بسم الله الرحمن الرحيم

Sudan Academy of Sciences (SAS)

Atomic Energy Council

Transport of radioactive material in Sudan: Practice and regulations

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(B.Sc.in Physics & Postgraduate Diplaoma in nuclear science)

A thesis submitted in partial fulfillment of the requirements for the degree of Master in Radiation and Environmental Protection

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December 2010

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Date of Examination 12/01/2011

بسم الله الرحمن الرحيم

قال تعالي:

((وَقُل رَّبِّ أَدْخِلْنِي مُدْخَلَ صِدْقٍ وَأَخْرِجْنِي مُخْرَجَ صِدْقٍ وَاجْعَل لِّي مِن لَّدُنكَ سُلْطَانًا نَّصِيرًا))

صدق الله العظيم

سورة الاسراء الآية 80

Say: "O my Lord! Let my entry be by the Gate of Truth and Honour, and likewise my exit by the Gate of Truth and Honour; and grant me from Thy Presence an authority to aid (me)

Al-Isra

Dedication

To

This work is dedicated to my family who offered me unconditional love and support throughout the course of this thesis.

I dedicate this work

M.KH.ELTIY

ACKNOWLEDGMENTS

FROM THE FORMATIVE STAGES OF THIS THESIS, TO THE FINAL DRAFT, I OWE AN IMMENSE DEBT OF GRATITUDE TO MY SUPERVISOR, DR. IBRAHIM IDRIS SULIMAN . I THANK ALL THE LECTURERS IN THE (SAS) FOR EFFORT THEY GAVE TO US ALSO I THANK AL THE MEMBERS OF THE AUTHORIZATION AND INDUSTRIAL INSPECTION UNIT IN (SNNRA) FOR THE VALUABLE ASSISTANCE HAVE GIVEN ME TO ACCOMPLISH THIS WORK.

M.KH.ELTIY

ABSTRACT

In the last couple of decades there has been an impressive increase in applications of radioactive material. Such an extensive and widely spread usage of radioactive materials demands safe transportation of radioactive material from the production site to the application location, as well as quick and effective response in a case of an unexpected transportation event according to Sudan Atomic Energy Commission (SAEC) regulation.

The thesis described the local practice for transport of radioactive material as compared to the international standards for radiation protection, and also discussed the emergency procedures that must be follow in case of accident during transport of radioactive material. Furthermore, the objective of this study was also to set proposals for how to cope in the event of a radiological accident,

The study methods included survey of current literature on safe transport of radioactive material, survey of national regulations on the subjects in additional to case studies aimed at investigating the practical issues pertinent to transport of radioactive materials in Sudan.

A comprehensive review was presented on how to classification of radioactive packages and general requirement for all packaging and packages according to international standard. Transport of number of radioactive sources from Khartoum airport to the field was evaluated with regard transport index, category of source, type of package, dose rate around the source, time to destination and means of transport of doses to public, worker are be made. All results were within the limit specified in the national as well as international regulation. The study has addressed for the first time the practice of transport of radioactive material in Sudan. It is anticipated that the results will encourage national organizational and professional bodies to enhance radiation protection and safety of radioactive sources.

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الخلاصة

في العقدين الماضيين كانت هناك زياد لكبيرة في تطبيقات المواد المشعة لذلك زاد إنتشار إستخدامها بصورة كبيرة وهذا يتطلب توفير الحماية والآمان المناسبين عند نقل المواد المشعة من منطقة الإنتاج إلي موقع الإستخدام فضلاً عن الإستجابة السريعة والفعالة في حالة وقوع حادث غير متوقع .

من خلال هذه الأطروحة تناولت المعايير العالمية في مبادئ الوقاية من الإشعاع وناقشت إجراءات الطوارئ التي يجب إتباعها في حالة وقوع حادث أو واقعة إشعاعية أثناء النقل ووضعت مقترحات لكيفية معالجة هذا الحادث الإشعاعي ، وإحتوت الأطروحة علي دراسة شاملة حول كيفية تصنيف المواد المشعة و الطرود المشعة والمتطلبات العامة لها وِفقاً للمعاير الدولية المنظمة لذلك .

الجانب العملي من الأطروحة تم عن طريق تقويم عملية نقل بعض المصادر المشعة من مطار الخرطوم إلي مكان الإستخدام أو النقل الداخلي من منطقة عمل إلي منطقة أخري وتم التقويم بناءاً علي دليل النقل وتصنيف المصادر المشعة ومعدل الجرعة حول المصدر المشع و وسيلة نقل المصادر المشعة ونوع الطرد ... الخ .

وأهدف من التقويم للوقوف علي معدل الجرعات الإشعاعية للعاملين والجمهور أو تلوث البيئة ووجِد أن النتائج متوافقة مع اللوائح المحلية والعالمية . تطرقت إلي بعض الإعتبارات الأمنية التي تودي إلي فقدان المصادر المشعة ووضعت عدد من التوصيات التي يجب القيام بها لضمان تحقيق نظام نقل آمن وفعال . تُعتبر هذه أول دراسة لتقويم الجانب العملي في نقل المواد المشعة في السودان وهذه الدراسة تتدفع أو تحُث المنظمات المحلية والجهات المختصة في تحسين وضع الوقاية من الإشعاع وأمن وأمان المواد المشعة في حالة النقل.

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Chapter One:

Introduction

1.1 Introduction:

Radioactive materials are used throughout the world for many applications that benefit humankind, encompassing agriculture, industry, medicine, electric power generation and research purposes. In almost all cases, the materials are generated in Locations other than those where used, and the resulting radioactive wastes are usually moved to other locations. In the transportation, the radioactive materials are often placed outside of controlled facilities, in the public domain, and often entail movement between countries. As the peaceful uses of radioactive material grew, the international community recognized that rigid and uniform standards were needed to ensure the safety of handlers, the public and the environment. The International Atomic Energy Agency (IAEA) has supported projects and produced publications to enhance the safe transport of radioactive material. The IAEA Safety Standards Series included regulations for the safe transport of radioactive materials. The Fundamental safety principles of which were laid in the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS). In Sudan, radioactive materials are used in a variety of useful and steadily increasing applications. Efforts were initiated in 1998 by the Sudan atomic energy commission (SAEC) to provide code of practice for safe transport of radioactive materials, under the SAEC ACT issued in January1996. People are concerned about risk of radioactive shipments which might affect human being and the environment. This research addresses some of these concerns about the transport of radioactive materials in Sudan.

1.2 Biological effects of ionizing radiation

Ionizing radiation in very high dose levels is known to increase the incidence of cancer, birth anomalies, erythema, and other problems. In low levels, these effects are either very, very small compared to natural incidences or non-existent depending on the biological model used for estimating the potential risk. Biological effects of ionizing radiation are classified as follow:-

1.2.1 Stochastic effects

Effects that occur by chance, generally occurring without a threshold level of dose, whose probability is proportional to the dose and whose severity is independent of the dose. Stochastic effects may result from injury to a single cell of a small number of cells. In these, once the effect is induced the severity is already determined by the nature of the effect, stochastic effects are assumed to have some chance of occurring no matter how low the dose. In the context of radiation protection the main stochastic effects are cancer and genetic effects.

