

Radiological Aspects of Uranium

Objectives:

- **Identify the radiological properties of uranium.**
- **Describe the toxicological properties and behavior of uranium.**
- **Identify appropriate instrumentation, measurement techniques, and special radiological survey methods for uranium.**

Radiological Aspects of Uranium (cont.)

Objectives:

- **Describe personnel protection requirements, external dose control techniques, and internal dose control techniques.**
- **Describe special controls and considerations required for uranium operations.**

Radiological Properties

Uranium can:

- **Occur naturally**
- **Be man-made**
- **Become enriched for reactor fuel or weapons**
- **Be depleted**

Radioisotopes

- **Alpha and beta emitters**
- **Emit neutrons**
- **Fissile material**

Detection and Measurement

- Health physics program ensures detection
- Exposure rate surveys using photon-sensitive instruments
- Beta detectors (decay products)
- Neutron surveys
- Continuous air monitors

Survey Techniques

- **Monitoring practices:**
 - **Contamination surveys of the workplace**
 - **Release surveys**
 - **External exposure surveys**
 - **Airborne contamination surveys**
 - **Routine surveillance by a RCT**
- **Regularly scheduled monitoring (all work areas)**

Workplace Characterization

- **Airborne contamination surveys:**
 - **Prompt detection**
 - **Personnel dose assessment**
 - **Monitoring of trends**
 - **Special studies**

Personnel Protection

- Personnel air sampling
- Protective clothing
- Respiratory protection

External Dose Control

- **Beta radiation**
- **Gamma radiation:**
 - **Time**
 - **Distance**
 - **Shielding**
- **Neutron radiation**

Internal Dose Control

Hazard must be controlled by:

- **Appropriate facility and equipment design**
- **Contamination control procedures**
- **Protective clothing**
- **Control verified by:**
 - **Bioassay program**

Special Controls

- **Criticality safety:**
 - **Alarm systems**
 - **Nuclear accident dosimetry**
 - **Fire prevention**
- **Hydrofluoric acid**
- **Separation/concentration of decay products**

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Radiological Aspects of Tritium

Objectives:

- Describe the radiological properties of tritium.
- Identify personnel protection requirements and dose control techniques.
- Identify the biological effects of internally deposited tritium.

Radiological Aspects of Tritium (cont.)

Objectives:

- **Describe appropriate instrumentation, measurement techniques, and special radiological survey methods for tritium.**
- **Identify special controls and considerations required for the use of tritium.**

Radiological Aspects of Tritium

- **Primary sources:**
 - **Environmental**
 - **By-product of power reactors**
 - **DOE production**

Overhead 7.3

Chemical Forms

- **Elemental tritium**
- **Tritiated water**
- **Organically bound tritium (OBT)**
- **Stable metal tritides (SMT)**

Radiological Properties of Tritium

- Radiological properties:
 - Beta particle emitter
 - Weak beta particle energy (18 keV max)
 - 12.3 yr half-life
 - High specific activity (9619 Ci/g)

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Dose Pathways

- Inhalation
- Ingestion
- Skin absorption

General Sources of Release

- **Gaseous releases (ventilation exhaust systems)**
- **Liquid wastes**
- **Solid wastes**

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Dose Controls

- Airborne controls
- Contamination controls
- Personnel protection equipment

Modes of Entry

- **Inhalation**
- **Ingestion**
- **Absorption**

Containment

- **Primary**
- **Secondary**
- **Tertiary**

Airborne Controls

- **Differential room pressure zones**
- **Dilution ventilation**
- **Room-air detritiation systems**
- **Local exhaust ventilation**

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Measurement Techniques

- **Air monitoring**
- **Differential monitoring**
- **Discrete sampling**
- **Process monitoring**
- **Surface monitoring**
- **Liquid monitoring**

Special Controls (Bioassay)

- **Chronic exposure:**
 - **Periodic urinalysis**
- **Acute exposure:**
 - **Wait one to two hours.**
 - **Void bladder.**
 - **Collect sample as soon as possible.**
 - **Collect daily.**

Special Controls (cont.)

