

REGULATIONS ON MANAGEMENT AND SAFE DISPOSAL OF RADIOACTIVE WASTE IN JORDAN

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ABSTRACT

The first use of ionizing radiation in Jordan was in the medical applications when the first X-ray machine was installed in a big governmental hospital more than fifty years old, and the solid sealed radiation sources were used in medicine applications (brachytherapy) are the first radioactive wastes generated over the kingdom in the absence of any appropriate national legislation on radiation protection and waste safety. The nuclear energy and radiation protection law was adopted by the Jordanian Parliament in 1987 and authorized the Ministry of Energy and Mineral Resources (MEMR) as the national competent authority to implement the law in co-operation with other national institutions. The present paper will discuss in some details the draft of the regulations on management and safe disposal of radioactive wastes in Jordan which was formulated with the assistance of the IAEA experts and adopted by the national commission on radiation protection and these regulations are in the final stage of approval by the council of ministries according to the law mentioned above.

INTRODUCTION

Under Jordanian Law No. 14 of 1987, "Nuclear Energy and Radiological Protection law", the Commission on Radiation Protection (hereafter called "the Commission") is authorized" to regulate, supervise, and provide guidance on rules and procedures relating to radiation safety in the areas of use of radioactive material, production, import, export, transport, purchase, manufacture, use, and storage and disposal of nuclear and radioactive material [1]. Under this mandate the Commission regulates the generation, management, treatment, storage , transportation, discharge, and disposal of radioactive waste. The law has authorized the Nuclear Energy Directorate (NED) of the Ministry of Energy and Mineral Resources (MEMR) to implement and enforce these regulations. The Nuclear Energy Directorate implements these regulations by licensing of all persons generating or processing radioactive waste, and by enforcing these regulations through inspection and surveillance of licensees. The Nuclear Energy Directorate will also operate a centralized interim storage facility and a national low level waste disposal site. The Nuclear Energy Directorate will establish waste acceptance criteria for radioactive waste disposal and establish exempt quantity levels for discharge of radionuclides not considered to be radioactive waste.

The magnitude of spent sources and decommissioned radioactive instrument/ equipment and the risks associated with the interim storage of these spent sources in organizations generating, storing, and disposing of radioactive waste throughout the country of Jordan are as detailed in Annex (II).

There are number of organizations in Jordan possessing sealed sources which are considered waste. These sources are stored under inconsistent controls and at multiple independent facilities. Therefore, the Nuclear Energy Department (NED) will operate immediately an interim storage facility to allow consolidation and centralized control of radioactive waste generated through the Kingdom. This storage facility will also provide conditioning services for disposal of small volume wastes amenable to accumulation prior to stabilization by

cementation (e.g., spent sources, etc.) or other methods to be selected by the Nuclear Energy Directorate. Such facility is located in a remote location, at the near surface burial site which is co-located with a hazardous waste disposal facility (see Annex 1) to be operated by the Ministry of Municipal and Rural Affairs and the Environment [2].

It appears that there are a significant problems relating to inadequate storage and lack of a treatment facility for liquid radioactive wastes with toxic chemical constituents, as detailed in Annex (II). It is the responsibility of the Ministry of Municipal and Rural Affairs and the Environment to co-operate with the MEMR to take a corrective action for storage of such wastes until such wastes are regulated and a disposal method is identified according to these regulations.

Radiation Protection Infrastructure in Jordan

Regulatory Infrastructure:

The law No.14 of 1987. “ Nuclear Energy and Radiological Protection Law” has authorized the Ministry of Energy and Mineral Resources “MEMR” to control and regulate the work with radiation sources and radioactive materials and to be responsible for the development of nuclear science and technology and radiation protection in the Kingdom.