1.2.2 Deterministic effect (Tissue reaction)

The health effects of radiation, the severity of which vary with the dose and for which there is a threshold for occurrence. Tissue reaction effects appear in cases of exposure to a high levels of radiation dose, and become more severe as the exposure increases, deterministic effects are those in which the severity of the effect varies with the dose. For these types of effects a threshold dose exists. Radiation-induced cataract formation, skin ulcerations, or burns, depletion of blood forming cells in bone marrow and impairment of fertility are examples of deterministic effects

1.3 Principles of radiation protection

There are three principles of radiation protection apply in all exposure situations:-

Justifications

Any decision that alters the radiation exposure situation should do more good than harm. This means that, by introducing a new radiation source, by reducing existing exposure, or by reducing the risk of potential exposure, one should achieve sufficient individual or societal benefit to offset the detriment it causes.

Optimization

The likelihood of incurring exposures, the number of people exposed, and the magnitude of their individual doses should all be kept as low as reasonably achievable, taking into account economic and societal factors. This means that the level of protection should be the best under the prevailing circumstances, maximizing the margin of benefit over harm. In order to avoid severely inequitable outcomes of this optimization procedure, there should be restrictions on the doses or risks to individuals from a particular source.

Dose limits The total dose to any individual from regulated sources in planned exposure situations other than medical exposure of patients should not exceed the appropriate limits recommended by the regulatory authority. Dose limits are determined by the regulatory authority, taking into account the international recommendations, and apply to workers and to members of the public in planned exposure situations. Dose limits proposed by International commission of radiological protection are summarized in Table 1.

Table 1. Dose limits

Dose limit	**Effective dose**	**Equivalent dose**
Occupational dose limit	20mSv per year averaged over five consecutive years but not more than 50mSv in any single year	150 mSv per year to the lens of the eye. 500mSv per year to the extremities (skin, hands and feet)
Apprentices and students	6mSv per a year	50mSv per year to the lens of the eye 150mSv per year to the extremities
Public	1mSv per year averaged over five years	15mSv per year to the lens of the eye 50mSv per year to the skin

Radiation protection issues relevant to the transport of radioactive materials

Radiation protection arrangements

Radiation protection arrangements in the transport of radioactive material may be diverse in nature, for example, include the following elements:

1. Review of individual and collective dose profiles and comparison with predicted dose profiles with a view towards identifying any problem areas,
2. application of suitable segregation distances,
3. adequate shielding arrangements,
4. specific stowing, loading, unloading and tie down instructions for high TI packages,
5. availability and application of operational dose limits,
6. access restrictions for "high background" areas,
7. Application of "dose minimizing" working schedules for personnel, e.g. job rotation provisions depending on the occupational dose incurred,
8. routine use of auxiliary package movement and lifting equipment,
9. driving and routing restrictions depending on the road and weather conditions (minimization of potential exposures)

1.4 Radiation protection programme

A radiation protection programme shall be established for the transport of radioactive material. The nature and extent of the measures to be employed in the programme shall be related to the magnitude and likelihood of radiation exposures. Programme documents shall be available, on request, for inspection by the relevant competent authority.

For occupational exposures arising from transport activities, where it is assessed that the effective dose:

1. Is likely to be between 1 and 6mSv in a year, a dose assessment programme via workplace monitoring or individual monitoring shall be conducted; or

2. Is likely to exceed 6mSv in a year, individual monitoring shall be conducted. When individual monitoring or workplace monitoring is conducted, appropriate records shall be kept.

1.5 Emergency response

In spite of all measures taken to ensure the safe transport of radioactive material there is still a finite probability that incidents and accidents involving radioactive material may take place in the public domain.

Such events may occur for various reasons with several outcomes. The operators may generally be responsible for their emergency plans for events occurring during their operations. However there will be other events which need broader arrangements, for example packages may be lost, incorrectly delivered, unclaimed or unexpectedly found. The objective of emergency response is to minimize the risk associated with transport incidents and accidents by providing a rapid and adequate response to such accidents. An adequate response may be defined as one in which potential or actual damage to persons, property and the environment is stabilized and ameliorated to the extent possible. This includes adequate medical and radiological care for any injured or contaminated persons, proper disposition of the radioactive material and cleanup of any radioactive material dispersed by the accident and restoration of the accident site to its normal condition and function. In some cases some actions may require a longer time; in such cases the initial response should at least assure adequate medical care for any injured persons and stabilization of any damage to property or the environment. Planning and advance preparation is generally necessary to assure that emergency response is timely and adequate when needed. The emergency response plan should address immediate actions that will be taken in the event of transport emergencies.

The plan should also contain a mechanism to immediately contact a person knowledgeable and professionally trained in radiation protection procedures, to assess the state of the radioactive material involved, and to determine how it should be dealt with (e.g., authorizing continued transport of undamaged packages, controlling and cleaning up spills, properly disposing of spilled material or damaged packages, and assuring that doses to all persons involved are minimized during these activities).

1.6 Quality assurance

Quality assurance programs based on international, national or other standards acceptable to the competent authority shall be established and implemented for the design, manufacture, testing, documentation, use, maintenance and inspection of all special form radioactive material, low dispersible radioactive material and packages and for transport and in-transit storage operations to ensure compliance with the relevant provisions of these Regulations. Certification that the design specification has been fully implemented shall be available to the competent authority. The manufacturer, consignor or user shall be prepared to provide facilities for competent authority inspection during manufacture and use and to demonstrate to any cognizant competent authority that:

1. The manufacturing methods and materials used are in accordance with the approved design specifications; and

2. All packagings are periodically inspected and, as necessary, repaired and maintained in good condition so that they continue to comply with all relevant requirements and specifications, even after repeated use. Where competent authority approval is required, such approval shall take into account and be contingent upon the adequacy of the quality assurance programme.

1.7 Training

Workers well receive appropriate training concerning radiation protection, including the precautions to be observed in order to restrict their occupational exposure and the exposure of other persons who might be affected by their actions.

Persons engaged in the transport of radioactive material shall receive training in the contents of the Regulations commensurate with their responsibilities.

Individuals such as those who classify radioactive material; pack radioactive material; mark and label radioactive material; prepare transport documents for radioactive material; offer or accept radioactive material for transport; carry or handle radioactive material in transport; mark or placard or load or unload packages of radioactive material into or from transport vehicles, bulk packagings or freight containers; or are otherwise directly involved in the transport of radioactive material as determined by the competent authority; shall receive the following training:

1. General awareness/familiarization training:
2. Each person shall receive training designed to provide familiarity with the general provisions Regulations issued by the competent authority;
3. Such training shall include a description of the categories of radioactive material; labelling, marking, placarding and packaging and segregation requirements; a description of the purpose and content of the radioactive material transport document; and a description of available emergency response documents.
4. Function specific training: Each person shall receive detailed training concerning specific radioactive material transport requirements which are applicable to the function that person performs.

1.8 Literature review

In this section, review of the current literature in this field of transport of radioactive materials is given.

Regulations for the Safe Transport of Radioactive Material, Safety Requirements No. TS-R-1, International Atomic Energy Agency (IAEA), Vienna, 2009 (Edition)

These Regulations establish by IAEA to standards of safety which provide an acceptable level of control of the radiation, criticality and thermal hazards to persons, property and the environment that are associated with the transport of radioactive material. These Regulations are based on the Fundamental Safety Principles, Safety Fundamentals No. SF-1 jointly sponsored by the European Atomic Energy Community (EAEC), the Food and Agriculture Organization of the United Nations (FAO), the IAEA, the International Labour Organization (ILO), the International Maritime Organization (IMO), the OECD Nuclear Energy Agency (NEA), the Pan American Health Organization (PAHO), the United Nations Environment Programme (UNEP) and the World Health Organization (WHO).

