Operational Strategies for Low-Level Radioactive Waste Disposal Site in Egypt - 13513

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Abstract

The ultimate aims of treatment and conditioning is to prepare waste for disposal by ensuring that the waste will meet the waste acceptance criteria of a disposal facility. Hence the purpose of low-level waste disposal is to isolate the waste from both people and the environment. The radioactive particles in low-level waste emit the same types of radiation that everyone receives from nature. Most low-level waste fades away to natural background levels of radioactivity in months or years. Virtually all of it diminishes to natural levels in less than 300 years. In Egypt, The Hot Laboratories and Waste Management Center has been established since 1983, as a waste management facility for LLW and ILW and the disposal site licensed for preoperational in 2005. The site accepts the low level waste generated on site and off site and unwanted radioactive sealed sources with half-life less than 30 years for disposal and all types of sources for interim storage prior to the final disposal. Operational requirements at the low-level (LLRW) disposal site are listed in the National Center for Nuclear Safety and Radiation Control NCNSRC guidelines. Additional procedures are listed in the Low-Level Radioactive Waste Disposal Facility Standards Manual. The following describes the current operations at the LLRW disposal site:

Introduction

Radioactive waste is generated in Egypt through the operation and decommissioning of research reactors, the use of radioactive materials in industry, medicine, education, research and consumer products, the mining and milling of ores and their processing and in the remediation of contaminated sites. Radioactive waste must be safely managed for protection of human health and the environment. The low and intermediate level radioactive waste from nuclear applications in medicine and industry and radioisotope production facility can be diverse and variable in nature, with a wide range of radioactivity levels and containing many different radionuclides. The radiation protection legislation and radioactive waste manual establish requirements for the safe management of radioactive waste prior to its disposal. It is the policy of Egyptian Atomic Energy Authority (EAEA) to conduct its radioactive waste management operations in a manner that ensures that the health and safety of all its employees, contractors, and the general public. In achieving this objective, EAEA shall ensure that radiation exposure to its workers and the public and releases of the radioactivity to the environment are maintained below regulatory limits and

deliberate efforts are taken to further reduce exposures and releases in accordance with ALARA principles.

In meeting this policy, EAEA should make extra efforts to:

1. *Ensure personnel responsible for performing radiological work activities are appropriately trained*. Standards shall be established to ensure the technical competency of the EAEA work force as appropriate, through implementation of standardized and mandated radiological training and development programs.
2. *Ensure the technical competence of personnel responsible for implementation and overseeing the radioactive waste management program.* An appropriate level of technical of technical competence gained through education, experience and job related technical and training is critical component for achieving the goals of managing radioactive waste.
3. *Ensure radiological measurements, analyses, worker monitoring results and estimates of public exposures are accurate and appropriately made.* The capability to accurately measure and analyze radioactive materials and workplace conditions and determine personnel exposure is fundamental to the safe conduct of radiological operations.
4. *Conduct radiological operation in a manner that controls the spread of radioactive materials and reduces exposure to the work force and the general public and that utilizes a process that seeks exposure levels as low as reasonably achievable.* Radioactive waste management operations and activities shall be preplanned to allow for the effective implementation of the dose and contamination reduction and control measures. Operations and activities shall be performed in accordance with EAEA and/or international operations requirements and shall include reasonable control directed towards reducing exposure, preventing the spread of radiological contamination and minimizing the generation of contaminated wastes and release of effluents.
5. *Incorporate dose reduction, contamination reduction and waste minimization features into the design of new facilities and significant modification to existing facilities.* Wherever possible, facility design features shall be directed towards controlling contamination at the source, eliminating airborne radioactivity, maintaining personnel exposure and effluent releases below regulatory limits and utilizing a process that seek exposure levels and releases as low as reasonably achievable.
6. *Conduct oversight to ensure radioactive waste management unit requirements are being compiled with and appropriate radiological work practice are being implemented.*

Waste Receipt

Inspections, radiological surveys, sample collection and analyses, as applicable, and acceptance of incoming waste shipments will be performed and documented in accordance with the appropriate facility SOP's and Radiological Work Permit(s). These procedures are described below.

