Radioactive Waste Characterization and Management

Student/Instructor Guide

March 4, 2017

Table of Contents

Items contained in blue text are instructor notes and can be "hidden" for a cleaner look for the students.

Recommended – Instructor should coordinate a tour at a local facility that handles radioactive waste. A copy of the policies and procedures that support the facility can be very useful.

Presentation Methods

Classroom

Evaluation Methods

Pre-Course Assessment

Post-Course Assessment

Research project – Students should be required to look up and present the waste types and activities of a radioactive waste site.

Training Aids

Associated Training Materials

Whiteboard

Notes to Instructor

Make copies of references and student handouts prior to class. Make them available to students to use as additional materials for study.

References

Disposal of Commercial Low-Level Radioactive Waste. Nuclear Energy Institute, Apr. 2014. Web. 20 Feb. 2017. <https://www.nei.org/Master-Document-Folder/Backgrounders/Fact-Sheets/Disposal-Of-Commercial-Low-Level-Radioactive-Waste>.

Packaging and Transportation. Department of Energy, n.d. Web. 20 Feb. 2017. <https://energy.gov/em/services/waste-management/packaging-and-transportation>.

Radioactive Waste Management | Nuclear Waste Disposal. World Nuclear Association, Oct. 2016. Web. 20 Feb. 2017. <http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-wastes/radioactive-waste-management.aspx>.

Strategy and Methodology for Radioactive Waste Characterization. Vienna: International Atomic Energy Agency, 2007. Mar. 2007. Web. 20 Feb. 2017. <http://www-pub.iaea.org/MTCD/publications/PDF/te_1537_web.pdf>.

US. Department of Energy. Environmental Management. Radioactive Material Shipping Packages. N.p., Mar. 2005. Web. 20 Feb. 2017. <https://training.fema.gov/emiweb/is/is302/ss_mod05_sg.pdf>.

US. Department of Energy. Environmental Management. Integrated Safety Management System Description. N.p.: n.p., May 2008. Print.

US. Department of Energy. Environmental Management. Radioactive Waste Management Manual - DOE M 435.1-1. N.p.: n.p., 2007. Print.

US. Department of Energy. Health, Safety, and Security. Personnel Selection, Training, Qualification, and Certification Requirements for DOE Nuclear Facilities - DOE O 426.2. N.p.: n.p., 2010. Print.

What Are Nuclear Wastes and How Are They Managed? World Nuclear Association, 2016. Web. 20 Feb. 2017. <http://www.world-nuclear.org/nuclear-basics/what-are-nuclear-wastes.aspx>.

Title - Slide 1

Introduction

1. **Introduce Self**
   Introduce self and break ice

2. **Learning Objectives**
   Hand out and review Learning Objectives

3. **Overview**
   Describe to the students how the course is to be taught and evaluated.

4. **Motivator** – What's In It for Me? Proper identification and handling of radioactive packages and a complete understanding of the radioactive waste management program are important to the safe operations of nuclear facilities.

5. **Questions**
   Student Background
   Inquire to find out what kind of background the students may have to help tailor the discussions.
   Student Questions
   Convey to the students the ability to feel free to ask questions at any time.

Course Objectives

Objective Review – Slides 2 through 4
Discuss the course objectives

Knowledge Objectives

EO 1 - For the following radioactive waste types, state their most common source:

- Uranium tailings
- Low-level waste
- Intermediate-level waste
- High-level waste
- Transuranic waste

EO 2 - For the following radioactive waste types, determine what items typically make up the waste and the hazards associated with them:

- Uranium tailings
- Low-level waste
- Intermediate-level waste
- High-level waste
- Transuranic waste

EO 3 - Regarding low-level radioactive waste, state the classifications including the defining characteristics of each one.

EO 4 – State the two common types of high-level radioactive waste.

EO 5 – Discuss the generation, processing, and storage of the two types of high-level radioactive waste.

EO 6 – For the following areas of Radioactive Waste Management, describe their importance to the operator and the information is involved in each area:

- Conduct of Operations
- Criticality Safety
- Emergency Management
- Environmental Monitoring
- Packaging and Transportation
- Radiation Protection
- Safety Management System

EO 7 – Discuss the guiding principles and core functions of Integrated Safety Management.

EO 8 – Discuss radioactive material shipping package types, including integrity, typical contents, and testing.

EO 9 – State the responsibilities and duties of an operator at a nuclear facility.

EO 10 – Describe the certification process for a fissionable materials handler.

Radioactive Waste Characterization and Disposal

Waste Characterization – Slide 5

There are many industries like mining, defense, medicine, scientific research, nuclear power generation which produce by-products that include radioactive waste. The radioactive waste can remain radioactive for few months, years or even hundreds of years and the level of radioactivity can vary.

Radioactive wastes are usually by-products of nuclear power generation and other applications of nuclear fission or nuclear technology, such as research and medicine.

As the waste types increase in hazards, the regulations in shipping, packaging, handling, and storage also increase.