- **Dose assessment for SMTs and OBT may need to be based on air monitoring**
- **Tritium effluent recovery system:**
 - **Reduces tritium available for release**
 - **Tritium gas converted to tritiated water**
 - **Inventory control and accountability:**
 - **Tritium = nuclear material**

Radiological Aspects of Plutonium

Objectives:

- **Identify the radiological properties of plutonium.**
- **Identify the biological effects of plutonium.**
- **Identify special controls and considerations required for plutonium operations.**

Radiological Aspects of Plutonium (cont.)

Objectives:

- **Describe appropriate instruments, measurement techniques, and special radiological survey methods for plutonium.**
- **Describe personnel protection requirements and dose control techniques for plutonium.**

Radiological Properties of Plutonium

- **15 isotopes, all radioactive**
- **Pu-238 (heat source)**
- **Pu-239 (reactor fuel, weapons)**
- **Pu-240 (reactor fuel, weapons)**
- **Alpha-emitters:**
 - **Some associated gamma radiation**

Biological Effects of Plutonium

- **Exposure pathways:**
 - **Inhalation**
 - **Ingestion**
- **Retention in body**
- **Removal (chelating agents)**
- **Long-term concerns:**
 - **Lung cancer**
 - **Leukemia**

Survey Techniques

- **Health physics program for detection of all types of radiation**
- **Alpha-sensitive instruments**
- **Continuous air monitors**
- **Neutron surveys**
- **Exposure rate surveys**

Survey Techniques (cont.)

Monitoring practices:

- **Regularly scheduled contamination surveys**
- **Release surveys**
- **External exposure rate surveys**
- **Airborne radioactivity surveys**
- **Routine surveillance by Radiological Control Technician**

Monitoring Instruments

- **Meet site specific requirements**
- **Effluent monitors**
- **Criticality alarms**

Sources of External Dose

- High-energy gamma photons
- Low-energy photons:
 - Extremity dose
 - From large amounts of Pu-238, Pu-241, Am-241
- Neutrons

External Dose Control

- **Time**
- **Distance**
- **Shielding**
- **Other work practices:**
 - **Good housekeeping**
 - **Specially designed tools and equipment**

Internal Dose Control

- **Confinement systems:**
 - **Primary**
 - **Secondary**
 - **Tertiary**
- **Confinement devices:**
 - **Fume hoods**
 - **Glove boxes**
 - **Ventilation**

Personnel Protection

- **Training**
- **Air sampling**
- **Protective clothing**
- **Respiratory protection equipment**

Special Controls

- **Inventory and accountability**
- **Criticality safety:**
 - **Alarm systems**
 - **Nuclear accident dosimetry**

Radiological Work Permits

Objectives:

- Identify types of job hazards that are not addressed by Radiological Work Permits (RWPs).
- Describe the two basic types of RWPs.
- Determine the types of jobs that may and may not be worked under the controls imposed by RWPs.

Radiological Work Permits (cont.)

Objectives:

- **Identify typical time limits for the two basic types of RWPs.**
- **List essential elements of an effective RWP.**
- **List RWP program elements which may be included in a radiological assessment.**

RWP Process

- Requester submits RWP request form.
- Radiological Control Supervisor accepts form, assures completion of surveys of work area.
- Trained personnel perform surveys.
- RWP controls established.
- RWP form completed and posted.

RWP Process (cont.)

- **Radiological Control and work group review RWP:**
 - **Pre-job briefings**
 - **ALARA reviews**
- **Radiological Control terminates RWP when job is finished or RWP expires.**
- **Radiological Control maintains survey and RWP documentation.**

Types of RWPS

- **Job-specific RWP:**
 - **Potential for significant radiation dose, airborne radioactivity, or spread of contamination**
 - **“Hands on” work with potential health physics concerns**
- **General RWP:**
 - **“Hands on” and other work with less potential for health physics concerns**

RWP Time Limits

- **Job-specific RWP:**
 - **Duration of job**
 - **Usually ≤ 30 days**
- **General RWP:**
 - **Standing use (tours, rounds)**
 - **Usually ≤ 1 year**
 - **Often renewed on calendar year basis**

Elements of an RWP

- **Description of work (detailed)**
- **Radiological conditions**
- **Dosimetry requirements**
- **Pre-job briefing requirements**
- **Radiological Control Technician coverage requirements**
- **Training requirements**

Elements of an RWP (cont.)