Waste Assessment

There are two types of waste assessment required for the LLRW disposal site. They are point-of-origin Inspections and onsite Inspections.

Point of-Origin assessment

The Hot Laboratories Waste Facility, HLWF is going to begin the point-of-origin assessment Program. The goal of the program is to identify any deficiencies at conditioning unit prior *to* waste being shipped for disposal. Identifying deficiencies before the waste is shipped will reduce subsequent packaging or waste form violations upon receipt at the LLRW disposal site. HLWF achieves this goal through random inspections of conditioning facility.

Onsite Assessment

HLWF has full-time onsite assessors at the LLRW disposal site. HLWF is required by their license to inspect the containers on each shipment for physical integrity, marking and labeling requirements, and correlation with the shipment manifest. A waste form confirmation program is also in place at the facility. This program requires HLWF to inspect a minimum of one shipment per week, or one shipment out of every ten, whichever is more frequent. Shipments that undergo this inspection are set aside and all packages are individually examined, using nondestructive testing. At least one of these packages is opened and/or punctured in the presence of a HLWF inspector to determine compliance with waste form requirements.
In addition to the inspections noted above, both HLWMC and HLWF inspect trucks entering the facility for compliance with NCNSRC and /or U.S. Department of Transportation (US DOT) regulations. The US DOT requirements address such things as shipment and package radiation levels, physical integrity of containers, and proper paperwork.

Radioactive Waste Identification and Disposal

Packaging Requirements

The waste contents should be identified to fulfill the waste acceptance criteria requirements before sending the package to LLW disposal facility. Packaging refers to the types of containers the waste must be placed in for transport and disposal. Packaging requirements have changed over the past 30 years. In the past, cardboard and wood packages were allowed. Typical packaging today includes 200 L metal drums and steel boxes. There are packaging requirements for both waste stability and waste isolation. (Unstable waste must be placed in approved packaging such as high integrity containers (HICs) or engineered concrete barriers (ECBs).) Packaging requirements for waste isolation focus on package integrity. Containers received for disposal at the facility cannot show significant deformation, degradation, or any signs that radiation has dispersed through the container.

Radioactive Waste Forms

The Nuclear and Radiological Regulatory Authority NRRA, developed a specific requirements should be followed to obtain a waste form in very stable shape to fulfill all safety requirements against workers, public and environment before it can be disposed of. For example, liquid wastes must be stabilized, or solidified. Absorbed liquids are not allowed. Liquids treated by stabilization must be processed to eliminate all freestanding liquid. Liquid wastes must also be rendered non-corrosive. Solid material containing incidental liquids is allowed, provided that the dry material contains less than 0.5% volume percent of liquid within the package. Other wastes subject to specific waste form requirements include all class B and C waste, radioactive consumer products, chelated wastes, biological wastes, and Class B tritium wastes. Void spaces within all classifications of waste must be reduced to the extent practicable. However, void spaces in Class A stable, Class B, or Class C waste may not exceed 15% of the total volume of the waste package, unless disposed of in a HLWF.

Acceptance Criteria for Radioactive Waste Disposal

Radioactive waste that is acceptable for disposal in a near-surface repository should conform to the requirements of low level radioactive waste which developed by NRRA. As well known the objective of treating and conditioning radioactive waste is to produce waste packages that can be handled, transported, stored and disposed of securely and safely. In particular, the final packaging should meet the waste acceptance criteria of the disposal facility. If a disposal facility is not established and the waste acceptance criteria are not known, an assessment should be undertaken to determine the type of disposal appropriate to the particular waste stream and an estimate made of the range of likely waste acceptance criteria for that type of disposal. Generic waste acceptance criteria are discussed in Annex I. In some cases, it may be necessary to place packaged waste in an overpack which meets the specific waste acceptance criteria for the particular disposal facility. Waste acceptance criteria for disposal in a range of facilities are likely to require minimal voids in the waste package, minimal free liquids and that toxic materials are below specified limits.