Radioactive Waste Types

Radioactive Waste Types – Slide 6

There several different waste types defined by the various government and industrial agencies. Each has its own history and concerns regarding characterization, management, and control.

Waste by Volume – Slide 7

Volumes listed on slide differ slightly from student guide, the student guide is the testable information. The difference is from year of information and source (from the UK). But as you can see, they are very close and not likely to change significantly.

Waste by Activity – Slide 8

Slide also represents UK data.

Uranium Tailings

Uranium Tailings – Slide 9

The image on the slide is a new disposal cell, on the north side of Interstate 70 in eastern Utah and is for uranium mill tailings and debris from a mill site in Moab, Utah.

Uranium tailings are the radioactive materials that remain after uranium is extracted by milling ore mined from the earth. The uranium is extracted by leaching using acids and the remaining material is left to dry. The most important radioactive component of uranium mill tailings is radium, which decays to produce radon. Other potentially hazardous substances in the tailings are selenium, molybdenum, uranium, and thorium. Uranium mill tailings are primarily the sandy process waste material from a conventional uranium mill. This ore residue contains the radioactive decay products from the uranium chains (mainly the U-238 chain) and the heavy metals previously mentioned. The tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content is byproduct material.

This includes discrete surface waste resulting from uranium solution extraction processes, such as in situ recovery, heap leach, and ion-exchange. Byproduct material does not include underground ore bodies depleted by solution extraction. The wastes from these solution extraction facilities are transported to a mill tailings impoundment for disposal. To keep them isolated, tailings are placed in piles for long-term storage or disposal. A tailings pile may be a large trench or a former mine pit and must meet Nuclear Regulatory Commission (NRC) criteria. They are usually lined, covered, and monitored for leaks. The NRC also requires adequate funds to be available to decommission the site, properly close the tailings pile, and maintain and monitor the site over the long term.

Low-Level Radioactive Waste

LLW – Slide 10

Low-level waste (LLW) is general term for a wide range of items that have become contaminated with radioactive material or have become radioactive through exposure to neutron radiation. A variety of industries, hospitals and medical institutions, educational and research institutions, private or government laboratories, and nuclear fuel cycle facilities generate LLW as part of their day-to-day use of radioactive materials. Some examples include radioactively contaminated protective shoe covers and clothing; cleaning rags, mops, filters, and reactor water treatment residues; equipment and tools; medical tubes, swabs, and hypodermic syringes; and carcasses and tissues from laboratory animals. The radioactivity in these wastes can range from just above natural background levels to much higher levels, such as seen in parts from inside the reactor vessel in a nuclear power plant. Low-level waste is typically stored onsite by licensees, either until it has decayed away and can be disposed of as ordinary trash, or until the accumulated amount becomes large enough to warrant shipment to a low-level waste disposal site. Worldwide it comprises 90% of the volume but only 1% of the radioactivity of all radioactive wastes.

LLW Classification – Slide 11

Note the data is 20 years old, but still very accurate.

LLW is separated into three classes based on the concentration, half-life, and types of radionuclides it contains. The requirements for packaging and disposal of each class of waste is defined by the Nuclear Regulatory Commission (NRC).

Class A low-level waste contains radionuclides with the lowest concentrations and the shortest half-lives. About 95 percent of all low-level waste is categorized as Class A. The radioactivity in this class of LLW fades to background levels within 100 years and has half-lives less than 30 years. Class A waste is generally from medical, research, and laboratory facilities.

Classes B and C contain greater concentrations of radionuclides with longer half-lives, fading to background levels in less than 500 years. They must meet stricter disposal requirements than Class A waste. Class B waste is typically from reactor sites.

Under federal law, low-level waste that exceeds the requirements for Class C waste is the responsibility of the U.S. Department of Energy (DOE). This material accounts for less than 1 percent of all low-level waste.

The NRC establishes technical requirements for low-level waste disposal sites that include provisions on avoiding natural resources in the area, such as wildlife preserves. The site also must be sufficiently isolated from groundwater and surface water and must not be in an area affected by geological activity like volcanoes or earthquakes. All low-level waste disposal sites use a series of natural and engineered barriers to contain radiation.

LLW Disposal Sites – Slide 12

Four disposal facilities accept low-level radioactive waste:

- Barnwell, S.C. Barnwell is licensed by South Carolina to receive wastes in Classes A, B and C. The facility accepts waste from Connecticut, New Jersey and South Carolina.
- Richland, Wash. The facility is licensed by the state of Washington to receive wastes in Classes A, B and C. It accepts waste from states that belong to the Northwest Compact (Washington, Alaska, Hawaii, Idaho, Montana, Oregon and Wyoming) and the Rocky Mountain Compact (Colorado, Nevada and New Mexico).
- Clive, Utah. Clive is licensed by the state of Utah to accept Class A waste only. The facility accepts waste from all regions of the United States.
- Andrews County, Texas. Licensed by the Texas Commission on Environmental Quality, the facility opened in 2012. It accepts Classes A, B and C low-level radioactive waste from Texas, 34 states that do not have operating compact facilities, and the federal government.

