The History of Radioactive Material Classifications

KRMC Training Program

Module 4: Classification, Conceptual Design and Management of Nuclear Waste Disposal Facilities

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Introduction

- **History of Radioactive Materials and Wastes**
  - **Radiation discovered in the late 1800's (electromagnetic/ionizing - X-rays, U, Ra & Po)**
  - **Prior to the early 1900's the hazards of radiation and radioactive materials were not known**

Introduction

- It was not until the 1930's that the hazards of ionizing radiation were recognized
- It was not until the 1940's that disposal of radioactive materials was recognized as a potential problem

History of Radioactive Materials and Waste

- Prior to 1946 most all nuclear materials produced by U.S. Government
  - Early Nuclear Research and Weapons Production
  - No regulations governing use and disposal of nuclear materials
  - Nuclear activities either military or institutional research
  - Nuclear wastes disposed in trenches and canyons

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History of Radioactive Materials and Waste

- **Atomic Energy Acts of 1946 and 1954**
  - **Atomic Energy Commission (AEC)**
  - **Allowed nuclear research for commercial energy, medical and other uses**
  - **Defined types of nuclear materials that were controlled by the AEC**

History of Radioactive Materials and Waste

- Early Nuclear Research and Weapons Waste
  - Early nuclear work assumed all spent fuel would be reprocessed and future use of breeder reactors
  - U production
    - Waste relating to U mining, processing, enrichment, reactor research and reactor operations
    - Commercial reactors and military reactors (e.g., Naval reactors, research, propulsion)
  - Pu production
    - Pu production generated high activity (fission products) liquid wastes and variable activity solid waste that included scrap materials, contaminated equipment and research derived materials

History of Radioactive Materials and Waste

- Atomic Energy Acts created the framework for commercial nuclear power and separated Government and Commercial programs

- Originally called for Government ownership of all fissionable materials and spent fuel
  - Defined three materials: *Source, Byproducts and Special Nuclear Materials*

Atomic Energy Acts - Definitions

- **Source material**
  - **The term "source material" means (1) uranium, thorium, or any other material which is determined by the Commission pursuant to the provisions of section 61 to be source material; or (2) ores containing one or more of the foregoing materials, in such concentration as the Commission may by regulation determine from time to time.**

Atomic Energy Acts Definitions

- **Byproduct material**
  - **The term "byproduct material" means (1) any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material, and (2) the tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content**

Atomic Energy Acts Definitions

- **Special nuclear material**
  - **The term "special nuclear material" means (1) plutonium, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Commission, pursuant to the provisions of section 51, determines to be special nuclear material, but does not include source material; or (2) any material artificially enriched by any of the foregoing, but does not include source material.**

Atomic Energy Acts Definitions

- **The term “low-enriched uranium” means uranium enriched to less than 20 percent of the uranium-235 isotope, including that which is derived from highly enriched uranium.**

Atomic Energy Acts Definitions

- **The term “highly enriched uranium” means uranium enriched to 20 percent or more in the isotope U-235**

Atomic Energy Act Amendments Definitions

- **Atomic Energy Act Amendments introduced other waste definitions**
  - **The term "transuranic waste" means material contaminated with elements that have an atomic number greater than 92, including neptunium, plutonium, americium, and curium, and that are in concentrations greater than 10 nano-curies per gram, or in such other concentrations as the Nuclear Regulatory Commission may prescribe to protect the public health and safety.**

Atomic Energy Act Amendments Definitions

- The terms “high-level radioactive waste” and “spent nuclear fuel” have the meanings given such terms in Section 2 of the Nuclear Waste Policy Act of 1982

High Level Waste

- The term “high-level radioactive waste” means
  - (A) the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and
  - (B) other highly radioactive material that the Commission, consistent with existing law, determines by rule requires permanent isolation.

Spent Nuclear Fuel

- The term “spent nuclear fuel” means fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing

Low-Level Radioactive Waste Policy Act of 1982 and 1985

- Act to facilitate the disposal of low-level waste
- Defines categories of radioactive waste

Low-Level Radioactive Waste Policy Act of 1982 and 1985

- The term “low-level radioactive waste” means radioactive waste not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or byproduct material as defined in section 11e.(2) of the Atomic Energy Act of 1954.

