ORAU Team **NIOSH Dose Reconstruction Project** Technical Basis Document for the Pantex Plant – Introduction	Document Number: ORAUT-TKBS-0013-1 Effective Date: 02/18/2004 Revision No.: 00 Controlled Copy No.: ______ Page 1 of 7
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RECORD OF ISSUE/REVISIONS

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Draft	11/26/2003	00-A	New technical basis document for the Pantex Plant – Site Profile. Initiated by Jerome B. Martin
Draft	01/12/2004	00-B	Incorporates NIOSH comments. Initiated by Jerome B. Martin.
02/18/2004	02/18/2004	00	First approved issue. Initiated by Jerome B. Martin.

ACRONYMS AND ABBREVIATIONS

EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
DoD	Department of Defense
DOE	Department of Energy
DU	depleted uranium
IFI	in-flight insertable
IMBA	Integrated Modules for Bioassay Analysis
IREP	Interactive RadioEpidemiological Program
NIOSH	National Institute for Occupational Safety and Health
ORAU	Oak Ridge Associated Universities
TBD	technical basis document

1.0 EXECUTIVE SUMMARY

In enacting the Energy Employees Occupational Illness Compensation Program Act of 2000 (EEOICPA), the U.S. Congress officially recognized the hazardous nature of producing and testing nuclear weapons. Under the Act, workers who have developed selected types of cancer (or their survivors) may be entitled to compensation and medical benefits. This program is administered by the U.S. Department of Labor, Office of Worker Compensation. The National Institute for Occupational Safety and Health (NIOSH), a part of the U.S. Department of Health and Human Services, is responsible for determining the individual worker's dose. Oak Ridge Associated Universities (ORAU) leads a team to support NIOSH in conducting this major program.

The Act requires the estimation of radiological doses from ionizing radiation received by workers in the nuclear weapons production programs of the U.S. Department of Energy (DOE) and its predecessor agencies. Methods for implementing provisions of the Act have been promulgated in Title 42 of the Code of Federal Regulations, Part 82, "Methods for Radiation Dose Reconstruction Under the Energy Employees Occupational Illness Compensation Program Act of 2000."

This technical basis document (TBD) is a specific support mechanism to the ORAU Team concerning documentation of historical practices at the Pantex Plant. Dose reconstructors should use the information in this TBD to evaluate both internal and external dosimetry data for unmonitored and monitored workers. In addition, the document serves as a supplement to, or a substitute for, individual monitoring data. This document provides a site profile of the Pantex Plant that contains technical basis information for the ORAU Team to use to evaluate the total occupational radiation dose for EEOICPA claimants.

In addition, this document provides supporting technical data to evaluate, with claimant-favorable assumptions, the total Pantex Plant occupational radiation dose that can reasonably be associated with worker exposures. This dose results from exposure to external and internal radiation sources in Pantex facilities; to Pantex occupationally-required diagnostic x-ray examinations, and to on-site environmental releases. The discussion includes the doses that workers could have incurred while not monitored or that could have been missed.

Over the years new and more reliable radiation protection measures, as well as improved techniques and equipment for radiation detection and measurement, have been developed. The methods needed to account for these changes are also identified in this document.

The doses are to be evaluated using the NIOSH Interactive RadioEpidemiological Program (IREP) and the Integrated Modules for Bioassay Analysis (IMBA) computer programs. Information on measurement uncertainties is an integral component of the NIOSH approach. This document describes how the uncertainty for Pantex exposures and dose records is to be evaluated.

The document comprises six sections: this introduction, Site Description, Occupational Medical Dose, Occupational Environmental Dose, Occupational Internal Dose, and Occupational External Dosimetry. Some sections are accompanied by an attachment that provides the critical data for the specialists reconstructing the doses.

Section 2, Site Description, briefly describes the facilities and processes that have been used in the assembly and disassembly of nuclear weapons since operations began at Pantex in December 1951. Between 1952 and 1954, the primary mission at Pantex was to precision-machine high explosive castings and send them to Sandia National Laboratory in Albuquerque, New Mexico for assembly. Between 1954 and 1958 with the in-flight insertable (IFI) design, the only nuclear components handled at Pantex were depleted uranium (DU) cases and tritium reservoirs; during this time there was no processing of nuclear material. In 1958, the sealed-pit design replaced the IFI design and sealed plutonium pits were delivered to Pantex for assembly.