Intermediate-Level Radioactive Waste

ILW – Slide 13

Intermediate-level waste (ILW) contains higher amounts of radioactivity than low-level waste and requires special shielding. It comprises of chemical sludges, nuclear reactor parts and contaminated materials from reactor and weapons decommissioning. It makes up 7% of the volume and only 4% of the radioactivity of all radioactive waste. Like low-level nuclear waste, it is not considered a big issue. Typically, because of the low volume of ILW, it is handled and disposed of with HLW from the same location.

High-Level Radioactive Waste

HLW – Slide 14

Issues regarding safe storage of HLW are in congresses hands. Yucca Mountain in Nevada was considered the best place, but recent administration changes and political wrangling has halted efforts to finish building and commissioning this location. The discussions continue today.

High-level radioactive wastes are the highly radioactive materials produced as a byproduct of the reactions that occur inside nuclear reactors. High-level wastes take one of two forms:

- Spent (used) reactor fuel when it is accepted for disposal
- Waste materials remaining after spent fuel is reprocessed

Because of their highly radioactive fission products, high-level waste and spent fuel must be handled and stored with care. Since the only way radioactive waste finally becomes harmless is through decay, which for high-level wastes can take hundreds of thousands of years, the wastes must be stored and finally disposed of in a way that provides adequate protection of the public for a very long time.

High-level waste (HLW) is, according to most sources, the biggest problem with nuclear waste. The waste products come from nuclear fission via the nuclear reactor fuel or processed fuel. Comprising only 3% of the volume of radioactive waste, it has 95% of the radioactivity. It contains the highly-radioactive fission products and some heavy elements with long-lived radioactivity. In the case of spent reactor fuel, it generates a considerable amount of heat and requires cooling, as well as special shielding during handling and transport.

Spent Fuel Rods

Spent Fuel Rods – Slide 15

Spent nuclear fuel is used fuel from a reactor that is no longer efficient in creating electricity, because its fission process has slowed. Spent fuel rods, the fuel for most nuclear reactors, consists of pellets of ceramic uranium dioxide that are sealed in hundreds of metal rods. These rods are bundled together to form what is known as a "fuel assembly." Depending upon the type and size of the reactor, a fuel assembly can weigh up to 1,500 pounds. As the nuclear reactor operates, uranium atoms fission (split apart) and release energy. When most of the usable uranium has fissioned, the "spent" fuel assembly is removed from the reactor. Until a disposal or long-term storage facility is operational, most spent fuel is stored in fuel pools for up to ten years at the reactor site where it was produced because it is still thermally hot, highly radioactive, and potentially harmful. The water removes left-over heat generated by the spent fuel and serves as a radiation shield to protect workers at the site.

Spent Fuel Disposal – Slide 16

There are two acceptable storage methods for spent fuel after it is removed from the reactor core that include:

- spent fuel pools
- dry cask storage

Spent Fuel Pools are the most common. Spent nuclear fuel is safely stored in specially designed pools at individual reactor sites around the country. Facilities may also store spent nuclear fuel in dry cask storage systems at independent spent fuel storage facilities (ISFSIs) at the following sites:

- At Reactor – Facilities may use dry storage systems when approaching their pool capacity limit.
- Away-From-Reactor – Facilities may use dry storage systems of one of these types:
    - Decommissioned Reactor Sites - After terminating reactor operations and removing structures used in reactor operations, the licensee stores spent fuel on-site pending off-site transport to either a site-specific ISFSI that is authorized to receive the spent fuel, or a permanent geologic repository licensed for disposal.
    - Consolidated Interim Storage Facility (CISF) – Dry cask storage at an away-from-reactor site pending disposal at a permanent disposal facility.

Reprocessed Reactor Fuel

Fuel Reprocessing – Slide 17

Reactor fuel reprocessing extracts isotopes from spent fuel that can be used again as reactor fuel. Commercial reprocessing is currently not practiced in the United States, although it has been allowed in the past.

Fuel reprocessing Sites – Slide 18

However, significant quantities of high-level radioactive waste were produced by the defense reprocessing programs at Department of Energy (DOE) facilities, such as Hanford, Washington, and Savannah River, South Carolina, and by commercial reprocessing operations at West Valley, New York. These wastes are generally managed by the DOE.

The attempts to re-use reactor fuel or to process fuel to extract the plutonium and uranium to produce nuclear weapons has left a large volume of highly radioactive sludge and liquid in the mentioned locations. In these locations, the fuel assemblies were dissolved in acid and then chemical processes were used to remove the plutonium and uranium. The remaining dissolved assembles and all other fission products were placed in underground storage tanks to be “disposed of” later.

Vitrification Process – Slide 19

At the Hanford and Savannah River sites, LLW is also processed through a vitrification process. At West Valley, the LLW was processed into concrete and stored in drums.