According to the section “5” of the law, the commission on radiation protection (CRP) which is headed by the Secretary General of MEMR and has other (8) members from all concerned ministries is responsible for:

- 1) Protection of man and environment from harmful effects of ionizing radiation.
- 2) Development national plans, policies, standards, recommendations, guidelines, and regulations on radiation safety.
- 3) Licensing and inspection of radiation sources and facilities, production, import, export, transport, purchase, manufacture, storage, use, and disposal of radioactive materials.
- 4) Establishment and providing radiation protection services.
- 5) Emergency planning and preparedness.
- 6) Research and studies for developing radiation protection activities.

According to the sections (37 and 39) of the law, the council of ministers shall issue the necessary regulations for the implementation of the provisions of this law, and the prime minister and the ministers shall be responsible for the implementation of the provisions of this law.

Since 1987 several rules, regulation and code of practice in the area of radiation safety have been issued such as [10]:

- Licensing requirement and procedures.
- Procedures for inspection of facilities, installation and activities of nuclear technology and ionizing radiation.
- Recommendations on decontamination of personnel, surfaces and equipment.
- Draft regulation on the management of radioactive waste .
- Shielding requirement for x-ray machines used in medical diagnosis.
- Regulation on the transport of radioactive materials.

Operational Infrastructure

Personal Exposure Control

Personal monitoring services are provided by Royal Scientific Society (RSS) for more than 1200 radiation workers by using a vinten multiscard TLD reader. LiF dosimeters used for personal monitoring and CaSo₄ dosimeters for environmental monitoring. The occupational exposure measured every three months and the record keeping is available at the MEMR.

Medical Exposure Control

QA programme was established in the country with the help of IAEA to cover the nuclear medicine, radiodiagnosis, and radiotherapy with all the necessary equipment for the implementation of this programme.

Food And Environmental Monitoring

A national food and environmental programme is established by the MEMR for measuring the potential contamination in food and environmental samples. The MEMR has a network for early warning and continuous environmental radiation monitoring for gamma radiation.

Licensing and Inspection

Procedures and systems for notification, registration, licensing and inspection of medical, industrial, agricultural, research and teaching installations are established by the regulatory authority MEMR with the help of the IAEA and a national registry of radiation sources and users was established with the assistance of the IAEA.

Emergency Response and Preparedness

A national emergency response plan was adopted in 1990 and the MEMR established emergency unit with the necessary equipment and the plan is tested by conducting an emergency exercises.:

Calibration Programme

The RSS is responsible for instrument calibration and Jordan University for the nuclear instrumentation maintenance.

Waste Management Programme

The MEMR co-operates with IAEA through WAMAP mission to Jordan in 1989 and through TC project JOR/9/005 to formulate a national radioactive waste regulation and to establish a storage facility for the spent sources and radioactive waste materials generated by industrial, medical, and research centres [3].

Training And Education

The MEMR is organizing an intensive radiation protection courses for RP officers and a specific training in the radiation protection field (medical, diagnostic, nuclear medicine, industrial radiography,... etc.) in addition to the general training course on radiation protection for the purpose of issuing a license to the radiation workers. Also, the MEMR is arranging regional and interregional training courses, fellowships, scientific visits for his radiation workers with the help of the IAEA. A central nuclear library is available at MEMR

Radioactive Waste Management and Disposal System

Legislation of Radioactive Waste Management :

Jordan realized the importance of a suitable radioactive waste management programme in order to deal with radioactive wastes in a manner to protect human health and the environment now and in the future without imposing undue burdens on future generations.

The legal provisions on the radioactive waste management is included in the law No.14 of 1987 "Nuclear Energy and radiological protection law that states the following:

Section.3.6 states that the (CRP) is authorized to regulate, supervise and provide guidance on rules and procedures relating to radiation safety in the areas of use of radioactive raw material, production, import, export, transport, purchase, manufacture, use, storage, and disposal of nuclear and radioactive material, and section 11 states that except in cases authorized under this law, no natural or juridical person may disposal or burial of radioactive waste or its residues or any part thereof anywhere in the Kingdom.