Protection of the General Population from Releases of Radioactivity

Concentrations of radioactive material which may be released to the general environment in groundwater, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public. Releases of radioactivity in effluents to the general environment must be maintained as low as reasonably achievable.

Protection of Public Health and the Environment

Construction, operation, closure, and the post-closure conditions of the land disposal facility must comply with all applicable laws and regulations including but not limited to environmental, labor, and public health laws and regulations.

Packaging Criteria

Waste must be packaged in conformance with license conditions and applicable NRRA technical regulations. Waste cannot be packaged for disposal in cardboard or fiberboard boxes. However, wastes may be shipped to HLWF in cardboard or fiberboard boxes if allowed under applicable NRRA, technical regulations. Wastes that are received in cardboard or fiberboard boxes will be placed within reinforced modular concrete canisters at the HLWF, LLRW facilities prior to disposal.

Waste Form and Stability Requirements

In accordance with Technical regulation Class B and C waste must exhibit sufficient structural stability prior to disposal to ensure that the waste does not degrade and allow the overall stability of the disposal unit to be compromised through slumping, collapse, or other failure that could lead to water infiltration. A structurally stable waste form will generally maintain its physical dimensions and its form, under the expected disposal conditions such as weight of overburden and compaction equipment, the presence of moisture, and microbial activity and internal factors such as radiation effects and chemical changes, consistent with NRC guidance in *Waste Form Technical Position, Revision 1* (WFTP). Structural stability can be provided by the waste form itself, by processing the waste to a stable form prior to acceptance at the HLWF, facilities, or by placing the waste in a disposal container or structure that provides stability after disposal. Compliance with the free liquids limitations identified in the NRRA, technical regulations. Void spaces within the waste and between the waste and its package must be reduced to the extent practicable, the maximum void space within any waste container shall not exceed 7.5% based on engineering analyses performed to support the design of the disposal vaults. For low-radiation hazard Class A waste (dose is less than 0.1 rem in one hour at a distance of 30 centimeters) that is disposed of in the HLWF site. The subcategory of Class A waste that contains radionuclides with half-lives greater than 30 years and transuranic in concentrations greater than 10 nanocuries/gram (nCi/g) is required to meet the stability requirements of NRRA, technical procedures unless an alternative criteria is approved by Egyptian regulator. An alternative criterion is proposed by HLWF for low level radioactive waste subcategory that meet specific waste acceptance, confirmation, and waste placement requirements to ensure long-term stability of the bulk waste fill.

Waste Disposal Design

The LLRW site uses conventional shallow-land burial. In shallow-land burial, large, lined vaults are used for waste disposal. The vaults concrete walls are the primary method for containing the radioactive waste. The vaults are designed for long-term isolation and minimum active maintenance after site closure. The maximum dimensions allowed for any vault is 5 meters in width, 3 meters in depth, and 10 meters in length. Soils excavated during vault construction are used for backfilling. A registered professional land surveyor documents the vault location, and a civil engineer performs a visual inspection of the vault walls, prior to waste emplacement.

Waste Emplacement and Backfilling

Emplacement

Waste placed in reinforcement concrete boxes is stacked in vaults in an orderly manner, while drums are placed in the vault more randomly. Waste must be emplaced in a manner that maintains the package integrity during emplacement, minimizes void spaces between packages, and permits the void spaces to be back filled with site soils or sand. Certain wastes must be segregated. Class A unstable waste is segregated from other waste by placing it into separate vaults. Class C waste is required to be disposed of in the bottom of vault. Waste with a surface radiation level greater than 2mSv/hr must also be disposed at a maximum depth of three meters below natural grade. Waste containing chelates in excess of 0.1% by weight must be segregated from other waste by placing it into ECBs. Packages containing gases must be placed in a manner that maintains package integrity, and with a minimum of 3 meters from other gas containers. Waste can only be held in storage for a maximum of 180 days. Storage of waste is monitored so that exposures are maintained as low as reasonably achievable and the dose limits are not exceeded.