The disposition of this waste is typically handled through a process called vitrification. The liquid waste is processed to remove the high-level radioactive constituents, such as Cesium-137 and Co-60 and then combined with sand and other elements to make a stable glass form that is considered LLW. The remaining high-level waste (including the Cs-137 and Co-60) and sludge is also vitrified, but as HLW. Separating the waste into these two types minimizes the amount of high-level waste requiring long-term storage and monitoring.

HLW Vitrification On-Site Storage – Slide 20

Long-term storage and monitoring are required for the disposal of HLW. All HLW produced so far is currently being stored; no permanent disposal has yet occurred. Among the options discussed for disposing of HLW, an international consensus has emerged that deep geological disposal on land is the most appropriate means for isolating such wastes permanently from man's environment. However, the full range of options also includes disposal in geological formations under the deep ocean floor, disposal on the ocean floor, disposal in glaciated areas, extraterrestrial disposal, and destruction by nuclear transmutation. In addition, extended storage, whether at production sites or in a centralized store, may, in principle, be considered an acceptable waste management strategy, provided it is not supposed to be perpetuated for longer than feasible and safe and is to be replaced by a more permanent solution later. The Yucca Mountain side in Nevada is considered the leading location in the United States.

Transuranic Waste

TRU Waste – Slide 21

Transuranic (TRU) Waste originates mostly from nuclear weapons production facilities, as mentioned above. Transuranic refers to atoms of man-made elements that are heavier than uranium. The most prominent element in most TRU waste is plutonium. Most TRU waste does not emit high levels of penetrating radiation but, poses a danger when small particles of it are inhaled. The major contributor from this is alpha radiation. The radiation from the alpha particles is damaging to lung tissue and internal organs. Another problem with TRU waste is that most of its radioactive elements are long-lived. For example, half of the original amount of plutonium-239 in the waste will remain harmful after 24,000 years. Because of the dangers and long half-lives associated with TRU waste, it is typically handed and disposed of in the same manner as HLW.

Radioactive Waste Management

Radioactive Waste Management – Slide 22

The management of radioactive waste involves several aspects to ensure the safety of the worker, the public, and the environment. Strict guidelines are established by the governing organizations. This course will focus on the requirements established by the U.S. Department of Energy in DOE M 435.1-1, *Radioactive Waste Management Manual*. This manual prescribes the requirements under DOE order 435.1. The manual is broken down in to general requirements and further broken down to requirements of the individual waste types: high-level waste, transuranic waste, and low-level waste. The manual points to several other federal agencies and DOE orders and directives to ensure the program is sound. In general, waste handlers and field personnel are not required to understand the over-arching requirements but are responsible for compiling with the individual orders and directives in several key areas.

Waste Management Program Field Elements

Waste Management Program Elements – Slide 23

The areas in which field personnel are required to be most knowledgeable are:

- Conduct of Operations
- Criticality Safety
- Emergency Management
- Environmental Monitoring
- Packaging and Transportation (discussed later)
- Radiation Protection
- Safety Management System

Each of these important areas are discussed in more detail below.

Conduct of Operations

Conduct of Operations (CON OPS) is a program by which a facility establishes its culture for the worker. CON OPS consist of formal documentation, practices, and actions implementing disciplined and structured operations that support mission success and promote worker, public, and environmental protection. The goal is to minimize the likelihood and consequences of human fallibility or technical and organizational system failures.

The term “operations” encompasses the work activities of any facility or organization, from building infrastructure, to print shops and computer centers, to scientific research, and to nuclear facilities. While many hazards can be dealt with through engineered solutions, people still must perform operations, and they can and do make mistakes.

The purpose of a conduct operations program is to ensure that management systems are designed to anticipate and mitigate the consequences of human fallibility or potential latent conditions and to provide a vital barrier to prevent injury, environmental insult or asset damage, and to promote mission success.

Conduct of Operations – Slide 24

The CON OPS program is broken down into several chapters, each in a specific area, to promote the success of the mission. The chapters include:

Organization and Administration to defines the roles and responsibilities of key personnel.

Shift Routines and Operating Practices to establish and implement operations practices that ensure that shift operators are alert, informed of conditions, and operate equipment properly.

Control Area Activities that establish and implement operations practices that promote orderly, business-like control area operations.

Communications to ensure accurate, unambiguous communications among operations personnel.

On-shift Training to control on-shift training of facility operators and prevent inadvertent or incorrect trainee manipulation of equipment.

Investigation of Abnormal Events, Conditions, and Trends for investigating events to determine their impact and prevent recurrence.

Notifications to ensure appropriate event notification for timely response, especially by outside organizations and regulators.

Control of Equipment and System Status that is used to establish initial equipment lineups and subsequent changes to ensure facilities operate with known, proper configuration as designed.

Lockout and Tagouts that address proper control and isolation of facility systems and components during operational and maintenance activities.

Conduct of Operations – Slide 25

Independent Verification practices to verify that critical equipment configuration is in accordance with controlling documents.

Logkeeping requirements that ensure thorough, accurate, and timely recording of equipment information for performance analysis and trend detection.