Therefore, the MEMR with the co-operation of the IAEA formulates a national regulations on management and disposal of radioactive waste, a summary of these regulations is shown in Annex (III) [3,9].

Radiation Sources Used in Jordan

Jordan Government supports safe and economic peaceful applications of ionizing radiation. There are no reactors in Jordan but many radiation sources including radiation generating machines, sealed and unsealed radiation sources which are used in medical, industrial and research and training applications.

Annex (I) shows approximately the type and number of radiation sources used in different applications in Jordan.

The centralized interim storage Facility and The Disposal Site

There are a number of organizations in Jordan having a radioactive waste in the form of spent solid sealed sources or unsealed solid and aqueous radioactive waste arising from medical, industrial and research applications. Annex (II) shows the type of these spent radiation sources along with the risks associated with these uncontrolled stored spent radiation sources[3]. The number of decommissioned radioactive instruments to be declared waste is expected to increase significantly in the future and the most significant near-term risk faced by Jordan is an accident due to inconsistent controls currently applied to spent sources and decommissioned equipment at a multiple independent facilities. Therefore, the MEMR with the help of the Ministry of Municipal and Rural Affairs and the Environment constructed and operated a centralized interim storage facility and a permanent disposal site for a radioactive waste among the hazardous waste disposal facility at the south of Jordan.

The disposal site is located 60 Km south of the capital (Amman) and will begin operation in early 1998. It contains an area of about 10 000 m² that will be used as a centralized interim storage and a near surface disposal facility. Here are a small room used for interim storage of the conditioned low level waste pending disposal, and one a reinforced concrete bunker of 1.25 m in diameter and 6m deep is built for the disposal of spent sealed sources and intermediate level waste (ILW) [4,8]. It is planned to construct more bunkers and a suitable

interim storage hall of a dimension of approximately 20m X 20m of height 5m to accommodate the radioactive wastes generated over the kingdom which can meet the country's need for the next decade

Methods and Procedures for Radioactive Waste Management:

Decay Storage for Short Lived Radionuclides

Such radioactive waste arising from medical, Universities and research laboratories with a radionuclides of short half-lives as :

I-131 (8d), I-125 (60 d), Ir-192 (74 d), Mo-99 (66h), Ga-67 (78h), Tl-201 (3 d), and Co-57 (271 d) . This type of radioactive waste can be considered inactive after a decay storage of ten half-lives and dumped with the approval of the licensing authority (Ministry of Municipal and Rural Affairs and the Environment) along with municipal refuse as conventional wastes [5,6] .

Conditioning of spent sealed sources:

The second type of radioactive wastes which contain radioisotopes of long half-life or intermediate level activity will be solidified by cementation for final disposal. This preferred option to reduce the safety risks for accidents associated with spent radiation sources is the conditioning or immobilization of spent sealed sources in matrix. The method has the advantage of using unsophisticated technology, material and equipment which are easily available. The product package (drum) is stable for a long time under interim storage conditions. Using additional shielding inside the drum is always possible to reduce the surface dose rate. By proper conditioning a spent source in concrete, the source is transformed into a form which can not cause any large exposure even if the waste package is handled without special precautions [4,6].

It is required that the drum should be fixed in its position after the waste has been immobilized for a few days for solidification and coherence of cement mixture and then the drum is allowed to be transported to the interim storage facility of the conditioned low level wastes.

Annex (III): Summary of the Regulations on the Management and Safe Disposal of Radioactive Waste in Jordan

Section I: Basic Safety Principles

To protect the public and the environment from the harmful effects of radioactive waste.

To dispose of waste in such a manner that the risk to future generations is no greater than that which is determined acceptable to present generations.

To perform all waste management activities in a manner that limits radiation close to radiation workers and the public to levels that are as low as reasonably achievable.

To minimize the transfer of responsibility for radioactive waste monitoring and control to future generations.