Safety of Transport of Radioactive Material (proceedings of an international conference Vienna, 7-11 July 2003.

This international conference on the Safety of Transport of Radioactive Material took place in Vienna, Austria from 7 to 11 July 2003, the subject of this conference, the Safety of Transport of Radioactive Material. The conference is published and contributed many paper on Safety of Transport of Radioactive Material.

Safety series no. 115, International Basic Safety Standards for Protection against Ionizing Radiations and for the Safety of Radiation Sources, IAEA, 2003

The Standards comprise basic requirements to be fulfilled in all activities involving radiation exposure. The Standards lay down basic principles and indicate the different aspects that should be covered by an effective radiation protection program. The Standards recognize that radiation is only one of many sources of risk in life, and that the risks associated with radiation should not only be weighed against its benefits but also viewed in perspective with other risks**.**

ICRP Publication 103

These revised Recommendations for a System of Radiological Protection formally replace the Commission's previous, 1990, Recommendations; and update, consolidate, and develop the additional guidance on the control of exposure from radiation sources issued since 1990.Thus, the present Recommendations update the radiation and tissue weighting factors in the quantities equivalent and effective dose and update the radiation detriment, based on the latest available scientific information of the biology and physics of radiation exposure. They maintain the Commission's three fundamental principles of radiological protection, namely justification, optimisation, and the application of dose limits, clarifying how they apply to radiation sources delivering exposure and to individuals receiving exposure.

Guidelines for the safe transport of radioactive material. (South African Department of Health).

This code provides information concerning the safe transport of radioactive material not related to the nuclear fuel cycle. It is not intended to be comprehensive, but aims to summarizes and supplement the IAEA transport regulations. The IAEA regulations, drawn up by the International Atomic Energy Agency, must be adhered to at all times when radioactive material is being transported in South Africa, or internationally.

Security in the Transport of Radioactive Material. IAEA Nuclear Security Series No.9

The guidance contained in Section 2 to be applied to the transport of radioactive material is intended to be used by a State to develop a nuclear security system. Section 3 uses the radioactivity level of the contents of a single package as the basis for defining security levels, Section 4 sets out baseline measures and guidance for those States that may not already have a well-defined and developed security system, including a regulatory infrastructure and a threat assessment process. States with a well-defined and developed regulatory infrastructure and threat assessment process may already have an adequate degree of security in place. However, even these States may also find this guidance useful.

1.9 Thesis objectives

The objective of this Research is to establish orientation and requirements that must be satisfied to ensure safety and to protect persons, property and the environment from the effects of radiation in case the transport of radioactive material. This protection is achieved by requiring.

In the transport of radioactive material, the safety of persons and the protection of property and the environment are assured when the local Regulations are complied with international recommendation. Confidence in this regard is achieved through quality assurance and compliance assurance programmes.

Containment of the radioactive contents;

Control of external radiation levels;

Prevention of criticality; and

Prevention of damage caused by heat.

These requirements are satisfied firstly by applying a graded approach to contents limits for packages and conveyances and to performance standards applied to package designs, depending upon the hazard of the radioactive contents. Secondly, they are satisfied by imposing requirements on the design and operation of packages and on the maintenance of packagings, including consideration of the nature of the radioactive contents. Finally, they are satisfied by requiring administrative controls, including, where appropriate, approval by regulatory authorities.

1.10 Thesis outlines

This research is structured so that chapter (1) provides general provisions for transport of radioactive materials and requirements for packagings and packages ; chapter (2) provides requirements and control of Transport of radioactive materials, determination of

TI, CSI and hazard associated with the content. Chapter (3) provides a historical overview of regulation that regulate radiation uses in Sudan, , Chapter (4) are provide procedures for license from regulatory authority, action should be take in case of incidents or accident ; security measures that could be used to implement safety and security in transport of radioactive material and case study .

Chapter Two:

Transport of radioactive materials

2.1 Classification of material:-

Radioactive material shall be assigned to one of the UN numbers specified in Table1, depending on the activity level of the radionuclides contained in a package, the fissile or non-fissile properties of these radionuclides, the type of package to be presented for transport, and the nature or form of the contents of the package, or special arrangements governing the transport operation, [2]

2.1.1 Basic radionuclide values:-

The following basic values for individual radionuclides are given in:

1. A1 and A2 in TBq;
2. Activity concentration for exempt material in Bq/g; and
3. Activity limits for exempt consignments in Bq.

2.1.2 Low specific activity (LSA) material

Low specific activity is given to any radioactive material which is uniformly dispersed throughout a substance to such an extent that it poses little hazard even if released in an accident. To be classified as low specific activity, the concentration must be greater than 0.002 microcuries per gram (otherwise it would not be radioactive) but less than specified concentration limits, which are based on the "A" values [2]. LSA material shall be in one of three groups:

1. LSA-I

a. (Uranium and thorium ores and concentrates of such ores, and other ores containing naturally occurring radionuclides which are intended to be processed for the use of these radionuclides;

b. Natural uranium, depleted uranium, natural thorium or their compounds or mixtures, that are unirradiated and in solid or liquid form;
c. Radioactive material for which the A2 value is unlimited, excluding fissile material not excepted or
d. Other radioactive material in which the activity is distributed throughout and the estimated average specific activity does not exceed 30 times the values for activity concentration, excluding fissile material not excepted.

2. LSA-II
1. Water with a tritium concentration of up to 0.8 TBq/L; or
2. Other material in which the activity is distributed throughout and the estimated average specific activity does not exceed 10–4A2/g for solids and gases, and 10–5A2/g for liquids.
3. LSA-III Solids (e.g. consolidated wastes, activated materials)
1. The radioactive material is distributed throughout a solid or a collection of solid objects, or is essentially uniformly distributed in a solid compact binding agent (such as concrete, bitumen, ceramic, etc.);
2. The radioactive material is relatively insoluble, or it is intrinsically contained in a relatively insoluble matrix, so that, even under loss of packaging, the loss of radioactive material per package by leaching when placed in water for seven days would not exceed 0.1A2; and
3. The estimated average specific activity of the solid, excluding any shielding material, does not exceed 2×10^3 A2/g. [2]

2.1.3 Surface contaminated object (SCO)

SCO means a solid object that is not itself classed as radioactive material ،but which has radioactive material distributed on any of its surfaces. An SCO must be in one of two groups with surface activity not exceeding the following limits :

1. SCO-I: A solid object on which:

a. (The non-fixed contamination on the accessible surface averaged over 300 cm^2 , or the area of the surface if less than 300 cm^2 , does not exceed 4 becquerel per cm^2 (10^{-4} µCi/cm^2) for beta and gamma and low toxicity alpha emitters, or 0.4 becquerel per cm (10 µCi/cm^2) for all other alpha emitters;

b. The fixed contamination on the accessible surface averaged over 300 cm^2 , or the area of the surface if less than 300 cm , does not exceed $4x10^4$ becquerel per cm (1.0 µCi/cm^2) for beta and gamma and low toxicity alpha emitters, or $4x10^3$ becquerel per cm (0.1 µCi/cm) for all other alpha emitters; and

c. The non-fixed contamination plus the fixed contamination on the inaccessible surface averaged over 300 cm^2 , or the area of the surface if less than 300 cm^2 , does not exceed $4x10^4$ becquerel per cm2 (1 µCi/cm2) for beta and gamma and low toxicity alpha emitters, or $4x10^3$ Becquerel per cm2 ^{2} (0.1 µCi/cm2) for all other alpha emitters.

