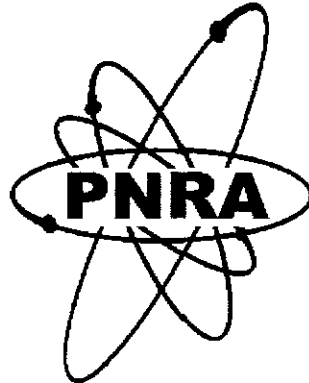




**TRANSPORTATION OF RADIOACTIVE MATERIAL  
BY ROAD IN PAKISTAN**

**REGULATORY GUIDE**

**PAKISTAN NUCLEAR REGULATORY AUTHORITY  
P.O. Box 1912, Islamabad**



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## **ABSTRACT**

A large number of radioactive sources are being used for industrial, medical and research applications which may requires frequent transportations. To regulate the safe transportation of such materials, PNRA has gazette notified the transport regulations PAK/916 by adopting the IAEA Transport Requirements (TS-R-1 1996 Edition as amended 2003). This document provides guidance for safe and secure transportation of radioactive materials by road.



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## 1. Introduction

Many types of radioactive material for various applications are transported by all the major modes of transport for decades from one place to another to benefit mankind. Effective and efficient regulatory control and good safety practices by the 'transport industry' i.e. consignors, carriers, and consignees have, so far, maintained a good safety record as no incident with serious human health effects, adverse environmental or economic impact, has occurred due to the transport of radioactive material. However, the regulators and the transport industry should remain alert in the light of advancement in the technology and assessment skill. Moreover, the incident of 9/11 and changing threat levels require additional measures to address security concern during transportation of radioactive material.

The Federal Government has entrusted Pakistan Nuclear Regulatory Authority (PNRA) under section 16 of PNRA Ordinance No. III of 2001 to control, regulate and supervise all matters related to nuclear and radiation safety in Pakistan <sup>[1]</sup>. This also includes measures related to radiation safety aspects during movement of radioactive materials from and within Pakistan.

A large number of low to medium activity sealed radioactive sources (SRS) are being used in Pakistan for industrial radiography, well logging, level and thickness gauging, etc.<sup>[2]</sup> High activity SRS are used in radiotherapy, irradiators etc. Besides the SRS, the radionuclides in unsealed form are used in medicine and research every day. Isotope Production Division (IPD) of PINSTECH prepares some radionuclides for medical application. However, a large amount of radioisotopes are still imported for medical and research applications. After useful application of such sealed sources, these are either returned to the manufacturer/supplier or transferred to PINSTECH, Islamabad and KNPC, Karachi, as specified in Regulations on Radioactive Waste Management PAK/915 <sup>[3]</sup>. All these radioactive material require frequent transportation from one place to another according to the job requirements. Therefore, their safe and secure transportation is essential in order to protect the workers, the public and the environment from the harmful effects of radiation during transportation. Currently, Pakistan is following the IAEA Transport Requirements (TS-R-1 1996 Edition as Amended 2003<sup>[4]</sup>) in the country. In order to further elaborate the requirements as specified under Section V and at other relevant sections of this IAEA Standard, this regulatory guideline has been prepared. The document mainly concentrates on transportation of such consignments by road within Pakistan. The non-compliance of the transport requirement is punishable under section 44 of PNRA Ordinance No. III of 2001<sup>[1]</sup>.

## 2. Objective

The objective of this document is to provide guidance for the safe transport of radioactive material so that the workers: -consignors, carriers, and consignees,

the public and the environment can be protected from the harmful effects of radiation during transport of radioactive material.

### **3. Scope**

This document will cover the different phases of transport of radioactive material by road. It will also elaborate appropriate measures regarding security during transport of radioactive material.

### **4. Interpretation**

The interpretation or explanation of any section, phrase, term or word of this document will be referred to Member corporate, PNRA and his decision will be final. No changes in this coding system may be carried out without prior approval of Member Corporate, PNRA.

### **5. Applicability**

The applicability of this guide will be from the date of its issuance, and it will remain in use until it is reviewed or superseded by some other guide issued by PNRA.

## **6. Transportation of Radioactive Material**

The transportation involved different phases such as receiving, shipping and carrying of radioactive material. Appropriate measures should be followed during all three phases of transport.

### **6.1 Receipt**

The radiation survey of the packages should be performed to check any contamination. The package should also be examined for any evidence of physical damage and assured that the security seal if any, is intact. The packages containing radioactive material should be picked up from the carrier promptly so that carrier personnel are not unnecessarily exposed to radiation. Only the authorized persons should receive the shipment of radioactive material.

### **6.2 Shipping**

Prior to preparing a package for shipment, ensure that radioactive source/material is in proper shielded position. It should also be ensured that the security seal if any of the package is intact. If the package of radioactive source/material is packed inside a crate or other outer package i.e, overpack, the outer packaging must be strong enough to withstand normal transport conditions. The out side of the package must be marked "RADIOACTIVE". The package marking should be durable, legible and visible. In case of excepted packages there is no need to mark "RADIOACTIVE" on the package. The radiation level on the surface of a package not under exclusive use should not exceed 2 mSv/h. For exclusive use transportation, the radiation level on the surface of a package should not exceed 10 mSv/h. The non-fixed



contamination on the external surface of a package should not exceed i) 4 Bq/cm<sup>2</sup> for beta and gamma emitters and low toxicity alpha emitters and ii) 0.4 Bq/cm<sup>2</sup> for all other alpha emitters. The weight of the package must be written on each package if it is greater than 50 Kg. Each package except excepted packages should have the following information for its safe and secure transportation;

- i. Type of radionuclide
- ii. Activity of the radionuclide
- iii. Transport Index
- iv. Radiation label
- v. Identification number/specification number
- vi. UN number with proper shipping name
- vii. Name and address of consignor
- viii. Name and address of consignee

In case of excepted packages, the name of consignor/consignee and UN number is sufficient.