Section II: General Instruction

The hazardous characteristic of the radioactive wastes should be monitored in addition to their radiation hazards.

The national regulation for the safe transport of radioactive material shall apply to transportation of radioactive materials including radioactive waste within Jordan and internationally (based on IAEA safety series No.6, 1985 edition as amended in 1990).

No person may receive, possess, generate, store, transport, discharge or disposal of radioactive waste unless authorized by a license issued by the MEMR upon recommendation by the commission.

Each person shall develop and implement comprehensive plans for management of radioactive wastes from the time of initial possession of radioactive materials through the processes of waste generation, treatment, storage, conditioning, transportation, and disposal. Plans shall be submitted to the Nuclear Energy Directorate for approval as part of the licensing process.

Limits for discharge of exempt quantities may not be achieved by dilution of radioactive wastes. Dilution as treatment method is prohibited.[3]

Containers shall be clearly identified with radiation symbol placards as well as permanent identification providing tractability of the radioactive contents to documentation describing the origin source of these materials.

Section II: Discharge and Disposal of Radioactive Wastes

Discharge of exempt quantities of radionuclides via the sewage system, municipal refuse dump or to the atmosphere should be in accordance with authorized limits and under a license issued from the commission.

The maximum monthly discharge of liquid radionuclides to a municipal sewage system shall not exceed (10) times ALI and in no case shall individual discharges exceed the annual limit on intake (ALI) published by the (ICRP).

Facilities using short-lived radionuclides with a half-life of 2 months or less for medical or research purposes may dispose of their waste using a controlled decay and discharge system. They shall be confined for a period not less than (10) half-lives before they are discharged or disposed. Treatment by controlled decay and discharge shall be approved by the MEMR and the discharge of waste shall be performed under the supervision of a licensed qualified person from the Ministry of Municipal and Rural Affairs and the Environment.

The discharge or disposal of radioactive wastes shall be performed under the provisions of the above conditions and a license issued by the ministry of Municipal and Rural Affairs and the Environment for a case-by- case basis.

A Special forms shall be filled for the discharge and disposal of radioactive wastes via the sewage system and Municipal refuse dump.

Section V: Waste Acceptance Criteria

Wastes should be classified on the basic of their physical type.

All radioactive waste generated from different laboratories should be accumulated at one licensed location.

The following requirements are the minimum requirements for all classes of waste and are intended to facilitate handling at the disposal site and provide protection of health and safety of personnel at the disposal site [3].

- 1) Waste must not be packaged for disposal in cardboard or fiberboard boxes.
- 2) Liquid waste must be solidified or packaged in sufficient absorbent material to absorb twice the volume of the liquid.
- 3) Waste must not be readily capable of detonation or explosive decomposition or reaction at normal pressure and temperatures, or of explosive reaction with water.
- 4) Waste must not contain , or be capable of generating, quantities of toxic gases, vapors, or fumes harmful to persons transporting, handling, or disposing of the waste.
- 5) Waste must not be pyrophoric (nonflammable).
- 6) Waste containing hazardous, biological, pathogenic, or infectious material must be treated to reduce to the maximum extent practicable the potential hazard from the non-radiological materials.

Naturally occurring Radioactive materials excavated and/or concentrated by mining and milling operations shall not be considered as radioactive waste due to the large volumes of materials involved and relatively low specific activity of the materials. However, persons operating uranium, phosphorus, and gypsum mining and milling facilities are responsible for applying best industry practices to limit radiation doses to the public and the workers.

Mine tailings and/or milling residues shall be covered with sufficient overburden to minimize the air suspension of particulate and aerosol radionuclides, where covering of milling residues is not economically, the facility owner shall conduct sufficient sampling and analysis of the residues to determine statistically the mean concentrations of radionuclides in the residues.