The nuclear weapon assembly process was highly standardized and consistent. Rigorous procedures were followed to ensure product quality and uniformity. Most of the parts for nuclear weapons were manufactured with the nuclear weapons complex of government-owned or contracted vendors. Pantex received those parts as completed major components. These components supported one of three major processes: high explosives assembly, physics package assembly, or mechanical assembly. The physics package operation involved the mating of the high explosives with the nuclear components. Completed and packaged weapons were staged for shipment to the U.S. Department of Defense (DoD).

From 1951 through 1987, weapons were shipped between Pantex and the DoD sites primarily by rail in specially designed and built railcars, escorted by DOE couriers. From 1977 to the present, weapons have moved between Pantex and DoD sites in specially designed and built tractor trailers, also escorted by DOE couriers.

The facilities at Pantex are primarily those for assembly and disassembly of weapons and the special purpose and nuclear staging facilities that have handled complete nuclear weapons and components. Bays and “Gravel Gertie” cells are the facilities used for assembly and disassembly. The principal function of the bays is the assembly and disassembly of nuclear explosives, particularly the mechanical portion, which includes the electrical components and tritium reservoirs.

Physics package assembly and disassembly, where bare pit and high explosive operations occur, take place in the cells. During the process of assembly of a nuclear explosive, operations begin in an assembly cell then move to an assembly bay for completion. The reverse is true for disassembly. Disassembly of weapons with insensitive high explosives occurs only in bays.

“Gravel Gertie” cells are round structures with a gravel and earth cover supported by a cable system. The design is based on experiments that showed that the mounded gravel roof over the round room would lift and vent the gas pressures produced in an accidental explosion. Plutonium would be filtered from the vented gases by the gravel and releases to the environment would be minimized.

Special purpose facilities at Pantex include the Paint Facility, the Separation Testing Facility, the Mass Properties Facility, the Weapons Aging Facility, and the Weapons Transfer Station. Nuclear staging facilities include the Zone 4 igloos for staging or interim storage of weapons, weapon components, and other process-related materials. Zone 12 staging facilities include pit vaults, warehouses, and staging facilities for special nuclear material components.

Section 3, Occupational Medical Dose, provides information about the dose that individual workers received from x-rays that were required as a condition of employment. These x-rays included pre-employment chest and lumbar spine x-rays and annual chest x-rays during physical exams.

Pantex required pre-employment and annual physical examinations as part of its occupational health and safety program. These medical examinations typically included annual diagnostic PA (posterior-anterior) chest x-rays from the beginning of Atomic Energy Commission operations in 1952, with a change in frequency to every 5 years beginning in 1982. Additionally, Pantex required a single set of pre-employment lumbar spine radiographs, both AP (anterior-posterior) and lateral views, for men (but not for women) from 1952 through 1982. Using documented Pantex x-ray techniques (machine settings), entrance skin exposures could have been as high as 14 R (about 14 rems) for the lumbar spine x-rays.

Both the x-ray equipment and the techniques used for taking x-rays have changed over the years covered by this TBD. These factors have been taken into account in determining the dose that a worker would have received from an x-ray. When there was a doubt about the technique used, the most claimant-favorable assumptions have been made to ensure that the dose is not underestimated. The investigated parameters include the tube current and voltage, exposure time, filtration, source to skin distance, the view (posterior-anterior or lateral), and any other factor that could affect the dose received by the worker.

The organ doses resulting from the x-rays have been calculated. The calculated dose takes into account the uncertainty associated with each of the parameters mentioned above. Tables present the doses received by the various organs for convenient reference by the dose reconstructors.

Section 4, Occupational Environmental Dose, applies to workers who were not routinely monitored for external or internal radiation exposure. The environmental dose is the dose unmonitored workers could receive when working outside the buildings on the site from inhalation of radioactive materials in the air, direct radiation from plumes, contact with particles on the skin, and from direct exposure to radionuclides in the soil.

Exposure to these sources can result in an internal dose to the whole body or body organs from inhaling the radioactive materials and in a whole- or partial-body external dose from deposited radionuclides or submersion in a cloud of radioactive material.

Radionuclides present at the Pantex Plant include tritium, uranium (primarily ^{238}U), plutonium, and thorium. There were no noble gases released at the Pantex site. The primary radionuclides of concern are tritium and DU. There have been no environmental releases of plutonium or thorium. A significant release of tritium occurred in May 1989, but environmental doses were minimal. Chronic low-level releases of DU have been monitored and are characterized in this section.

