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## **Practical guidance dealing with the challenges related to NORM management; Egyptian approach**

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### **ABSTRACT**

Naturally occurring radioactive materials (NORM) occur in the environment and are present in most materials. Certain industrial activities such as oil and gas industries can increase the potential for human exposure to NORM by generating residues or wastes with radionuclide concentrations above natural background levels. If the NORM is not properly managed, it can present unacceptable radiation risks to workers, the general public, and the environment. Many countries have developed strategies to ensure proper management of NORM, not all countries have done so. Even in countries with well-developed NORM policies, strategies, and regulatory structures, there are still challenging issues associated with the management of NORM residues/wastes. NORM concentration may vary from background levels that require no special safety precautions up to elevated levels which need careful radiation safety measures.

The oil fields in Egypt are distributed in the North and in Gulf of Suez. In this industry, scale and sludge containing primarily radium can accumulate in equipment and can cause harmful effect to the workers and also contamination to the environment.

This document focus into the main point that should be considered during preparation of safety guides for safe handling of NORM that produced from oil and gas industries in Egypt. These safety guides are based on the decree of the Egyptian AEA Chairman No.: 1297 on 21 December 1999 (Regulatory Role No: Pet-1.2) and issued in the Egyptian gazette on 2006, the IAEA

international safety standard and ICRP recommendations as well as the guidelines set by other countries of well recognized radiological health practices.

## **Introduction**

Naturally occurring radioactive elements such as uranium, radium, and radon are dissolved in very low concentrations during normal reactions between water and rock or soil. Ground water that coexists with deposits of oil can have unusually high concentrations of dissolved constituents that build up during prolonged periods of water/rock contact. Many oil-field waters are particularly rich in chloride, and this enhances the solubility of other elements including the radioactive element radium. Some of this saline, radium-bearing water is unavoidably brought to the Earth's surface with the oil and must be separated and then disposed, usually by return to depth in an injection well. At some oil-field sites the pipes and tanks that handle large volumes of this "produced water" can become coated with scale deposits that contain radium. Radium bearing scale is the type of "diffuse NORM waste" that occurs in the oil industry. The oil and gas industry has sought to better define the extent of the oilfield NORM problem, and to develop techniques for the prediction, prevention, remediation, and disposal of oil-field NORM. This document concerning into the main point that should take into our considerations during prepare of requirements and guidelines for safe handling of NORM that produced from oil and gas industries in Egypt.

## **Egyptian Legal Framework**

These guides are in compliance with the IAEA safety standard.

The following documents were used in the establishment of these guides:

- 1- Law no.7 for the year 2010 "Egyptian Law that regulates the Nuclear and radiological activities" and its executive regulations;
- 2- Law no 4 for the year 1994 " Environmental law" and its executive regulations;
- 3- Decree of the Egyptian Atomic Energy Authority Chairman No.: 1297 on 21 December 1999 (Regulatory Role No: Pet-1) and issued in the Egyptian gazette on 2006;
- 4- IAEA international safety standard GSR part 3;
- 5- ICRP recommendations as well as the guidelines set by other countries
- 6- IAEA Radioactive waste management glossary 2003;
- 7- Ministerial decree no. 202 for the year 2008;

8- Ministerial decree no. 534 for the year 2004;

9- Ministerial decree no.535 for the year 2004;

10- Radioactive waste management regulations produced from the users of radioactive materials, Egyptian gazette no.152 for the year 1999.

Accordance to Article (2) item No.(g), from the Egyptian Nuclear Law which states "The provisions of this law on the activities and installation of nuclear and radiological practices in various fields, including in particular: (g) "The handling of natural occurring radioactive materials that produced from oil and gas production and raw materials".

### **Exemptions [1-4, 7]**

- Materials and waste media such as sludge/scale containing NORM at levels below those listed in Table 1 shall be exempted from the requirements of this procedure.
- Soil shall not have a Radium-226 contamination above 0.185 Bq per gram (5 pCi per gram) above background averaged over any 10 square metres or unless risk assessment demonstrates an acceptable level of risk.
- Equipment, vessels, and clothing shall be considered 'NORM contaminated' if internal or external surface contamination measures double the radiation background level.