Backfilling

Backfilling between waste containers must be done frequently enough that the radiation level at the vault edge does not exceed 50 μSvhr. If possible, backfilling is to be performed concurrent as the waste is placed in the vault. For all types of wastes with specific package segregation requirements, backfilling is required so that each layer is covered prior to subsequent waste emplacement. More frequent backfilling may be performed to minimize radiation exposures.

Manifest Tracking and Record Keeping

Each shipment of LLRW and disused radioactive sealed sources SRSS arriving at the LLRW disposal site is required to have shipping documents properly completed by the shipper. Each generator using the HLWF must also have a valid site use permit issued by the NRRA prior to shipping any waste for conditioning, storage and disposal.

NRRA's license requires that waste shipments arriving at the disposal facility be accompanied by a shipment manifest approved by HLWMC and civil defense Department, HLWF requires that each manifest contain a detailed physical and chemical description of the waste, including the identity and quantity of radionuclides. The shipper must certify that the material is properly classified, packaged, and labeled for onsite transport and disposal.

The onsite inspector reviews all shipping papers prior to acceptance of the shipment for disposal. No shipment may be offloaded unless the inspector has stamped and initialed the paperwork. A copy of the manifest accompanies the load to the vault for offloading. During the disposal process, a HLWF operator records which vault the load was placed in, depth of waste burial, three-dimensional location of Class B and C waste, and the date of disposal. Detailed reports on waste disposal are required monthly, annually, and whenever a vault is closed.

Interim Closure

As vaults are filled to within 2 meters of natural grade, filling the void space using sand and gravel are placed over the vault. The interim vault cover is not considered a low-permeability cover. Interim vault markers are installed at each end of the vault and are inscribed with total activity, vault number, dates of operation, the volume of waste in the vault, and the coordinates of the disposal unit. Each quarter, visual inspections and radiation surveys of completed disposal units are performed to determine the condition of vault caps, changes in radiation levels, general condition of the disposal facility, and status of security measures.

Rain or Flooding Management

The LLRW disposal site has a water management diversion channel designed to control surface water drainage. The channel was built in response to any water flooding, which resulted in run-on at the site. The drainage channel is engineered to accommodate heavy rain. The drainage channel is designed to minimize surface erosion, prevent run-on onto vault, and limit contamination resulting from run-on and run-off.

Institutional Controls

The institutional control activities assume that the site is functioning as designed and estimated to span a 300-year time frame. Institutional controls are used to secure and control the LLRW disposal site. In addition to the security provided by the EAEA, the LLRW disposal site is surrounded with a continuous three meters chain link fence that is topped with barbed wire. The entire fence is posted for radiation areas. The entrance gate to this area is under direct surveillance during working hours and is locked after working hours.

The major objectives of post-closure activities are to develop information to demonstrate that the facility continues to satisfy performance objectives and that responsibility for the closed facilities can safely be transferred to the designated custodial agency. Conditions that must be demonstrated include the following:

- The closure of the disposal site conforms with the Licensee's disposal site closure plan, as amended and approved
- The Licensee has provided reasonable assurance that the performance objectives are likely to continue to be met

- The Institutional Control Monitoring Program is operational for implementation by the HLWF
- The custodial agencies are prepared to assume responsibility and ensure that the institutional requirements will be met

HLWF will ensure that the information necessary to transfer the facility to the Institutional

Control Period will be complete and accurate. The surveillance and Institutional Control care activities described below will provide the information necessary to make these demonstrations. The Institutional Control Period provides a means of ensuring the continued safe and effective function of the disposal facilities following facility post-closure activities

Environmental Monitoring

Beginning in 1956, soil, groundwater, and vegetation monitoring have been performed periodically. Air quality monitoring began in 1969. Ambient air and other experimental monitoring began in the mid-1980s. In 1987, a comprehensive environmental monitoring plan was initiated. Today there are nine permanent environmental monitoring stations surrounding the LLRW disposal site, and several other stations throughout the site. Table 1 lists monitoring requirements included in the NCNSRC. Reporting levels, established in the license for each of the monitoring requirements, are based on the protection of public health. NCNSRC publishes an annual environmental report documenting results of the previous year's monitoring.