Section 5, Occupational Internal Dose, describes the internal dosimetry program at Pantex Plant. Internal dose at Pantex occurs primarily from intakes of radioactive material that may have occurred during assembly and disassembly of nuclear weapons and potentially during radioactive waste management activities. Since 1990, measures to contain materials that may become airborne have been fairly successful. Between 1980 and 1990 when there was a large, ongoing disassembly effort, but controls to limit airborne contamination were not fully implemented, there was a higher likelihood of radionuclide intakes. Prior to 1980, most work was assembly of new, clean components so the potential for intakes was lower. In addition to the radionuclides used at Pantex that may result in worker intakes, this section addresses occupational internal dose from radon in the workplace. This section also addresses potential missed internal dose.

There was no routine bioassay program at Pantex prior to 1972; bioassay was performed for specific events. There are only four radionuclides handled at Pantex that are of concern for occupational intakes – tritium, uranium, thorium, and plutonium.

There is no specific data to substantiate any specific releases of tritium or uptakes of tritium prior to 1972. It is reasonable to assume that there were no significant intakes of tritium before 1980. Around 1980, disassembly of nuclear weapons was performed more often than assembly and releases of tritium were more likely to occur. A method is described for assigning a small chronic intake of tritium to workers who handled tritium reservoirs from 1980 on. The only exception is for 1989, when a significant release of tritium occurred in one event. Only one individual received a significant dose during that event.

Uranium contamination at Pantex is either uranium metal or air oxidized uranium. During disassembly, aged components may have uranium oxide and uranium metal in the form of “black dust” that is potentially present as airborne contamination that exhibits class S aerosol behavior. Bioassay data for a group of 305 workers collected in 1990 were analyzed to determine the potential magnitude of doses from occupational intakes of uranium, the probabilistic corrections for non-occupational intakes of uranium, and use of isotope ratios to distinguish occupational intakes from environmental intakes. A method is presented to determine default intake values for workers who were exposed to uranium contamination during disassembly of nuclear weapons.

Thorium and plutonium are also handled at Pantex, but no machining or other processing is conducted. The potential for removable contamination and uptakes by workers is very low. A few small uptakes of thorium have been recorded since 1999. No intakes of plutonium have occurred except for claimants that may have been involved in the 1961 incident and its subsequent cleanup.

Occupational internal dose from elevated radon in the Pantex workplace was also assessed. A DOE complex-wide survey of radon levels was performed in 1990. There were 137 locations sampled at Pantex, with duplicate measurements made at 13 locations. There were eight buildings at Pantex with radon concentrations above 4 pCi/L (the Environmental Protection Agency’s reference point for considering remedial action for indoor radon). Recommendations are provided for potential radon exposures and assessment of effective dose to the lungs of claimants.

Section 6, Occupational External Dosimetry, discusses the Pantex program for measuring skin and whole-body doses to the workers. The methods for evaluating external doses to workers 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 parameters, Pantex practices and policies, and dosimeter types and technologies for measuring the dose from the different types of radiation are described. The evaluation of doses measured from exposure to beta, gamma, and neutron sources are addressed. Tables present results for various dosimeters exposed to different exposure geometries and radiation energies.

The primary sources of external radiation exposure at Pantex are plutonium pits and DU or thorium components. Plutonium pits emit x-rays, gamma rays, and neutrons that are the major source of exposure to Pantex radiation workers. Direct handling of pits can result in relatively high extremity dose rates. Workers wear lead aprons during pit-handling work, which substantially reduces the low energy photon doses to the torso. Dosimeters are usually worn under the lead apron, which captures the reduced torso dose but underestimates the dose to the head (thyroid, lens of eye). Neutron doses measured under the lead apron may also be underestimated. Beta and photon exposures occur during handling of DU or thorium components. Exposures to thorium include the penetrating 2.6-MeV photons from ^{208}Tl.

Sources of bias, workplace radiation field characteristics, responses of the 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 discussed in detail.

There are sources of potential dose that could have been missed because of the limitations of dosimetry systems and the methods of reporting low doses. This missed dose is discussed as a function of facility location, dosimeter type, year, and energy range. Attachment F describes the use of the external dosimetry technical basis parameters to facilitate the efforts of the dose reconstructors.