2. SCO-II:

A solid object on which the limits for SCO-I are exceeded and on which:

a. The non-fixed contamination on the accessible surface averaged over 300 cm^2, or the area of the surface if less than 300 cm2, does not exceed 400 becquerel per cm2 (10-2 µCi/cm2) for beta and gamma and low toxicity alpha emitters or 40 becquerel per cm^2 (10-3 µCi/ cm^2) for all other alpha emitters;

b. The fixed contamination on the accessible surface averaged over 300 cm2, or the area of the surface if less than 300 cm2, does not exceed 8x104 becquerel per cm2 (20 µCi/ cm2) for beta and gamma and low toxicity alpha emitters, or 8x104 becquerel per cm2 (2 µCi/cm2) for all other alpha emitters; and

c. The non-fixed contamination plus the fixed contamination on the inaccessible surface averaged over 300 cm2, or the area of the surface if less than 300 cm2, does not exceed 8x105 becquerel per cm2 (20 µCi/ cm2) for beta and gamma and low toxicity alpha emitters, or 8x104 becquerel per cm2 (2 µCi/ cm2) for all other alpha emitters.

2.2 Classification of packages

Radioactive material, like other commodities, is transported every day by highway, rail, air, and water. Radioactive material is packaged to ensure that radiation levels at the package surface do not exceed regulations. This ensures that shippers, the public, and the environment are not exposed to radiation levels that exceed recognized safe limits [3].

2.2.1 General requirement for all packaging and packages:-

1. The package shall be so designed in relation to its mass, volume and shape that it can be easily and safely transported. In addition, the package shall be so designed that it can be properly secured in or on the conveyance during transport.
2. The design shall be such that any lifting attachments on the package will not fail when used in the intended manner and that if failure of the attachments should occur, the ability of the package to meet other requirements of these Regulations would not be impaired. The design shall take account of appropriate safety factors to cover snatch lifting.
3. Attachments and any other features on the outer surface of the package which could be used to lift it shall be designed either to support its mass or shall be removable or otherwise rendered incapable of being used during transport.
4. As far as practicable, the packaging shall be so designed and finished that the external surfaces are free from protruding features and can be easily decontaminated.
5. As far as practicable, the outer layer of the package shall be so designed as to prevent the collection and the retention of water.
6. Any features added to the package at the time of transport which are not part of the package shall not reduce its safety.
7. The package shall be capable of withstanding the effects of any acceleration, vibration or vibration resonance which may arise under routine conditions of transport without any deterioration in the effectiveness of the closing devices on

the various receptacles or in the integrity of the package as a whole. In particular, nuts, bolts and other securing devices shall be so designed as to prevent them from becoming loose or being released unintentionally, even after repeated use.

8. The materials of the packaging and any components or structures shall be physically and chemically compatible with each other and with the radioactive contents. Account shall be taken of their behavior under irradiation [6].
9. All valves through which the radioactive contents could escape shall be protected against unauthorized operation.
10. The design of the package shall take into account ambient temperatures and pressures that are likely to be encountered in routine conditions of transport.
11. For radioactive material having other dangerous properties, the package design shall take into account those properties.

2.3 Type of packages:-

Different shipping packaging is required for various types, forms, quantities, and levels of radioactivity. Four packaging types are presented [5]:

1. Excepted Packaging
2. Industrial Packaging
3. Type A Packaging
4. Type B Packaging

2.3.1 Accepted Packaging:-

Excepted Packaging is used to transport material with extremely low levels of radioactivity. Excepted packagings 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 packagings are excepted (excluded) from specific packaging, labelling, and shipping paper requirements; The radiation levels on the external surface of the package shall not exceed 5uSv/h they are however, required to have the letters "UN" and the appropriate four-digit UN identification number marked on the outside of the package.

2.3.2 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. The regulations must 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.

2.3.3 Type A Packaging:

Type A packaging is used to transport small quantities of radioactive material with higher concentrations of radioactivity than those shipped in industrial packagings. 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. 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 packagings are only used to transport non life-endangering amounts of radioactive material.

2.3.4 Type B Packaging:-

Type B packaging is designed to transport material with the highest levels of radioactivity. Type B packagings 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 packagings include spent nuclear fuel, high-level radioactive waste, and high concentrations of other radioactive material such as caesium 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.

2.4 Requirements before the first shipment:-

All radioactive materials must be properly packaged so that the radiation level at the package surface does not exceed regulations. This protects package handlers, transporters, and the public against receiving dose rates in excess of recognized safe limits. After radioactive materials are placed in the proper packaging, they are sealed, surveyed with special instruments to determine that radiation is within SAEC regulatory limits, and checked for external contamination.

The package is then marked and labelled to provide information about its contents. Four basic types of packaging are used: Excepted, Industrial, Type A, and Type B. Another option, the Strong-tight packaging, is still available for some domestic shipments of radioactive materials [2].

2.5 Customs operations

Customs operations involving the inspection of the radioactive contents of a package shall be carried out only in a place where adequate means of controlling radiation exposure are provided and in the presence of qualified persons. Any package opened on customs instructions shall, before being forwarded to the consignee, be restored to its original condition.

Where a consignment is undeliverable, the consignment shall be placed in a safe location and the regulatory authority shall be informed as soon as possible and a request made for instructions on further action.

2.6 Control for Transport of Excepted Packages

There are some packages of radioactive material with such low levels of radioactivity that they present low radiological hazards and low security risks (e.g. consumer products, very small quantities of radionuclide, material with very low activity concentration) [2]. Because of the very limited potential consequences that could arise from their use in malicious acts, excepted packages with contents not exceeding the activity allowed for non-special form material, and LSA-I and SCO-I not need to be subjected to transport security provisions more stringent than those ordinarily applied to a commercial shipment. The normal commercial controls applied to these shipments are appropriate for their very low potential consequences if used in a malicious act.

2.7 Determination of transport index (TI)

Determine the maximum radiation dose level in units of millisieverts per hour (mSv/h) at a distance of 1 m from the external surfaces of the package, overpack, freight container or unpackaged LSA-I and SCO-I. The value determined shall be multiplied by 100 and the resulting number is the TI.

The TI for each overpack, freight container or conveyance shall be determined as either the sum of the TIs of all the packages contained, or by direct measurement of radiation level, for which the TI shall be determined only as the sum of the TIs of all the packages.

2.8 Determination of criticality safety index (CSI) for consignments:-

The CSI for each overpack or freight container shall be determined as the sum of the CSIs of all the packages contained. The same procedure shall be followed for determining the total sum of the CSIs in a consignment or aboard a conveyance.

2.9 Marking, labelling and placarding

To distinguish between marking & labelling, you can think of marking as language and labelling as placarding for containers. Markings are designed to provide an explanation of the contents of a package by using standard terms and codes Labels are used to visually indicate the type of hazard and the level of hazard contained in a package. Labels rely principally on symbols to indicate the hazard

2.9.1 Marking

Some markings are required on the packagings, including the following:

1. a legible and durable mark of gross weight (if more than 50 kg) in order to facilitate mechanical handling, and observance of floor loading and vehicle loading limits;
2. Package design type, i.e. Type A, Type B(U) or B(M). For Type B packages, this marking provides information on the kind of competent authority design approval, and for Type A packages it signifies that the design has been made in accordance with the performance criteria in the Regulations and that the designer and/or consignor is satisfied that the package characteristics are adequate;
3. Identification markings assigned to the package design by the competent authority. This marking provides a link between the individual package and the corresponding national competent authority design approval; and
4. In some cases, the serial number to uniquely identify each packaging which conforms to that design. This marking is required because operational quality assurance and maintenance activities are oriented towards each packaging.