The total disposed activity via sewer system or municipal refuse dump for waste containing more then one radionuclides is given by the equation [5]:

$$\sum \frac{A_k}{ALI_{\min,k}} \leq G$$

Where A_k is the activity of radionuclide K in the waste . $ALI_{\min,k}$ means ALI_{\min} for the radionuclide K and $G = 1$ for individual releases and (10) for monthly quantities of waste.

Liquid scintillation counting waste which mainly contains tritium or C-14 and with an activity concentration more than 100 Bq/ml, can be considered as radioactive waste or if it contains alpha emitters.

Section VI: Interim Storage

It is a method used for the disposal of the spent sealed radiation sources where they undergo natural decay of their radionuclides to a level of activity that can be allowed to be disposed via sewer system or other means.

The waste shall be placed in a shielded container of a suitable capacity for keeping a large number of radioactive waste [7].

The following information shall be clearly identified on the container; warning radiation sign, type of radiation sources, serial no. of the source, the date of production and the activity at this date.

The ground floor of the interim storage facility of the spent sealed radiation sources should be easily cleaned from the decontamination and an accurate radiation protection procedures shall be implemented and the access is restricted to licensed and authorized persons.

The interim storage shall be licensed by the commission before construction and a regular report must be submitted to the commission.

Liquid radioactive wastes shall be stored in a suitable container that doesn't undergo chemical reaction with the stored radionuclides and tightly sealed that no vapor or radioactive gases can be released and a secondary shielded container is required to reduce the exposure to the permissible levels.

Section VII : Responsibilities

Generators are responsible for conducting a safety program for monitoring the containers of radioactive waste and their storage sites, performing a wipe-test for contamination and measuring radiation dose rate at the surface.

Generators are responsible to cover costs associated with the treatment, transportation, disposal and storage of their wastes at the centralized interim storage facility and the permanent disposal site.

Generators are responsible for notifying the Nuclear Energy Directorate of the generation and accumulation of radioactive waste.

Generators are responsible for controlling their waste in accordance with best technological practices until it is turned over to the interim storage facility of the conditioned low level wastes or exported outside Kingdom.

The Ministry of Energy and Mineral Resources will provide the technical assistance and supervision of the radioactive waste treatment at their origins and transportation of radioactive waste from its origin to the interim storage facility of the conditioned low level waste.

Disposal of radioactive waste will be only in the interim storage facility of the conditioned low level waste.

Section VIII: Working procedures

Persons generating radioactive waste should notify the Ministry of Energy and Mineral Resources of the generation and accumulation of radioactive waste .

All waste types over the Kingdom shall be accumulated at interim storage facility approved by the commission.

The Ministry of Energy and Mineral Resources shall notify the generators about all the necessary requirements for the treatment of their wastes.

The nuclear Energy Directorate shall controlling the treatment and conditioning treatment at the centralized interim storage facility.

Ministry of Energy and Mineral Resource shall notify the civil defence and other national Authorities for the case of emergency during the transportation of radioactive waste from the generator to the interim storage facility.

Ministry of Energy and Mineral Resources is responsible to provide all the necessary radiation survey meter and personal dosimeters during the transportation and disposal of radioactive waste.

Section X : General Provision

Any provisions of any other regulations that are in conflict with the provisions of these regulation are here by annulled [1].

These regulations do not apply to foreign interests operating in Jordan and they are not allowed to dispose of their wastes in any part of Jordan and they must export their wastes outside the Kingdom and radiation sources in case of no more use.

CONCLUSION

These regulations will be again reviewed and updated by the IAEA experts through the regional project RAW/9/006 and other sections concerning the design criteria, performance objectives, operational requirements, and closure provisions of the disposal facility will be added to these regulations so that reasonable assurance exists that exposures to humans are within the limits established by the national regulatory authority.