Turnover and Assumption of Responsibilities for thorough, accurate transfer of information and responsibilities at shift or operator relief to ensure continued safe operation.

Control of Interrelated Processes which ensures that interrelated processes do not adversely affect facility safety or operations.

Required Reading in a defined program that keeps operators updated on equipment or document changes, lessons learned, or other important information.

Timely Instructions/Orders to ensure timely written direction and guidance from management to operators.

Technical Procedures for developing and maintaining accurate, understandable written technical procedures that ensure safe and effective facility and equipment operation.

Operator Aids to provide accurate, current, and approved operator aids for use by operators.

Component Labeling that provides for clear, accurate equipment labeling.

Criticality Safety (Nuclear Safety)

Criticality Safety – Slide 26

The top picture shows the sphere (recreated) that was used during testing of the critical masses for the atomic bomb. During the testing, the scientist accidentally moved the two halves too close together and created a criticality event. He subsequently died from that mistake.

Watch the video embedded in the slide. While the video discusses reactor fuel, the same concerns exist when radioactive waste is stored in containers in high concentrations, such as HLW. The location, volume, and proper arrangement of the drums is essential to avoid criticality.

Certain materials, such as uranium-235 and plutonium-239 are capable of undergoing fission, that is the atoms can be split giving off heat and radiation. Each time these atoms split, particles called neutrons are also given off which can cause splitting of further atoms.

In a nuclear reactor, materials capable of undergoing fission are assembled under well-defined conditions to produce a controllable chain reaction (or controlled criticality) where neutrons from one fission go on to cause other atoms to fission. Splitting atoms releases large amounts of heat (used to generate electricity) as well as radiation. Very thick biological shields (usually a combination of concrete and steel walls) are present around the reactor to protect the workers from the radiation.

When the same materials are handled outside of a reactor it is possible that fissile material can accumulate in certain conditions and result in an accidental and uncontrolled chain reaction, or criticality accident. When a criticality accident occurs, it can give off high levels of radiation in a similar way to a nuclear reactor. This can present a dangerous or even lethal dose to anyone nearby if there is not sufficient shielding present.

The aim of criticality safety is preferably to ensure that the quantity of material and the conditions in which it is present remain such that a criticality cannot happen and the resultant high levels of radiation do not occur. In some circumstances, it is necessary to provide shielding such that in the unlikely event of a criticality accident the workforce is protected from the radiation.

Emergency Management

Emergency Management – Slide 27

Slide depicts a high-level look at the area surrounding a nuclear plant in Louisiana. Other plants and nuclear facilities around the US have similar plans.

Facilities are required to establish a policy and to assign and describe roles and responsibilities for the emergency management system. The system provides the framework for development, coordination, control, and direction of all emergency planning, preparedness, readiness assurance, response, and recovery actions.

Emergency planning must include identification of hazards and threats, hazard mitigation, development and preparation of emergency plans and procedures, and identification of personnel and resources needed for an effective response.

Emergency preparedness must include acquisition and maintenance of resources, training, drills, and exercises.

Emergency response must include the application of resources to mitigate consequences to workers, the public, the environment, and the national security, and the initiation of recovery from an emergency.

Both on-site and off-site emergency workers need to be aware of the plan and the communications protocols regarding accidents at a nuclear facility.

Recovery must include planning for and actions taken following termination of the emergency to return the facility/operations to normal.

Environmental Monitoring

Environmental Monitoring – Slide 28

The DOE requires that radioactive waste management facilities establish policies and procedures to ensure that the public is protected from radioactivity and radioactive materials. This includes but is not limited to safe site boundaries and off-site monitoring. Radiological activities on-site are management by the radiological protection program.

Radiation Protection

Radiation Protection – Slide 29

Worksites that expose personnel to radiation or radioactive material will have in place a radiation protection program. The occupational radiation protection program is governed by the Rule, specified as 10 CFR 835. The requirements given in 10 CFR 835 are matters of law, punishable by civil and criminal penalties. Elements include assessing external and internal doses, workplace monitoring, radiological equipment, and radiation dose reporting. Doses are required to be ALARA (as low as reasonably achievable) and must not exceed the limits given in 10 CFR 835.

Special qualifications and training programs are designed around this regulation and are strictly followed. In addition, specially trained radiation control technicians monitor the requirements and provide oversight for the workers.

Safety Management System

Integrated Safety Management – Slide 30

Part of a DOE radioactive waste management program is the implementation of an integrated safety management system (ISM). The objective of ISM is to integrate safety into management and work practices at all levels, addressing all types of work and all types of hazards to ensure safety for workers, the public, and the environment. To achieve this objective, the DOE has established guiding principles and core safety management functions. An effective ISM system addresses these DOE-wide principles and core functions while also considering site-specific factors, conditions, analyses, and processes.