2.9.2 Labeling

All packages, other than excepted packages, must bear labels. Transport workers need to be aware of the contents of Packages, overpacks, tanks and freight containers they are handling. It is necessary to be able to identify the precise radiological hazard associated with the content of the cargo unit and the storage and stowage provisions which may be applicable. In the event of an accident in which a package is damaged, the radioactive content and activity information marked on the label is useful to emergency response personnel. In terms of the radiation levels which may be encountered on the surface of the package, and in terms of transport index, packages are classified according to one of three categories. There is a different label for each category of package to simplify recognition and facilitate control by workers when handling packages. The labels are either white or yellow. The yellow labels indicate that limitations are placed upon how these packages can be stowed or stored to ensure radiation safety and guard against criticality. The packaging categories and labels are as follows (table2):

■ Category I - White, in which the maximum radiation level at the surface is not more than 0.005 mSv/h and the transport index does not exceed 0 Figure (1),;

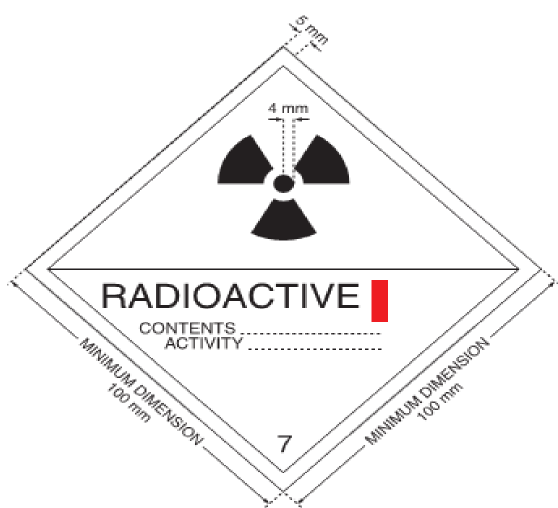


Figure 1. Category I-WHITE label. The background colour of the label shall be white, the colour of the trefoil and the printing shall be black, and the colour of the category bar shall be red

■ Category II -Yellow, in which the radiation level at the surface does not exceed 0.5 mSv/h and the transport index does not exceed 1shown in Figure1.

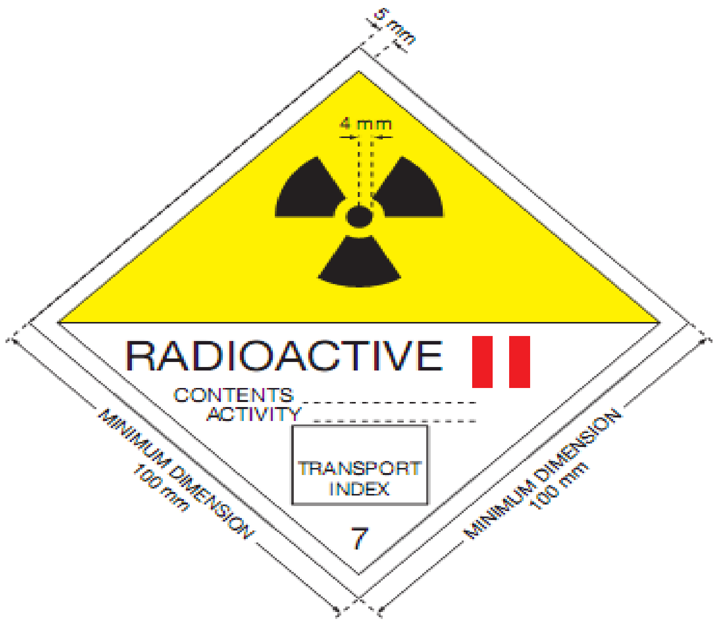


Figure 2. Category II-YELLOW label. The background colour of the upper half of the label shall be yellow and the lower half white, the colour of the trefoil and the printing shall be black, and the colour of the category bars shall be red.

■ Category III - Yellow, is usually for packages with a surface radiation level not more than 2mSv/h and a transport index of not more than 10 Figure (3).

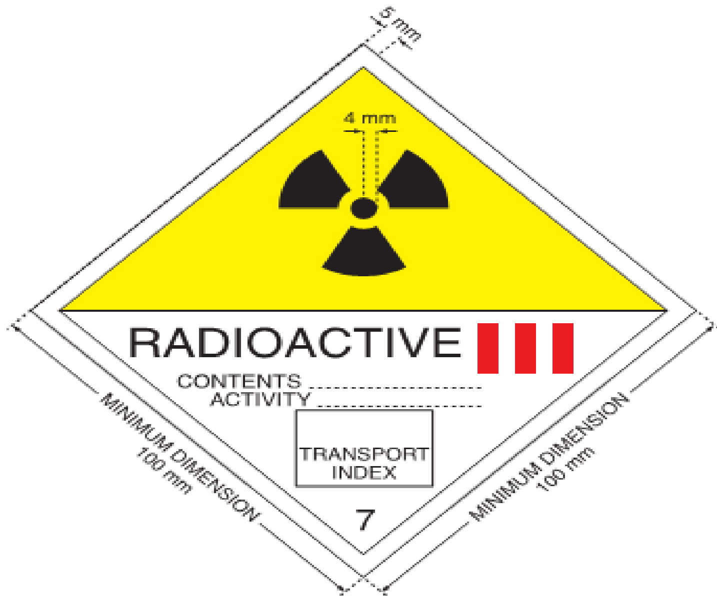


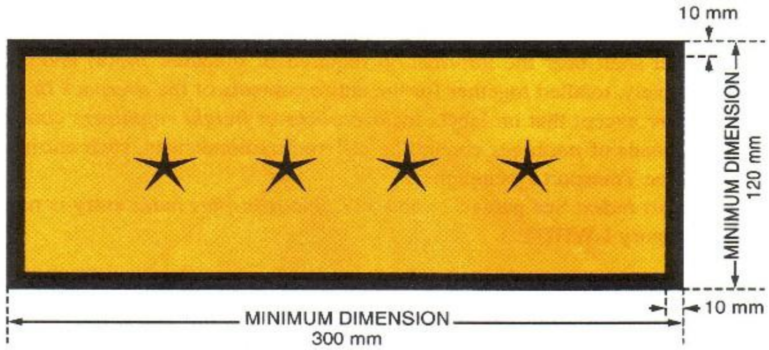
Figure 3. Category III-YELLOW label. The background colour of the upper. Half of the label shall be yellow and the lower half white, the colour of the Trefoil and the printing shall be black, and the colour of the category bars Shall be red.

The radioactive material labels constitute part of a set of labels implemented by the UN Recommendations on the Transport of Dangerous Goods and used internationally to identify the various classes of dangerous goods. Labels need to be affixed to packages and overpacks on two opposite sides so that at least one label is visible irrespective of how the package or overpack is placed. For tanks and freight containers the labels need to be displayed on all four sides in order to ensure that a label is visible without people having to search for it, and to minimise the chance of its being obscured by other cargo units.

2.9.3 Placarding:

Placards on vehicles, rail cars, freight containers and portable tanks are required in order to indicate the presence of radioactive material. Requirements may vary for different modes of transport, and for different types of consignment, but in all cases the placard indicates that radioactive material is present. These placards are designed in a similar way to the package labels (trefoil symbol and figure 7 indicated), although they do not bear the detailed information on transport Index, contents and activity. The size of the placard is intended to make it easy to read, even at distance.