Table 1: Environmental Monitoring Requirements

Media Sampled	Sample Sites	Sample Frequency
Groundwater	Eight wells	Monthly
Air Quality	One station	Continuous
Vegetation	Many samples	Quarterly

Personnel Training

The LLRW disposal site has a formalized written training program developed by HLWF and approved by the regulatory. The training program is reviewed and updated at least every two years. The program includes specific hours of classroom study, on-the-job training, and testing requirements for radiological workers, management, and unescorted visitors.

Quality Assurance Plan

The HLWF QA Program is designed to ensure that the necessary quality requirements for structures, systems, components and work activities are achieved. This objective is attained by ensuring that the organizational framework and the responsibility assignments are such that quality is achieved and maintained by those who have been assigned responsibility for performing work and, quality achievement is verified by individuals or organizations not directly responsible for performing the work. The radioactive waste operator and Division Manager, establishes the basic policies of the HLWF QA Program. The policies described in this QA Plan are transmitted to all levels of management and are implemented through approved procedures. The HLWF QA organization has responsibility for development, management and verifying the proper implementation of the HLWF QA Plan

QA Program Basis

The HLWF Quality Assurance Plan complies with regulatory requirements applicable to the specific HLWF business unit and applies to all levels of the organization, including contractors, who perform quality-affecting work activities. For purposes of understanding the applicability of the HLWF QA Program, "Quality Affecting" is defined as "deeds, actions, processes, tasks or work which influence the achievement or verification of quality requirements and objectives for Quality Level 1and 2 structures, systems and components and their associated work activities." The QA Program requires that quality affecting work be planned and accomplished under suitably controlled conditions. Controlled conditions include the use of appropriate equipment, suitable environmental conditions for accomplishing the activity, and assurance that prerequisites for the given activity have been satisfied. The QA Program provides for any special controls, processes, test equipment, tools and skills to attain the required quality and verification of quality.

Emergency Response

HLWF Radiological Emergency Group (REG) outlines the actions to be taken if there is a significant release of radioactive materials to the environment at the LLRW disposal site. The REG contains detailed procedures for notification, line communication and response in case of a radiological emergency. A radiation emergency is defined as:

- fire
- major release of radioactive materials to the air, soil, or ground water transportation accident
- any event requiring evacuation
- any other hazardous materials event involving radioactive materials

To ensure readiness in case of an emergency, REG performs periodic emergency drills at the HLWF. The drills are unannounced and at least three drills preformed per year. The drills cover many expected areas such as fire, release of radioactive material, and care of a contaminated injured person etc.

ALARA Information

To identify safe handling procedures that maintain worker radiological exposures to ALARA criteria, the following parameters must be known:

• Gamma and neutron radiation fields
• Alpha and beta contamination levels
• Package configuration
• Isotopic concentrations

This information will be used by the Radiation Protection Officer (RPO) to determine if an existing Radioactive Work Permit (RWP) provides appropriate time, distance, and shielding provisions that minimize operating personnel exposure and, if not, to develop an appropriate RWP in accordance with radioactive waste manual, "Radiation Work Permit".

References

1. 10 CFR 835, Occupational Radiation Protection
2. NCRP 116, Limitation of Exposure to Ionizing Radiation, 1993
3. PNL-6577, Health Physics Manual of Good Practices for Reducing Radiation Exposures to Levels that are As Low As Reasonably Achievable (ALARA), 1988
4. MN471016, Radiological Protection Procedures Manual, Chapter 12, "Radiation Instrumentation"
5. OECD. (2003). Engineered Barrier Systems and the Safety of Deep Geological Repositories (Report EUR 19964)
6. Push, R. (1994). Waste Disposal in Rock. Amsterdam: Elsevier. Ringwood, A. E. (1978). Safe Disposal of High Level Reactor Wastes: A New Strategy. Canberra: Australian National University Press. Introduction to Immobilization.