Table 1. NORM exemption levels [11-13]

<b>Radionuclide</b>	<b>Exemption level (Bq/g)</b>	<b>Exemption level (pCi/g)</b>
<sup>226</sup> Ra	1.1	30
<sup>228</sup> Ra	1.1	30
<sup>210</sup> Pb	0.2	5
<sup>210</sup> Po	0.2	5
<sup>238</sup> U	5.5	150
Uranium (nat)	3.0	80

- Materials and equipment in the recycling process contaminated with NORM scale or residue not otherwise exempted are exempt from the requirements of this section if the maximum

radiation exposure level dose not exceed 50 microrentgen per hour( $\mu\text{R/hr}$ ) including the background radiation level at any accessible point.

- Pipe (tubulars) and other downhole or surface equipment used in oil production contaminated with NORM scale or residue not otherwise exempted is exempt from the requirements if the maximum radiation exposure level dose not exceeds 50 ( $\mu\text{R/hr}$ ) [5] including the background radiation level at any accessible point.

### **Radiation survey instruments [1,3, 6-9]**

- 1) Radiation survey instruments used to determine exemptions shall be able to measure from 1  $\mu\text{R/hr}$  through at least 500  $\mu\text{R/hr}$ .
- 2) Radiation survey instruments used to make surveys shall be calibrated, appropriate, and operable.
- 3) Each radiation survey instrument shall be calibrated:

\*) by a person licensed or registered by ENRRA.

\*) at energies appropriate for the licensee's use;

\*) at intervals not to exceed 12 months, and after each instrument servicing

other than battery replacement; and

\*) to demonstrate an accuracy within plus or minus 20% using a reference source provided by a person authorized.

- 4) Records of these calibrations shall be maintained.

### **Worker protection requirement [3]**

Workers entering NORM-contaminated vessels or conducting intrusive work on NORM-contaminated equipment should adhere to the following guidelines:

- Personnel required to work with NORM should be trained in the associated hazards.

- All NORM operations shall be covered by a safe system of work which should identify the hazards and highlight the precautions to be taken.
- Any item or area with detectable levels of loose NORM contamination should be subject to radiological controls.
- Appropriate Personal protective equipments (PPE) should be worn (which may include but not be restricted to):

—‘Tyvek’ style coveralls

—Neoprene, PVC, or NBR gloves

—Half-face respirators with HEPA cartridges; these should be tested for fit

—Quarter-face HEPA disposable respirators.

- Eating, drinking, smoking and chewing are not allowed in work areas where there is potential NORM contamination.
- Only essential personnel should be allowed in the work areas of potential NORM contamination.
- Personnel should wash up thoroughly with copious quantities of soap and water, after working with contaminated equipment, and before eating, drinking, or smoking, and at the end of the workday.
- Use systems of work that minimise the generation of waste PPE (*ie* use PPE that can be cleaned, inspected and re-used).

### **Classification of working conditions [3]**

This system includes radiation surveying of the oil and gas production facilities to identify the level of NORM enhancement.

Each site will be classified according to the following categories:

**Category A:** where the radiation levels exceed 7.5  $\mu\text{R/hr}$  and specific activity of Ra-226 exceeds 2 Bq/gm.

**Category B:** where the radiation levels between 2.5-7.5  $\mu\text{R/hr}$  and specific activity of Ra-226 exceeds 2 Bq/gm.

**Category C:** where the radiation levels between 0.5-2.5  $\mu\text{R/hr}$  while the specific activity of Ra-226 exceeds 2 Bq/gm.

**Category D:** where the radiation levels is less than 0.5  $\mu\text{R/hr}$  and specific activity of Ra-226 is less than 2 Bq/gm.

**Category A requires:**

- Supervision by qualified NORM expert.
- Assignment of restricted areas.
- Detailed radiation survey every 3 months.
- Determination of specific activity of Ra-226 in the NORM wastes.
- Radiation measuring instruments.
- Radiation personal dosimetry.
- Cleaning of equipment or lands from radioactive contamination, by technical services is licensed from ENRRA.
- Training.
- NORM waste management programme.

**Category B requires:**

- Supervision by qualified NORM expert.
- Detailed radiation survey every 6 months.
- Determination of specific activity of Ra-226 in the NORM wastes.
- Radiation personal dosimetry.
- Cleaning of equipment or lands from radioactive contamination, by technical services is licensed from ENRRA.
- Training.
- NORM waste management programme.

**Category C requires:**

- Supervision by qualified NORM expert.

- Radiation survey every one year.
- Determination of specific activity of Ra-226 in the NORM wastes.
- Radiation personal dosimetry.
- Cleaning of equipment or lands from radioactive contamination, by technical services is licensed from ENRRA.
- Training.
- NORM waste management programme.