The following guiding principles are fundamental policies that guide actions, from development of plans and procedures to conduct of work:

1. Line Management Responsibility for Safety: Line Management is responsible and accountable for protection of the public, workers, and the environment;
2. Clear Roles and Responsibilities: Clear and unambiguous lines of authority and responsibility for ensuring safety is documented, communicated, and maintained;
3. Competence Commensurate with Responsibilities: Personnel possess the experience, knowledge, skills, and abilities necessary to discharge their responsibilities;
4. Balanced Priorities: Resources are effectively allocated to address safety and programmatic and operational considerations. Protecting the public, workers, and the environment is an overriding priority;
5. Identification of Safety Standards/Requirements (S/R): Before work is performed, the associated hazards shall be evaluated, and an agreed-upon set of safety S/R are established, which provide adequate assurance that the public, workers, and the environment are protected from adverse consequences;
6. Hazard Controls Tailored to Work Being Performed: Administrative and engineering controls to prevent and mitigate hazards are tailored to the work and associated hazards;
7. Operations Authorization: The conditions and requirements for operations to be initiated and conducted are agreed upon and clearly established.

The five ISM Core Functions provide the necessary structure for work activity that poses a hazard to the public, workers, and the environment. The Functions are applied as a continual cycle, with the degree of rigor appropriate to control the work hazards.

The five Core Functions upon which ISMS is developed are:

1. Define the Scope of Work: Missions are translated into work, expectations are set, tasks are identified and prioritized, and resources are allocated;

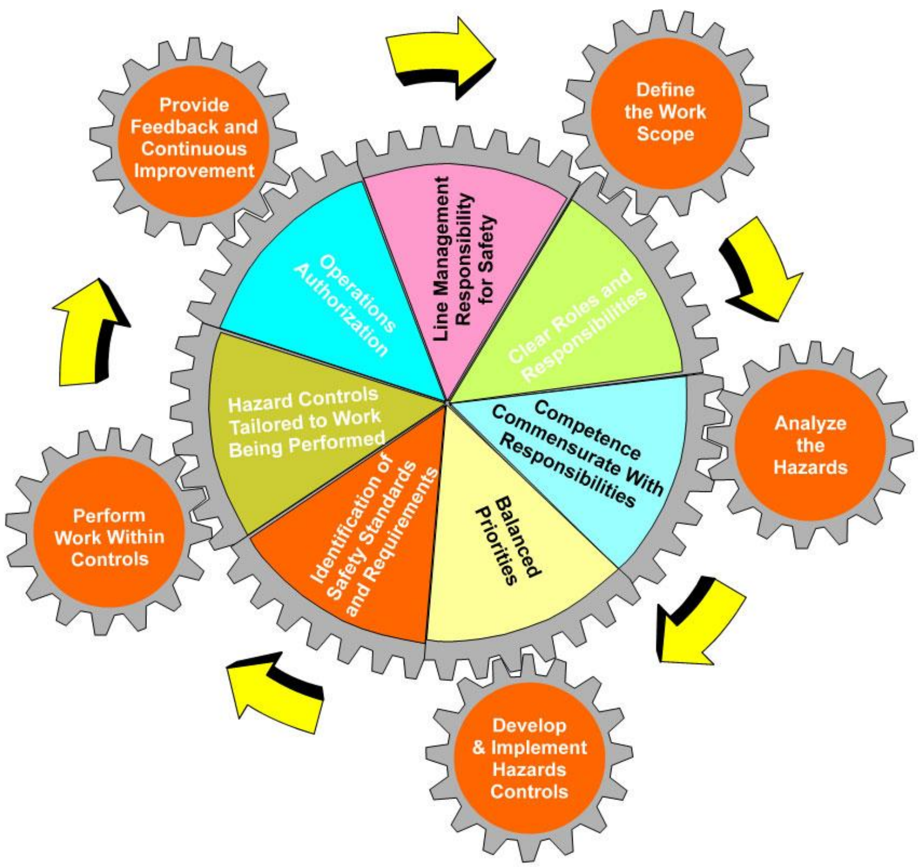
2. Analyze the Hazards: Hazards associated with the work are identified, analyzed, and categorized;

3. Develop and Implement Hazard Controls: Applicable standards and regulations are identified and agreed upon, controls to prevent/mitigate hazards are identified, the safety envelope is established, and controls are implemented;

4. Perform Work within Controls: Readiness is confirmed and work is performed safely;

5. Provide Feedback and Continuous Improvement: Feedback information on the adequacy of controls is gathered, opportunities for improving the definition and planning of work are identified and implemented, line and independent oversight is conducted and, if necessary, regulatory enforcement actions occur.

The ISM idea can easily be demonstrated on a wheel, below:



Radioactive Material Packaging

Radioactive Material Packaging – Slide 31

Radioactive material is transported every day by highway, rail, air, and water. Radioactive material must be shipped from where it is produced to where it is used. The use of radioactive material sometimes produces radioactive waste that must then be shipped to a disposal site. Radioactive materials are transported under very strict federal regulations. The regulations are designed to protect the public and the environment from risks associated with radioactive material during normal and accident conditions. The DOE complies with all applicable regulations pertaining to the transport of radioactive material.

