually compared these data with thermoluminescent dosimeter (TLD) data from offsite locations and literature values for state and regional exposure levels. The determination has always been that onsite ambient radiological conditions as 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 show an increase in external exposure as the inventory of depleted uranium increased. The approach for estimating external dose using this information is provided in the TBD.

The Occupational Internal Dosimetry TBD (ORAUT-TKBS-0019-5) 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 (TRU) 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 upon both *in vivo* and *in vitro* monitoring results. Data are available from 1952 to the present for both *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 uncertainty regarding enrichment and solubility, the contribution of environmental uranium, and because samples were collected at work and during the middle of the work week, meaning that cross-contamination and the inability to unfold soluble from insoluble intake fractions contribute to the uncertainty.

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, including instructions for assessing dose for both monitored and unmonitored employees. The detection limits of the various *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.

The Occupational External Dosimetry Program TBD (ORAUT-TKBS-0019-6) 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 the PGDP have also evolved over the years as new techniques and equipment have been developed. In addition, concepts in radiation protection have changed. The 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.