When an empty packaging is transported as an excepted package in accordance with regulation the previously displayed labels must not be visible.



Placard for separate display of UN number. The background colour of the placard shall be orange and the border and UN number shall be black. The symbol “****” *denotes the space in which the appropriate UN number for radioactive material,*

.

2.10 Consignor's responsibility

The consignor (entity presenting package for transport) shall undertake and be responsible for the following:

1. He shall ensure that the transport documents are correctly completed .
2. He shall ensure that the package is in a proper condition for transport and is requirements with the transport regulations.

2.11 Responsibilities of carriers:-

Segregation of packages during transport and storage in transit:

1. Packages, overpacks and freight containers containing radioactive material must be segregated during transport and during storage in transit [2]:

a. From places occupied by persons and from undeveloped photographic film, for radiation exposure control purposes
b. From other dangerous goods.

2. Category II-YELLOW or III-YELLOW packages or overpacks must not be carried in compartments occupied by passengers, except those exclusively reserved for couriers specially authorized to accompany such packages or overpacks.
3. No persons other than the driver and assistants must be permitted in vehicles carrying packages, overpacks or freight containers bearing category II-YELLOW or III-YELLOW labels. [2]

Chapter Three:

Status of transport of radioactive materials in Sudan

3.1 Regulations for the transport of radioactive materials.

In 1971 an Act was issued for "Regulation of use of Ionizing Radiation', establishing a committee and empowering it the right to license and inspect diagnostic X-ray facilities by the time. The Atomic Energy Committee was established in 1973 and was given the powers to oversee safety in all activities involving safe use of ionizing radiation.

Both 1971 and 1973 Acts did not enable establishment of a radiation protection regulatory framework or a technical authority. The Sudan Atomic Energy Commission (SAEC) Act was issued in January1996. Under this Act, the Council of Ministers of the government of Sudan appoints a national policymaking BOARD [1].

The SAEC BOARD, beside its promotional function, was given the mandate to establish the National Regulatory Authority named Radiation Protection Technical Committee 'RPTC'. RPTC as a national committee was given the responsibility for: -

1. Preparation of drafts of Radiation Protection Regulations and field specific Technical Guidelines to be issued by the BOARD,
2. Setting radiation protection and environmental monitoring policies and priorities and securing funds to enable implementation and promotion of these activities,
3. Supervision of implementation of Regulations and Safety Guides by the designated radiation protection institution.
4. Grant licenses as a basis for operating permits to governmental or private institutions and organizations or persons who keep, use, import, export, transport, store or trade in radioactive material and radiation equipment, and to inspect these institutions and organizations for compliance with radiation safety legislation; to enforce insurance obligations for implementing the above

activities; to cancel licenses temporarily or permanently in the event of noncompliance with radiation safety legislation; to decide to close down the above institutions and organizations; and to initiate legal investigations in accordance with general legal principles.

5. Prepare the decrees and regulations determining the principles of insurance obligations, usage, export, import and transport of radioisotopes.

Sudan regulations are based on international transport standards that are used to safely ship radioactive materials. SAEC and RPTC have primary responsibility for establishing and enforcing requirements for the safe transport of radioactive materials in Sudan. SAEC regulations set the standards for packaging, transporting, and handling radioactive materials, including labelling, shipping papers, placarding, loading, and unloading requirements. SAEC or RPTC regulations also specify training needed for personnel who perform handling and transport of hazardous materials.

3.2 The annual number of transports for radioactive materials.

In Sudan, many types of radioactive materials are employed in a variety of useful and steadily increasing applications. Applications include medicine, non-destructive testing (NDT), well logging, research and education. To the best of our knowledge none of these materials is manufactured locally and therefore they are transported to the field via diverse roots that include sea, air and land.

In the period from 2005 to 2008, the number of sealed radioactive material transported in the country was around 237 unsealed sources used in medical and research application in addition to 470 sources used in other applications. Based on the purpose for which the shipments of radioactive materials transported in Sudan are undertaken, they can be classified into the group of shipments related to the use of radioactive material in research, medicine and industry.

3.3 Case studies in transport of radioactive materials Form for transport of radioactive material:

3.3.1 Form 1 transport of radioactive source in industrial application well logging.

Source Information:

Oregon of the source (c)	Port of first inters	No. of transport license	Package type	Type of category	Number of sources	Radionuclide		Physical Form
FRANCE	Khartoum airport	10-TS-TS154 10-TS-TS155	OVERPACK TYPE A	4	2	Cs^{137} Am241Be		solid
Activity	Dose Rate @ surface	Dose Rate @ 1m from the Source	Dose Rate @ driver seat	Dose Rate @ vehicle surface	Max. Dose Rate @1m from the vehicle	Means of transport	Distance Per kg	Time to destination
1.7Ci 10Ci	N/A	N/A	N/A	N/A	N/A	Car	450	6

Transport from …ADAR ……………………….. To………HEGLIG……………………………………..

Notes: : this source will be used in industrial application part of well logging

3.3.2 Form 2 transport of radioactive source use in industrial application nuclear gauge

Name of facility: IA-NG-1 …………………………………………………………………………………..

Source information

Oregon of the source (c)	port of first inters	no. of transport license	package type	type of category	number of sources	radionuclide	physical form
Russa	Khartoum air port	10-IS-TS163	A-drum	5	1	Cf^{252}	Solid
activity	dose rate @ surface	dose rate @ 1m from the source	dose rate @ driver seat	dose rate @ vehicle surface	max. dose rate @1m from the vehicle	means of transport	time to destination
37.4 mCi	Gamma (79.5 - 78.4) µSv/h Neutron (37.35 – 39.20) µSv/h	Gamma 1.02 µSv/h Neutron 3.20 µSv/h	Gamma 0.78 µSv/h Neutron 0.63 µSv/h	Gamma (3.99 – 2.93) µSv/h Neutron (3.87 – 3.52) µSv/h	Gamma (1.53 – 1.15) µSv/h Neutron (1.90 – 1.98) µSv/h	TRACK	5h

Transport from …………… Khartoum air port ……………………………….. To……………… BERBER

Notes: this source will be used in industrial application part of nuclear gauge

3.3.3 Form 3 transport of radioactive source use in industrial application NDT

Name of facility: IA-NDT-2 ……………………………………………………………………………..

Source Information

Oregon of the source (c)	Port of first inters	No. of transport license	Package type	Type of category	Number of sources	Radionuclide	Physical Form	
South Africa	Khartoum airport	TS-179	GAMMAMAT	2	1	Ir-192	Solid	
Activity	Dose Rate @ surface	Dose Rate @ 1m from the Source	Dose Rate @ driver seat	Dose Rate @ vehicle surface	Max. Dose Rate @1m from the vehicle	Means of transport	Distance Per kg	Time to destination
107.84Ci	92.5µSv/h	4.80 µSv/h	2.58 µSv/h	10 µSv/h	1.5 µSv/h	Car	1200	N\A

Transport from …Khartoum airport………………………………….. To………belila……………………………………..

Notes: this source will be used in industrial application part industrial radiography (NDT).

3.3.4 Form 4 transport of radioactive source use in medical application nuclear medicine

Name of facility: ……………… MA-1 ………………………………………………………..