Radioactive material is generally shipped in its most stable form. Typically, that means they are shipped as solids. When radioactive liquids or gases are transported, federal regulations require additional precautions. Careful research and design goes into packaging radioactive materials. Emergency planning, driver training, and strict government inspections are a part of a program that has never resulted in a radiologically related death or injury from a transportation incident.

Hazard Evaluation

Federal regulations place strict administrative controls on the transport of radioactive material. The worldwide philosophy of radioactive material transport is that:

- Safety should be primarily focused on the package. Packaging is the first line of defense.
- Package integrity should be directly related to the degree of hazard of the material it contains.

This two-part philosophy means that small quantities of radioactive material (quantities that would present little hazard if released) may be shipped in less secure packages than those that contain higher levels of radioactive material.

Radioactive Material Packaging Types

Package Types – Slide 32

Radioactive material is packaged to ensure that radiation levels at the package surface do not exceed federal regulations. This ensures that shippers, the public, and the environment are not exposed to radiation levels that exceed recognized safe limits.

Different shipping packages are required for various types, forms, quantities, and levels of radioactivity. We will discuss four packaging types:

- Excepted Packaging
- Industrial Packaging
- Type A Packaging
- Type B Packaging

Note: Do not confuse Type A packaging with Type A LLW, etc.

Excepted Packaging

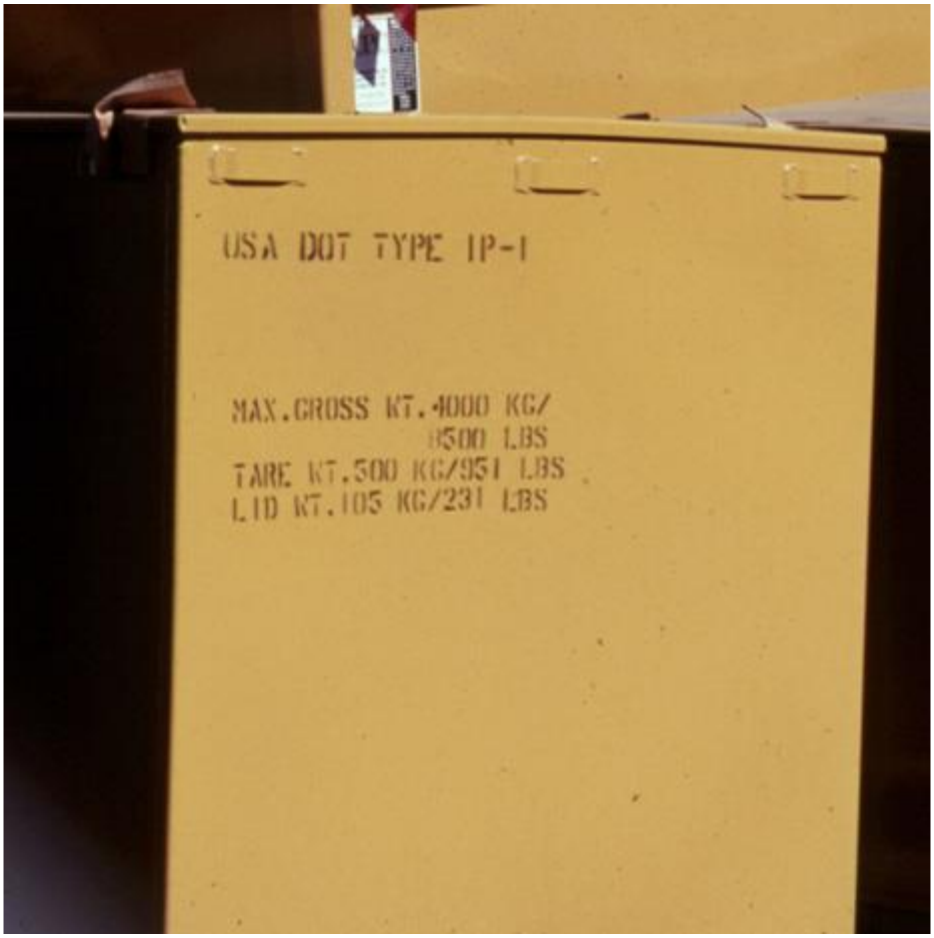
Excepted Packages – Slide 33

Excepted Packaging is used to transport material with extremely low levels of radioactivity. Excepted packages are authorized for limited quantities of radioactive material that would pose a very low hazard if released in an accident. Examples of material typically shipped in excepted packaging include consumer goods such as smoke detectors. Excepted packages are excepted (excluded) from specific packaging, labeling, and shipping paper requirements; they are however, required to have the letters “UN” and the appropriate four-digit UN identification number marked on the outside of the package.