Low-Level Classifications

- Low-Level Waste Policy Act defined LLW
- NRC disposal regulations defined LLW classifications
  - NRC regulations 10 CFR 61 “Licensing Requirements for Land Disposal of Radioactive Waste”

Low-Level Categories

- LLW wastes that were determined acceptable for near-surface land disposal
- Wastes that degrade and decay to an acceptable condition sooner require less stringent disposal requirements
- LLW classified as either A, B, C or greater than Class C

Low-Level Categories

- **LLW waste is categorized by (1) the concentrations of long-lived radionuclides, and (2) the short-lived radionuclide concentration over which the institutional controls, waste form and disposal methods are effective A being the least hazardous and C the most.**

Low-Level Categories

- **Class A**
  - **waste that is usually segregated from other waste classes at the disposal site. The physical form and characteristics of Class A waste must meet the minimum requirements set forth in § 61.56(a). If Class A waste also meets the stability requirements set forth in § 61.56(b), it is not necessary to segregate the waste for disposal.**

Low-Level Categories

- **Class B**
  - **waste that must meet more rigorous requirements on waste form to ensure stability after disposal. The physical form and characteristics of Class B waste must meet both the minimum and stability requirements set forth in § 61.56.**

Low-Level Categories

- **Class C**
  - **waste that not only must meet more rigorous requirements on waste form to ensure stability but also requires additional measures at the disposal facility to protect against inadvertent intrusion. The physical form and characteristics of Class C waste must meet both the minimum and stability requirements set forth in § 61.56.**

Low-Level Categories

- **Greater that Class C Waste**
  - **waste that is not generally acceptable for near-surface disposal is waste for which form and disposal methods must be different, and in general more stringent, than those specified for Class C waste. In the absence of specific requirements in this part,** *such waste must be disposed of in a geologic* **repository as defined in part 60 or 63 of this chapter unless proposals for disposal of such waste in a disposal site licensed pursuant to this part are approved by the Commission.**

Classification Summary

- Early Radioactive material types – not necessarily wastes
  - Special Nuclear Material
  - Source
  - Byproduct
- LLW
  - Class A, B, C and Greater than Class C
- HLW
  - From reprocessing SNF
  - Other material NRC believe need isolation

Classification Summary

- SNF
  - Irradiated reactor fuel
- TRU
  - Elements greater than 92, greater than 10 nCi/g, half-lives greater than 20 years

Disposal Requirements for the Types of Radioactive Wastes

- Basic Disposal Options
  - National Academies of Science 1957 report
  - Near-surface
  - Deep (Geologic)
  - Salt Formations most favorable
- Other studies analyzed deep seabed, injection in formations, transmutation and injection in outer space
- Current approaches use near-surface and geologic disposal

Regulations Governs Disposal

- Each waste type has a defined disposal option identified in governing waste disposal regulations
- Degree of isolation is related to the hazards of the wastes
  - Half-lives
  - Waste degradation impacts on disposal system stability
  - Material properties (e.g., solubility, chemical compatibility, reactivity, heat, density, etc.)

SN and Source

- **Special Nuclear and Source materials are not waste and therefore so not have a disposal option**

LLW Disposal

- LLW Disposal (10 CFR 61 – NRC)
  - Class A, B and C (not Greater than Class C; GTCC)
    - Near-Surface Disposal
- Design Requirements
  - Meet Performance Objectives of 10 CFR 61 Subpart C (public dose not to exceed 25 millirem whole body, 75 max to thyroid, 25 max to any other organ)
  - No Maintenance after Closure
  - Cover – divert water and minimize infiltration
  - Minimize contact with water
  - Ensure Protection of inadvertent intruder

LLW GTCC

- **Greater than Class C (10 CFR 61 - NRC)**
  - **NRC States that GTCC waste requires greater isolation than near-surface disposal**
  - **In the absence of specific requirements in this part [NRC LLW Regulations], such waste must be disposed of in a geologic repository as defined in 10 CFR 60 or 63 of this chapter unless proposals for disposal of such waste in a disposal site licensed pursuant to this part are approved by the NRC**

HLW Disposal

- **HLW Disposal (10 CFR 61 - NRC & 40 CFR 197 - EPA)**
  - **For HLW, the NWPA state; the term "repository" means any system licensed by the Commission [NRC] that is intended to be used for, or may be used for, the permanent *deep geologic disposal* of high-level radioactive waste and spent nuclear fuel**

TRU Disposal

- TRU Waste Disposal (NWPA – DOE National Security and Military Applications of Nuclear Energy Authorization Act of 1980 – 40 CFR 191/194 - EPA)
  - NWPA – Disposal of TRU in geologic repository
  - NSWA authorized DOE to construct research facility for defense TRU waste in geologic repository