Source Information

Oregon of the source (c)	Port of first inters	No. of transport license	Package type	Type of category	Number of sources	Radionuclide	Physical Form	
Netherlands	Khartoum airport	10-MU-IM071	TYPE A	4	1	I-131	SOLID	
Activity	Dose Rate @ surface	Dose Rate @ 1m from the Source	Dose Rate @ driver seat	Dose Rate @ vehicle surface	Max. Dose Rate @1m from the vehicle	Means of transport	Distance Per kg	Time to destination
20 GBq	1 mSv/h	150 µSv/h	4.80 µSv/h	20 µSv/h	5.4 µSv/h	Car	5	Half hour

Transport from …Khartoum air port ……………………….. To………facility in khartoum…………………………………….

Notes: : this source will be used in medical application nuclear medicine.

3.3.5 Form 5 transport of radioactive source use in medical application nuclear medicine

Name of facility: ………… MA-2

Source Information

Oregon of the source (c)	Port of first inters	No. of transport license	Package type	Type of category	Number of sources	Radionuclide	Physical Form	
TURKIA	Khartoum airport	10-MU-IM070	TYPE A	4	1	Mo-99	LIQUID	
Activity	Dose Rate @ surface	Dose Rate @ 1m from the Source	Dose Rate @ driver seat	Dose Rate @ vehicle surface	Max. Dose Rate @1m from the vehicle	Means of transport	Distance Per kg	Time to destination
20 GBq	150 µSv/h	150 µSv/h	1.5 µSv/h	9.2 µSv/h	3.1 µSv/h	Car	190	3 hour

Transport from …Khartoum airport ……………………….. To…wadmadani……………………………………..

Notes: : this source will be used in medical application in nuclear medicine.

Chapter Four:

License & security in transport of radioactive materials

4.1 Introduction

Radiation protection technical committee is the designated regulatory authority in charge of licensing and regulatory control of radiation sources in Sudan. A general license is hereby issued by RPTC to any licensee to transport, or to deliver to a carrier for transport, licensed material in a package for which a license, certificate of compliance, or other approval has been issued by the Radiation Protection Technical Committee 'RPTC'. Before the first shipment of any package requiring RPTC approval, the consignor shall ensure that copies of each applicable regulatory authority certificate applying to that package design have been submitted to the regulatory authority of the country through or into which the consignment is to be transported[1].

This general license applies only to a licensee who:-

1. Has a copy of the specific license, certificate of compliance, or approval by the regulatory authority.
2. Complies with the terms and conditions of the license, certificate, or other approval by the regulatory authority, and the applicable requirements.
3. Appropriate training must be provided to all workers involved in the transport, loading and unloading the material
4. Appropriate placards should be placed on the vehicle
5. Has a quality assurance program.

4.2 Transport documentation

Radioactive shipments must be properly documented and the shipping document must be carried with the shipment in the driver's compartment. General specifies the information that is required to be listed on the shipping document for each type of package transported. This information is to be provided on the standard shipping form shown in below.

Standard shipping form

Container number:	....	Maximum activity :	....
Shipping name	....	Physical/chemical form:	....
Class 7:	....	Radiation label (I-White, II-Yellow, III-Yellow)	....
UN number:	....	Transport index:	....
Radionuclide	....	Exclusive use:	....
Total activity of shipment(as multiple of A2 value):		....	

4.3 Radiation levels during transport

1. The radiation level must not exceed 2 mSv/hr on the exterior surface of any package except for exclusive use shipments in which case the radiation level must not exceed 10 mSv/hr on the external surface of the package.
2. The radiation level must not exceed 2 mSv/hr on the exterior surface of the vehicle and must not exceed 0.1 mSv/hr at a distance of 2 meters from the vehicle. [2]

4.4 Transportation incidents

4.4.1 Type:-

Conveyance carrying radioactive material may involve in an accident;

1. Package shows evidence of damage, tampering or leakage of its contents;
2. Any failure to comply with the Act or any license or certificate applicable to a package that may reasonably be expected to lead to a situation in which the environment, the health and safety of persons or national security is adversely affected;
3. Radioactive material is lost, stolen or no longer in control of a person who is required to have control of it .
4. Radioactive material has escaped from a containment system, a package or a conveyance during transport.
5. Accidental Release has occurred.

4.4.2 Actions shall be done:-

1. Contact the local police and provide details of the accident and its location request an ambulance or the fire department if necessary.

2. Contact the Radiation Protection Officer immediately.

3. Limit, to the extent possible, the spread of radioactive material.

4. Place barriers, signs or personnel at every point of entry into the affected area to control the entry of persons into the area.
5. Isolate any uninjured personnel or equipment suspected of being contaminated. Record the name, address and telephone number of any person who may have been exposed to or contaminated by radioactive material and request that the person remain available for assessment by an expert in radiation protection.
6. Do not touch or walk through spilled material. Keep upwind of the spill area and keep unauthorized personnel away. The area involving the radioactive spill or leak must be immediately isolated. When a large quantity of radioactive material is involved in a major fire, an initial evacuation should be set up for at least 100 meters in all directions.
7. Do not clean-up or dispose of radioactive contaminated material except under supervision of a specialist. Have an expert in radiation protection assess the situation and report the results of the assessment to the Regulatory authority.

4.5 Security considerations for transport RM

The transport of radioactive material is usually an interim phase between production, use, storage and disposal of the material. The potential radiological consequences of the loss of control due to theft of radioactive material during use, storage or transport do not differ in principle, although the potential consequences of an act of sabotage might differ very much depending on the location of the radioactive material.

In view of the potential vulnerability of radioactive material in transport, the design of an adequate transport security system incorporates the concept of defence in depth and uses a graded approach to achieve the objective of preventing the material from becoming susceptible to malicious acts [10]. The transport security system should be designed to take into account:

1. The quantity and the physical and chemical form of the radioactive material.
2. The mode(s) of transport.
3. The package(s) being used.
4. Measures that are required:
5. To deter, detect and delay unauthorized access to the radioactive material while in transport and during storage in transit to defeat any attempted malicious acts;
6. To identify the actual possible malicious acts involving any consignment while in transport or during storage incidental to transport to enable an appropriate response and to allow recovery or mitigation efforts to start as soon as possible;
7. To provide rapid response to any attempts directed towards, or actual, unauthorized access to radioactive material, or to other malicious acts involving radioactive material while in transport or storage incidental to such transport.
8. Capabilities for:
    a. Recovering any damaged, stolen or lost radioactive material and bringing it under secure regulatory control;
    b. Minimizing and mitigating the radiological consequences of any theft, sabotage or other malicious act.