Industrial Packaging

Industrial Packages – Slide 34

Industrial Packaging is used in certain shipments of low activity material and contaminated objects, which are usually categorized as radioactive waste. Most low-level radioactive waste is shipped in these packages. Department of Transportation (DOT) regulations require that these packages allow no identifiable release of the material to the environment during normal transportation and handling. There are three categories of industrial packages: IP-1, IP-2, and IP-3. The category of package will be marked on the exterior of the package as shown below:



Type A Packaging

Type A Packages – Slide 35

Type A Packaging is used to transport small quantities of radioactive material with higher concentrations of radioactivity than those shipped in industrial packages. They are typically constructed of steel, wood, or fiberboard, and have an inner containment vessel made of glass, plastic, or metal surrounded with packing material made of polyethylene, rubber, or vermiculite. Examples of material typically shipped in Type A Packages include nuclear medicines (radiopharmaceuticals), radioactive waste, and radioactive sources used in industrial applications. Type A packaging and its radioactive contents must meet standard testing requirements designed to ensure that the package retains its containment integrity and shielding under normal transport conditions. Type A Packages must withstand moderate degrees of heat, cold, reduced air pressure, vibration, impact, water spray, drop, penetration, and stacking tests. Type A Packages are not, however, designed to withstand the forces of an accident. The consequences of a release of the material in one of these packages would not be significant since the quantity of material in this package is so limited. Type A packages are only used to transport non-life endangering amounts of radioactive material.

Type B Packaging

Type B Packages – Slide 36

Type B Packaging is designed to transport material with the highest levels of radioactivity. As illustrated in the photos below, Type B packages range from small hand-held radiography cameras to heavily shielded steel casks that weigh up to 125 tons. Examples of material transported in Type B packages include spent nuclear fuel, high-level radioactive waste, and high concentrations of other radioactive material such as cesium and cobalt. These package designs must withstand all Type A tests, and a series of tests that simulate severe or "worst-case" accident conditions. Accident conditions are simulated by performance testing and engineering analysis. Life-endangering amounts of radioactive material are required to be transported in Type B Packages. Type B packages undergo careful testing in extreme condition. One such test includes a tractor-trailer like the one below, crashing into a wall at more than 80mph. Completed tests have shown only slightly dented packages.

Package Testing – Slide 37

The philosophy behind radioactive material transportation—where safety is primarily focused on packaging and package integrity being appropriate to the material hazard—dictates that Type B Packages be designed to withstand severe accident conditions. In DOE's 50-year history of transporting radioactive material, there has never been a release from a Type B Package. In addition, there has never been an injury or death resulting from the release of radioactive material in a transportation incident.

Radioactive Waste Handling

Radioactive Waste Handling – Slide 38

Personnel responsible for handling radioactive waste at DOE facilties are required to be trained and qualified for such operations.

Operators, as defined by the DOE, are persons responsible for performing operations associated with engineered safety features, operating support systems which could affect engineered safety features, or conducting activities with special nuclear materials and/or radioactive materials. Duties may include manipulating facility controls, monitoring parameters, and operating facility equipment. Operators include reactor operators, fissionable material handlers, tritium facility operators, chemical process operators, waste tank operators, and enrichment facility operators.

Fissionable Materials Handler

Fissionable Materials Handler – Slide 39

Beyond the definition of an operator, additional responsibilites exist for the handling of fissionable radioactive materials. A Fissionable Materials Handler is a person certified by facility management to manipulate or handle significant quantities of fissionable materials, or manipulate the controls of equipment used to produce, process, transfer, store, or package significant quantities of such materials.

Certification is the process by which contractor management endorses and documents, in writing, the satisfactory achievement of qualification of a person for a position. Certification follows the completion of the qualification program for those positions identified as requiring certification. The notable difference between certification and qualification is that certification requires official contractor management endorsement of an individual's qualification to ensure senior management involvement in the qualification of key operations positions (i.e., operators and supervisors). Other significant differences between qualification and certification are the requirements associated with continuing training, examination, and reexamination for recertification.

The certification process will include additional classroom, hands-on, and on-the-job training for the duties and responsibilites. These will include oral exams and recertification processses. Some of the elements included in the training program are:

- Criticality Safety
- Forklift Operations
- Hand Truck Use
- Packaging and Shipping Requirements
- Radiological Worker, and
- Emergency Preparedness

The training will also include the necessary systems and components that support the facility in which the materials are stored as well as the chemistry, phyical, and metallurgical reaction that are possible. Package arrangement, configuration, and limitations are also taught to ensure safety limits cannot be exceeded.

Fisionable material handlers are also required to remain active, qualified, and proficent in their jobs, with very strict documentation requirements.

Course Review

Questions?? – Slide 40

Review - Slide 41

The summary should provide a recap of what was covered.

A. Restate the Motivator
B. Restate the Terminal Objective
C. Review Enabling Objectives
D. Add Other Summary Items as Necessary

Include these elements in the order that best promotes learning:

Review Objectives and Major Learning Points - Tell them what you told them. Don't re-teach the lesson.

Elicit Questions - Ask for all unanswered questions related to the topic.

Connect to the Job - Explain how the transfer of the knowledge and skills back to the job supports performance.

Answer All Questions - Always.

Punctuate the Finish! – Revisit the motivator, "What's In It For Me?"