Appendix I

Generic Waste Acceptance Criteria for Disposal of Radioactive Waste

NEAR-SURFACE DISPOSAL

Radioactive waste that is acceptable for disposal in a near-surface repository should conform to the requirements of Categories A, B and C in the *Code of Practice for the Near-Surface Disposal of Radioactive Waste in Australia* (NHMRC 1992). Concentration limits for the different categories are given in the Appendix to the Near-Surface Disposal Code for a near-surface repository at an arid remote site for a 100 and a 200 year institutional control period. It would be reasonable to assume that a near-surface repository in an arid remote site in Australia would accept waste that meets the concentration limits provided in the Near-Surface Disposal Code for a repository with a 200 year institutional control period. The following is a list of generic waste acceptance criteria for waste that should be accepted at any Australian near-surface repository. The waste:

- is a solid;
- no alpha emitter
- half live not more than 30 years
- has stable chemical and physical properties;
- contains no free liquid;
- is compatible with concrete and natural barriers;
- does not contain compressed gases;
- contains no hazardous material, such as PCBs, infectious waste, putrescible materials;
- contains no organic liquids or chelating agents;
- is structurally stable and has long term compressive strength;
- will not generate gases;
- does not contain flammable material (excluding paper, plastics or cloth which may be included within normal radioactive waste);
- contains less than 10 percent voidage; and
- can be placed into a package that meets the *Code of Practice for the Safe Transport of Radioactive Material* (ARPANSA 2008).

Once a waste repository is established there will be clear specifications for each of these waste acceptance criteria. For example, the repository license could define ‘no free liquids’ as being less than 1 percent by volume, and provide that a given pressure will not result in the release of liquid. It might also define a threshold of 100 parts per million for defining when the presence of a ‘hazardous material’ would not be accepted. The license could also define, ‘will not generate gases’ to exclude that from normal decomposition of paper, plastics or similar material often included within radioactive waste. ‘No organic liquids’ could exclude minor amounts included in solid material, such as wipes. Until a repository is established, the above list of criteria could be used as a basis for a proposal to undertake irreversible treatment of radioactive waste that is

likely to be destined for a near-surface repository. Irreversible treatment of radioactive waste should only be undertaken where there are necessary safety or security benefits.

Intermediate BOREHOLE FACILITY

The following is a list of generic waste acceptance criteria for waste that could be accepted at a proposed Egyptian borehole disposal facility. The waste:

• is a solid;
• has stable chemical and physical properties;
• is small enough to fit in a borehole;
• contains no free liquid;
• is structurally stable; and
• can be placed into a package that meets the *Code of Practice for the Safe Transport of Radioactive Material* (ARPANSA 2008).

Although boreholes can be drilled with diameters of a meter or more, intermediate large diameter boreholes such as Greater Confinement disposal, GCD, Nevada, USA, are difficult and expensive. There is a tradeoff between total depth and borehole diameter. It is likely that the safety case for disposal of higher radioactivity sealed sources in a borehole facility would put greater emphasis on increased depth rather than increased diameter. Standard drill rigs used for petroleum exploration can drill deep and could be used to establish a deep borehole disposal facility. Boreholes produced by petroleum exploration drill rigs are likely to have an internal diameter of 150 mm or more (based on an 8.5 inch drill). To allow for overpacking, this suggests that to ensure it is suitable for any borehole facility, a stainless steel package for radium needles and tubes or higher activity sources should be 100 mm or less in diameter. Keeping packages 100 mm or less in diameter therefore gives confidence that the waste will be able to be disposed of in any borehole disposal facility. Of course, if a borehole facility is established with a larger diameter borehole, then the waste acceptance criteria would be designed to accept larger diameter packages.