- **Protective clothing requirements**
- **Respiratory protection requirements**
- **Stay time requirements**
- **Conditions limiting work or voiding RWP**
- **ALARA measures**
- **Contamination monitoring requirements**
- **Work document number**

Elements of an RWP (cont.)

- **Unique RWP number**
- **Permit issue and expiration date**
- **Signatures:**
 - **Read and understand RWP**
 - **Agree to follow controls**

RWP Elements for Radiological Assessment

- **RWPs appropriately required for activities and areas**
- **Completeness of information on RWPs**
- **Adequacy of radiological surveys to support RWP**
- **Worker adherence to RWP requirements**

RWP Elements for Radiological Assessment (cont.)

- **RWP appropriately reviewed and approved**
- **Adequacy of worker monitoring (TLDs, bioassay, air monitoring RCT coverage) specified on RWP**
- **ALARA considerations included in RWP**
- **RWP program implemented in accordance with written procedures**

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Contamination Containment and Temporary Control Measures

Objectives:

- **Describe what temporary engineered radiological controls can be used to reduce or eliminate contamination spread.**
- **Describe why engineered and administrative controls are needed.**

Overhead 10.1

Engineered Controls

- **Glove boxes**
- **Glove bags**
- **Portable filtration units**
- **Containment tents**
- **Portable shielding**

Overhead 10.2

Administrative Controls

- Access restrictions
- Work practices

Overhead 10.3

Use of Respiratory Protection

- **Airborne Radioactivity Areas**
- **Breach of contaminated systems**
- **High removable contamination**
- **Work may generate airborne radioactivity**

Overhead 10.4

Special Conditions

- **Use of respiratory protection contraindicated:**
 - **Physical limitations**
 - **Increased dose from respirator use**
 - **Written authorization required**
 - » **Prior to incurring internal dose**
 - » **Specific justification of dose acceptance**

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Radiological Work Site Mockup Demonstration

Objectives:

- **Identify poor radiological work practices, in and around a mock radiological work site.**
- **Inspect a typical contamination containment (glove bag).**
- **Develop field assessment notes to support findings (hands-on exercise).**

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Radiation-Generating Devices

Objectives:

- Identify radiation-generating devices.
- Describe the basic components of an x-ray machine.
- Identify the most common use of x-rays.
- Identify the potential hazards associated with x-rays.

Radiation-Generating Devices (cont.)

Objectives:

- **Identify the most common use of sealed gamma ray sources and the potential hazards.**
- **Identify the most common use of beta and neutron sources and the potential hazards.**

Radiation-Generating Devices (cont.)

To meet the intent of the 10 CFR 835 use:

- **DOE G 441.1- 5**
- **ANSI N43.3**
- **ANSI N43.2**
- **10 CFR Part 34**

Radiation-Generating Devices (cont.)

Include:

- **Devices producing ionizing radiation**
- **Sealed sources emitting ionizing radiation**
- **Small particle accelerators**
- **Electron-generating devices**

X-Ray Machine Design

Basic components include:

- **A source of electrons**
- **An electrical potential difference to accelerate the electrons**
- **An anode or target to strike**
- **An evacuated tube for all the above components**

X-ray Energy Spectrum

- **Characteristic x-rays**
 - **Discrete energies**
- **Bremsstrahlung photons**
 - **Produced with range of energies**

X-ray Machines

Radiography:

- **Medical applications:**
 - **Standardized appearance and installation**
- **Industrial applications:**
 - **Fixed installation**
 - **Mobile units**
 - **Enclosed cabinet system**

Analytical X-ray Machines

- Fluorescence analysis
- X-ray diffraction

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Sealed Gamma Ray Sources

Uses:

- Radiography
- Thickness gauges
- Level gauges
- Density gauges

Other Sealed Sources

- **Beta particles (thickness gauges)**
- **Neutrons:**
 - **Moisture gauges**
 - **Radiography of dense materials**

Radiation-Generating Device Installations

ANSI Categories:

- **Exempt shielded**
- **Shielded**
- **Unattended**
- **Open**

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