**Category D requires:**

- Disposal can be done as a non-radioactive waste.
- Radiation survey every 2 years.
- Training (Optional).

**Responsibility of licensees [4]**

Others and NORM producers can be engaged in handling and management of NORM waste that produced from oil and gas industries after obtaining the license from the regulatory authority (ENRRA).

The operator is responsible for the safety of all activities in the management of NORM waste and for the implementation of the programmes and procedures necessary to ensure safety. In accordance with the graded approach, the programmes and procedures necessary to ensure safety will generally be less extensive for the operator of a small facility.

**Storage facility**

The responsibilities of the operator of a large storage facility for NORM waste would typically include:

- (a) Making an application to the regulatory body to site, construct, operate, modify or decommission a waste storage facility;
- (b) Conducting appropriate environmental assessments and safety assessments to support the application for a license;
- (c) Operating the facility in accordance with the license conditions and the applicable regulations;
- (d) Developing and applying acceptance criteria for the storage of radioactive waste;

(e) Providing periodic reports to the regulatory body in relation to the safety of the facility (e.g. on the current inventory and the estimated future inventory and waste transfers into and out of the facility).

Not all of the items listed here may apply to small operators. For example, a small operator may not be expected to go through a siting process.

Prior to the authorization of a facility for the storage of radioactive waste, the operator should provide the regulatory body with plans for the long term management of the radioactive waste being stored.

The operator should demonstrate the safety of the facility by means of a safety assessment that is commensurate with the hazards envisaged. For smaller and simpler facilities, the regulatory body may set generic inventory limits instead of requiring a full safety assessment.

The operator of a storage facility for radioactive waste should use the safety assessment to propose facility specific operational limits and conditions. The operator may wish to set an administrative margin below the operational limits approved by the regulatory body as an operational target to remain within the approved operational limits and conditions.

The operator should determine the maximum quantities and concentrations of the radioactive materials or other hazardous materials that may be safely discharged to the environment and should document such discharges.

At an early stage in the lifetime of a waste storage facility, the operator of the facility should prepare plans for its eventual decommissioning. For new facilities, decommissioning should be taken into consideration at the design stage.

The operator of a large storage facility for radioactive waste should carry out pre-operational tests and commissioning tests to demonstrate compliance with the safety requirements established by the regulatory body.

As appropriate to the hazards associated with the waste storage facility, the operator of the facility should prepare plans and implement programmes for personnel monitoring, area monitoring and environmental monitoring, and for emergency preparedness and response.

The operator of a waste storage facility should put in place appropriate mechanisms to ensure that sufficient financial resources are available to undertake all necessary tasks throughout the lifetime of the storage facility, including its decommissioning.

### **Identification of Equipment Contaminated with NORM**

(a) Each person who owns or operates equipment used for production or disposal including each person who owns or operates equipment associated with a commercial facility relating to Fees and Financial Security Requirements, shall identify NORM-contaminated equipment with the letters "NORM" by securely attaching a clearly visible waterproof tag or marking with a legible waterproof paint or ink. Employers whose employees speak languages other than English may add to the tag the translation of the acronym "NORM" in those languages as long as the acronym "NORM" is also on the tag.

(b) Within six months of the effective date of this rule, each person whom the Commission has notified that the person owns or operates NORM-contaminated equipment shall, on each lease that is the subject of the Commission notice, identify NORM-contaminated equipment with the letters "NORM" by securely attaching a clearly visible waterproof tag or marking with a legible waterproof paint or ink. Employers whose employees speak languages other than English may add to the tag the translation of the acronym "NORM" in those languages as long as the acronym "NORM" is also on the tag.

(c) For an interconnected equipment system such as a wellhead, flowline, or facility piping system, the owner or operator of the system may identify the system as a whole with tags or markings that provide notice to workers on that system that the equipment in the system may be NORM-contaminated. The owner or operator shall identify NORM-contaminated equipment that is removed from an interconnected equipment system.

(d) The individual pieces of equipment or groups of equipment are kept in a common container or are wrapped, bound or tied securely together. Grouped equipment shall be tagged or marked to provide notice that any piece of equipment in the group may be NORM-contaminated.

(e) Radiation survey instruments used to determine whether equipment is NORM-contaminated shall comply with regulations adopted relating to Licensing of Naturally Occurring Radioactive Material (NORM).