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Annex I: Type and Application of Radiation Sources in Jordan

Application	Radionuclides	Approx. No.
Industrial Applications		
- Density gauges	Cs-137	250
- Level gauges	Cs-137, Am-241, Co-60	200
- Thickness gauges	Kr-85, Pm-241, Am-241, Sr-90	150
- Moisture gauges	Am241 Be, Cf-251	50
- Well logging	Am241 Be, Cs-137	30
- Industrial radiography	Ir-192	25
- XRF, XRD, Chromatography	Ni - 63	60
Medical Applications		
- Nuclear Medicine	I-125, I-131, Tc-99m, Ga-67, Tl-201	10
- Radioimmunoassay	I-125, Na-22, Co-57	25
- Radiodiagnosis		500
- Radiotherapy	Co-60 (2 units), linear accelerators (3	6
- Brachytherapy	units)	3
Research And Training Applications		
- Irradiator facility		1
- Van De Graph Accelerator	Co-60 of 10 Kci	1
- Calibration Sources & University research & Teaching	(1 unit) many different	300
- Tracers		2
	Cs-137, Co-60	

ANNEX (II): Summary of Spent sources and Decommissioned Equipment in Jordan

Organization	Results / comments
Royal Scientific Society (RSS)	RSS has a number of solution of radium (in mCi) which are stored in unsecured plastic containers in a shielded cabinet; spills are considered possible and a large (3) sources of Ir-192 which appeared very well controlled.
Ministry of Water	Scintillation vials containing environment levels of radium, tritium, and uranium stored outside the facility is an open and unmarked cardboard box (>200 vials)
King Hussein Hospital	Radiommuoassay is performed in a manner which segregates Tc-99 and Generators from patients. However, generators are given to an outside doctor before they are decayed.
Ministry of Health/ radiotherapy facilities (Al Bahsir Hospital)	<ul style="list-style-type: none"> - Unused Co-60 radiotherapy unit of a total activity (400 Ci) stored at the facility in a suitable place. - (70) unused Brachytherapy needles and tubes of Cs-137 sources with a present total activity (3 Ci) and (5) Brachytherapy Sr-90 sources with a present total activity (10 mCi). - Holding tank system for controlled decay discharge of short-lived radionuclides to sewer system, located one meter from vented door to hospital grounds ,making air suspension and inhalation by passers- by readily possible spill in discharge room results from inadequately discharge piping.
Jordan Phosphate Mines	<ul style="list-style-type: none"> - (4) Cs-137 density and level gauges of (500 mCi) stored in cement vault . Vault is (3m) deep with unsealed cement cap and no floor (which preferable in this case as rain intrusion is possible). Site is not marked as a radioactive waste storage facility. - (4) decommissioned Cs-137 density and level gauges of an activity (500 mCi for each) stored in a buried cement vault. Eevidence of surface waste drainage directly over vault ,indicating a high probability that vault is flooded to some degree. - Phosphogypsum wastes contains 300 ppm U-238, 35 ppm U-235, and 87 Bq/m3 Rn-222. There are no plans to cover these materials with overburden due to the site of the piles.
Cement Factory	- (16) nuclear density and level gauges of (50 mCi) for each. They are stored in a special cemented room at remote site of the factory.
Jordan University	<ul style="list-style-type: none"> - Solids wastes from bovine pregnancy tests (contaminated bottles and syringes containing I-125) not marked /dated and stored in unsealed plastic bags in an unmarked classroom laboratory. Disposal is in ordinary university trash system after an unspecified decay period. A considerable surface contamination of work and storage areas and surrounding cabinets. - Many unused sources stored in physics classroom (Pu-239, Np-237 (5 u Ci), Ra-226 (500 mCi), along with a number of other small sources of short-lived isotopes which are disposed in sewage lines in unknown quantities and without any system for controlled decay. .Solid wastes disposed in hospital waste system unmarked without any system of controlled decay.
Arab Potash Company	- (15) Cs-137 nuclear gauges for level and density measurments of (500 mCi) for each gauge, stored underground in vault and no floor and has no drainage system so that the salty water intrusion is possible and the muddy floor helps the heavey sources to sink down a cosiderable distance.