The achievement of effective security in transport can be assisted by considering transport schedules, routing, and security of passage, information security and procedures. In particular and as far as are operationally practicable, general recommendations to be regarded as best practice are as follows:

c. Regular movement schedules are to be avoided to the extent practicable.
d. Routes are planned in such a way as to avoid areas of natural disaster, civil disorder or known threats; in the case of shipments of Category 1 and 2 sources, alternative routes are identified in advance of such shipments in case they are required under circumstances such that the primary route is not available.

c. The total time that radioactive material is in transport, the number of intermodal transfers and the waiting times associated with the intermodal transfer are kept to the minimum necessary.
d. Advance knowledge of transport information and the security measures applied to the transport are restricted to the minimum number of persons necessary.
e. Packages or conveyances containing radioactive material are not left unattended for any longer than is absolutely necessary.
f. Radioactive material in transport and in temporary storage incidental to transport is subject to security measures consistent with those to be applied to the material in use and storage. [10]

4.5.1 Role of government for security transport of RM:

The establishment of an adequate security regime for the transport of radioactive material is the responsibility of the government. The government shall establish the basic requirements for legal and governmental infrastructure for transport security, including [12]:

1. Designation of an independent competent authority responsible for the implementation, application, inspection and enforcement of the legislative and regulatory framework, including effective sanctions;
2. Setting objectives for protecting individuals, society and the environment from radiation hazards, including those that might result from a malicious act involving radioactive material in transport;
3. Development and integration of formal objectives and standards in security regulations;
4. Identification of the State's domestic threat and the prescription of requirements for the design and evaluation of the security system in transport;
5. Review of the security system on a regular basis in order to take account of advances in technology and potential changes in the threat;
6. Procedure for submission by the operator and, where appropriate, approval by the competent authority of a security plan prior to transport of radioactive material;

7. Development of a programme for verifying continued compliance with the security regulations through periodic inspections and by ensuring that corrective actions are taken when needed;
8. Development of a policy to identify, classify and control sensitive information, the unauthorized disclosure of which could compromise the security of radioactive material in transport;
9. Determination of security clearance procedures, including a positive identification programme (with an officially issued photographic identification or biometric record that positively identifies the individual), for persons engaged in the transport of radioactive material, commensurate with their responsibilities;
10. Reporting of security related events, including losses;
11. Establishment of criminal penalties for non-compliance with the requirements for security in transport.

4.5.2 Security plans:

All operators (consignors, carriers, consignees) and other persons engaged in the transport of radioactive material packages requiring the enhanced security level should develop, adopt, implement, periodically review as necessary and comply with the provisions of a security plan. The security plan should include at least the following elements and should be modified as needed to reflect the threat level at the time of its application and any changes to the transport programme:

1. Specific allocation of responsibilities for security to competent and qualified persons with appropriate authority to carry out their responsibilities.
2. Provision for keeping records of radioactive material packages or types of radioactive material transported.
3. Review of current operations and assessment of vulnerability, including intermodal transfer, storage in transit, handling and distribution as appropriate.
4. Clear statements of measures, including: training, policies including response to conditions of a higher level threat, verification of new employees and employment, operating practices (e.g. choice and use of routes where known, use

of guards, access to radioactive material packages requiring the enhanced security level in temporary storage, proximity to vulnerable infrastructure), equipment and resources that are to be used to reduce security related risks.

5. Effective procedures and equipment for timely reporting and dealing with security related threats, breaches of security or security related incidents.
6. Procedures for evaluating and testing security plans and procedures for periodic review and update of the plans.
7. Measures to ensure the security of transport information contained in the security plan.
8. Measures to ensure that the distribution of sensitive transport information is limited, to maintain security of the information. Such measures should not preclude the provision of transport documents and consignor's declaration.
9. Measures to monitor the location of the shipment.
10. Where appropriate, details concerning agreements on the point of transfer of responsibility for security.

Chapter Five:

Discussions and conclusions

5.1 Discussion

Most radioactive materials used in Sudan and therefore their transport are in industrial and medical applications and there is no transport of nuclear fuel cycle in Sudan. Most radionuclide for industrial and medical uses is transported extensively by road. This category of material accounts for large number of package moved around 200 packages transported per year. Radiations doses at the surface and at specified distant from the transport means low compared to the local regulation and international recommendations (see form). This is clear evidence that the import of radioactive materials in Sudan dose not impose high dose levels for workers, public and the environment.

Our study dose not record or reported the occurrence of any accident or incident during the transport of radioactive material in the Sudan in the last five years. In general the regulatory frame work for the transport of radioactive material in the Sudan is not well developed there for the responsibilities for regulating; licensing and inspection should be more clearly separated from the operational and promotional function. It was observed that the Sudan customs regulations specify permission from Sudan Atomic Energy Commission (SAEC) in case of import and export of radioactive material which enhance the security of radioactive material transport. Transport of radioactive material by land is only carried out using road vehicles; trains are not used. It was observed that there are no dedicated Conveyance to transport of radioactive materials as recommended by international organisations such IAEA. Only companies licensed by (SAEC) can import, export and transport radioactive materials in Sudan.

It is therefore necessary to updating regulations taking into account new requirement for transport as well as development in technology and radiation protection. There is no comprehensive emergency plan to deal with any radiological accident in transport radioactive materials and issue that should considered when formulating new regulations cases studies indicated that there is lack of control of radioactive material during transportation from site to another in the field .

5.2 Conclusions

The development of radiation protection programmes and the refinement of risk-assessment methods, together with implementation of radiological protection principle in safe transport of radioactive materials are of paramount important feature of the new regulatory framework to be considered. The determination of the safety and security level should be in accordance with established international standards and guidelines for safe transport of radioactive materials. Issues of public and environmental health professionals concern must be taken into account. Such information will help increase the knowledge of appropriate responses to a radiological transportation incident.

There is a powerful message here: transport of radioactive material plays a vital role in implementation of peaceful uses of the atom for the benefit of society. Continuing reviewing and implementation of regulations, which regulate transport of radioactive material.

Appendix

• **Consignor**

Any person or organization that prepares a consignment of any radioactive materials for transport and send it through conveyance in or out of United Arab Emirates, is named as consignor in the transport documents.

• **Consignee**

Consignee shall mean any person, or organization that receives a consignment.

• **Carrier**

Any person or organization undertaking the carriage of radioactive material by any means of transport.

• **Vessel**

Vessel shall mean any seagoing vessel or inland waterway craft used for carrying cargo.

• **Vehicle**

Vehicle shall mean a road vehicle (including an articulated vehicle, i.e. a tractor and semi-trailer combination) or railroad car or railway wagon.

• **Radiation Level**

Radiation Level shall mean the corresponding dose rate expressed in milliSievert per hour.

• **A1 Value**

A1 shall mean the activity value of special form radioactive material to transport in type A package.

A2 Value

A2 shall mean the activity value of radioactive material, other than special form radioactive material to transport in type A package.

Special Form Radioactive Material

Special Form Radioactive Material shall mean either an indispensable solid radioactive material or a sealed capsule containing radioactive material.

• **Low Dispersible Radioactive Material**

Low Dispersible Radioactive Material shall mean either a solid radioactive material or a solid radioactive material in a sealed capsule that has limited disposability and is not in powder form.

- **Transport**

Transport comprises all operations and conditions associated with and involved in the movement of radioactive material, these include the design, manufacture, maintenance and repair of packaging, and the preparation, consigning, loading, carriage including in-transit storage, unloading and receipt at the final destination of loads of radioactive material and packages, in or out of United Arab Emirates.

Regulatory Authority

An authority or authorities designated or otherwise recognized by a government for regulatory purposes in connection with protection and safety.

- **Conveyance**

Conveyance means:

(1) Any vehicle moves on road or rail line.

(2) Any vessel, any hold, compartment, or defined deck area of a vessel especial for storage, and

(3) Any aircraft.

- **Millisievert (mSv)**

A metric unit measuring radiation's effect on the human body equal to one-thousandth of a sievert. 1**mSv** equals 100 millirem.

- **Package:**

The packaging and its radioactive contents as presented together for transport.

- **Packaging**:

For radioactive materials, the assembly of components necessary to ensure compliance with the packaging requirements of regulation . It may consist of one or more receptacles, absorbent materials, spacing structures, thermal insulation, radiation

- **Activity, A**

The expectation value of the number of nuclear transformations occurring in a given quantity of material per unit time. The SI unit of activity is per second (s) and its special name is becquerel (Bq).

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