Any employer of persons engaged in activities involving the disposal of oil and gas NORM waste shall comply with applicable provisions, as determined by relating to Standards for Protection Against Radiation from Radioactive Material adopted effective including but not limited to:

- (1) implementing a radiation protection program
- (2) controlling the occupational dose to all employees
- (3) conducting surveys and monitoring
- (4) assuring respiratory protection and implement controls to restrict internal exposure in restricted areas
- (5) posting signs and labels
- (6) keeping records of radiation protection programs and of special exposures
- (7) keeping reports

### **NORM contamination control procedures**

The following are basic control procedures that should be practiced when handling NORM contaminated equipment, tubulars, vessels, pipes or machinery:

(a) Establish a boundary around the work area. The boundary should be as small as possible, but large enough to allow for personnel and equipment access from the work area and to allow for all work to be accomplished in a safe manner. Containers or plastic bags should be provided for discarded protective clothing and contaminated trash at the exit of the work area.

(b) Only essential personnel should be allowed in the work areas where potential NORM contamination exists.

- (c) Prior to maintenance of contaminated equipment or opening inspection hatches, sludge traps or pig receivers, sufficient ground cover shall be placed below the item in the work area. The ground cover should be made of a plastic, waterproof type material capable of withstanding the work activities involved without tearing or ripping. Alternatively, a suitable drip-tray or catch-pan may be used. The ground cover should be sized to provide for the containment of leakage and waste and to allow ample room for related peripheral work.
- (d) Post the boundary with radiation warning signs “Caution: NORM Material”: (with radiation trefoil)
- (e) Hold a safety meeting for all personnel performing work. Radiological items which should be addressed during the meeting are, but are not limited to, protective clothing and respiratory protection requirements, radiation and contamination levels, maintenance activities which may cause radioactive material to become airborne, requirements for waste generated, heat stress, action to be taken in the case of emergencies.
- (f) Commence maintenance activity; any dry material that is NORM-contaminated should be wetted down to prevent the generation of airborne radioactive materials. Dry material should be wetted periodically throughout the maintenance work.
- (g) Openings of equipment or pipes that have internal NORM contamination should be sealed or wrapped by plastic or other suitable materials.
- (h) Obsolete NORM-contaminated pipes or equipment should be clearly labelled as “NORM Contaminated Materials” and removed to a designated area. The area should be labelled as “Containing Radioactive Materials” and restricted for the general public.
- (i) All contaminated waste generated during maintenance should be drummed or put into containers and marked or labelled. Representative samples should be collected from the waste and analysed for radioactivity.
- (j) Upon completion of maintenance, personnel should remove their protective clothing before leaving the work area.
- (k) All material, equipment and tools not placed in containers or drummed should be surveyed for both loose contamination and exposure rate levels upon exit from the work area. A reading greater than background levels is positive indication of contamination, and should be handled as such.

(l) Upon job completion, the accessible areas of the work area should be surveyed for loose contamination. Any loose surface contamination found should be promptly cleaned up and drummed.

(m) Once the work area has been verified free of loose surface contamination, the boundary and postings may be taken down.

### **Control of NORM contaminated waste**

Before NORM can be managed effectively, it is necessary to know where it is being produced. This requires an assessment of all process that identifies potential NORM contamination.

NORM waste disposal must adhere to applicable regulations pertaining to the disposal of radioactive waste.

In many cases short-term or interim storage may be required before final disposal of NORM waste. Where NORM waste is required to be stored, it should be kept in suitable container which should comply with the following requirements. The container;

- Should be in good condition with no visible indications of internal or external corrosion, and be made of a durable material such that it provides adequate containment of the NORM waste during the storage period.
- Should be made of or lined with materials that will not react with or be incompatible with the NORM waste so that the ability of the container is not impaired or compromised.
- Should be resistant to degradation by Ultra Violet radiation.
- Should be closed and sealed during storage, and practical to open and re-seal when it is necessary to add or remove waste.
- Should not be opened, handled, or stored in a manner that may rupture the container or cause it to leak.
- Should bear the radiation symbol and a label clearly indicating that it contains NORM contaminated waste.
- Should pay due regard to any other materials which may be present in the NORM waste matrix (*i.e.* oils, grease or chemicals...*etc*)
- Should be resistant to normally expected range of temperature in storage environment.
- Should be resistant to water ingress.
- Should be stored in a dry environment to prevent corrosion.

- Should be physically robust to prevent damage during transport.
- The storage location should be hard surfaced and bunded to prevent contamination of ground/surface waters and the creation of contaminated land from any potential leaks/spills as a result of incidents during storage period.

Areas where containers of NORM waste are stored should be inspected on a regular basis. Containers should be inspected for signs of leakage, overall deterioration and proper labelling. Records of these inspections should be documented and properly maintained.

Where NORM waste is disposed of, records shall be maintained of the disposal activities. These should include but not limited to:

- Waste material description (scale, sludge, scrapings, *etc*)
- Volume of waste material
- Mass
- NORM level (activity per unit weight) of waste material.
- Method of disposal
- Disposal location
- Organisation/facility where the NORM waste was generated
- Any other relevant information

### **Control of NORM contaminated equipment**

NORM contaminated equipment must be handled, transported, stored, maintained or disposed in controlled manner. Therefore, it is critical to understand and control how and where NORM materials can be transported. For example, drilling pipe that contains low-level NORM scale can be unrecognized and transported to a variety of secondary pipe reprocessing facilities with subsequent, inadvertent exposure and spread of NORM.

The following should be considered the minimum requirements for the control of NORM-contaminated equipment. Equipment should [17-19]:

- Be decontaminated prior to release for unrestricted use
- Be stored only in designated storage areas
- Be tagged or clearly marked as NORM contaminated.
- Be handled only by employees trained in NORM hazards and is using PPE

- Not be sent for maintenance/repair to workshops without informing the workshop that the component is contaminated with NORM.
- Be disposed of only in an approved NORM disposal facility from ENRRA.
- Be decontaminated only in an approved NORM decontamination facility from ENRRA or according to an approved decontamination protocol. Once verified as free from NORM contamination, the equipment may be :

—Re-used

—Sent for repair to a workshop prior to being re-used

—Sold or disposed of as scrap

- Be stored in areas which are exclusively used for the storage of NORM-contaminated equipment.

In addition:

- All open sections of equipment, *ie* flange or pipe ends, *etc* should be adequately covered by heavy-gauge UV-stabilised plastic or other suitable materials to ensure that NORM material does not leak from the item.
- Routine checks on all stored NORM-contaminated equipment should be undertaken to ensure that the integrity of the protective measures is adequate. Routine checks should be carried out at least on a quarterly basis.
  - Detailed and verifiable records should be maintained of all stored NORM contaminated equipment.

### **Transport of NORM contaminated equipment [14-16]**

#### **License for transportation**

The carrier must submit to the regulatory body at the request license transfer process.

License application must include information on:

Amount to be transferred, the nature of NORM waste transported, precautions taken to protect the workers, the public and the environment.

The regulator authority reviewing the information contained in the license application and make sure that it fulfill the requirements of safety standards.

## **Transportation process [7-9]**

NORM materials and/or NORM-contaminated components should be transported in ‘exclusive-use’ vehicles. No other cargo should be carried in the transportation vehicle.

Boats operating offshore and used to transport NORM contaminated material or equipment, should utilize standard transport containers appropriately segregated and marked to house the contaminated items. NORM-contaminated items that cannot be stored in standard transport containers should be protected in such a manner as to ensure no leak/spillage of NORM material during transport.

Before dispatch of any NORM materials/components, the receiving organization should be notified.

The operator of the vehicle (or boat) should be provided with a written contingency plan detailing the actions to be taken in the event of a reasonably foreseeable emergency.

The NORM transportation vehicle (or boat) operator should be aware and capable of implementing the contingency arrangements to be taken in the event of an accident.

The vehicle carrying NORM material or NORM-contaminated equipment should bear appropriate transports placard and signage as required by the International Atomic Energy Agency (IAEA).

Organizations should maintain records of all NORM transportation. These records should include the following:

- NORM material description (contaminated equipment, scale, sludge, scrapings, *etc*)
- Volume/quantity of NORM material transported
- Method of transportation
- Destination
- Organization/facility where the NORM waste was generated
- Any other relevant information.

The regulations involving the transportation of radioactive material are complex and therefore advice should be sought from a corporate expert on transportation particularly should cross-border transportation be required.

## Conclusion

The oil fields in Egypt are distributed in the North and in Gulf of Suez. In this industry, scale and sludge containing primarily radium can accumulate in equipment and can cause. These guides are based on the decree of the Egyptian AEA Chairman No.: 1297 on 21 December 1999 (Regulatory Role No: Pet-1) and issued in the Egyptian gazette on 2006, the IAEA international safety standard and ICRP recommendations as well as the guidelines set by other countries of well recognized radiological health practices.

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