The categorization of the packages should be carried out according to Table-1. The categorization label should be affixed on two opposite sides of the outside of a package/overpack and on all four sides of a freight/container.

**Table-1: Categorization of Packages and Overpacks**

Transport Index	Maximum Radiation Level at any Point on External Surface	Category
0 <sup>a</sup>	Not more than 0.005 mSv/h	I – WHITE
More than 0 but not more than 1 <sup>a</sup>	More than 0.005mSv/h but not more than 0.5 mSv/h	II – YELLOW
More than 1 but not more than 10	More than 0.5mSv/h but not more than 2mSv/h	III – YELLOW
More than 10	More than 2mSv/h but not more than 10mSv/h	III – YELLOW <sup>b</sup>

<sup>a</sup> If the measured TI is not greater than 0.05, the value quoted may be zero.

<sup>b</sup> Shall also be transported under exclusive use

### 6.3. Carriage

The dedicated vehicle such as wagon, truck should be used for the transportation of radioactive material with in the country. The closed vehicle should be used for the transport of radioactive material and integrity of locks and seals should be verified before dispatch and on arrival. However, packages

weighing more than 500 Kg may be transported on an open vehicle under secure conditions. No persons other than driver/conductor and radiation supervisor should be allowed to travel in the vehicle carrying radioactive material. The radiation dose in the driver compartment should be assessed to ensure that the radiation level is within permissible limits ( i.e.,  $0.5 \mu\text{Sv/h}$ ). The total sum of transport index and criticality safety index (for fissile material) of all packages on a vehicle should not be exceeded 50. The radiation level under routine conditions of transport should not exceed  $2 \text{ mSv/h}$  at any point on, and  $0.1 \text{ mSv/h}$  at 2 m from the external surface of the vehicle. The vehicles used regularly for the transport of radioactive material should be periodically checked to determine the level of contamination. The level of contamination should not exceed  $5 \mu\text{Sv/h}$ . If the contamination level exceeds  $5 \mu\text{Sv/h}$ , the vehicle should not be used for the transport of radioactive material unless it is decontaminated. The vehicle carrying II-YELLOW and III-YELLOW category of packages should be placarded with a "RADIOACTIVE" placard on three sides of the vehicle. The proper record of transport of radioactive material should be kept by the consignor. In addition, the following should be considered while transporting radioactive material;

- i. Transporter should be informed about the nature of material to be transported
- ii. Driver/radiation supervisor should have some communication arrangements such as mobile phone
- iii. Special arrangements should be made to keep the source(s) in vehicle, so that movement of source/container during transportation can be minimized
- iv. Proper documents/records for transportation of radioactive material should be prepared and signed by consignor and a copy of these documents should be provided to transporter
- v. Emergency contact numbers should be clearly mentioned on vehicle carrying radioactive material

It is recommended that each licensee should use their own vehicle for the transport of radioactive material. In case, the licensee hire some transport for this purpose, its trustworthiness should be ensured before transporting radioactive material

## **7. Emergency Arrangements**

Mobility of a radioactive material being transported involves certain safety and security risk. Consequently, nuclear and radiological emergencies may arise which may have detrimental impact not only on the workers and public in the vicinity but may also have long distance environmental degradation. Therefore, an emergency plan should be in place to reduce the risk.

During transport of radioactive material, the driver should have appropriate emergency arrangements such as fire extinguisher, rope, spare tyre, tools etc. The radiation supervisor accompanying the vehicle should have emergency kits (decontamination kit, gloves, plastic sheet etc.,) and equipment such as

radiation signs, tape, calibrated radiation survey meter and film badge/pocket dosimeter. In case of an incident/accident during transport of radioactive material, inform responsible person of consignor and also inform PNRA at the following address immediately:

Duty Officer  
NRECC  
Pakistan Nuclear Regulatory Authority  
P.O. Box 1912, Islamabad  
Ph: +92 51 9262019  
Cell: +92 300 8540319  
Fax: +92 51 9260201  
Email: nrecc@ins.pnra.org  
Web site: [www.pnra.org](http://www.pnra.org)  
Toll Free No: 0800-77766

## **8. Requirements for the Transport of High Activity Sources**

The following requirements should be followed while transporting high activity sources;

- i. Package containing radioactive materials should not contain any other item(s) in the vehicle
- ii. Consignments of radioactive materials should be securely stored in the vehicle
- iii. A qualified and fully equipped Radiation Protection Officer/Health Physicist/Radiation Supervisor should accompany the vehicle in a separate conveyance provided with mobile communication system.
- iv. Keeping in mind the safety of the packages, the vehicle should be safely driven. No specific speed limit is suggested, however, it should commensurate with road conditions.
- v. The Radiation Protection Officer/Health Physicist/Radiation supervisor must know the telephone numbers of the nearest Pakistan Atomic Energy Commission (PAEC) Centres on route so that he can get appropriate guidance, in case there is unforeseen increase in radiation level in the vehicle carrying radioactive sources/material
- vi. For the possible extent, the vehicle should be parked in the PAEC on route centres. If not possible, the vehicle should be parked in some other safe and secure premises.
- vii. The vehicle should not be left unattended during parking.
- viii. The vehicle should be allowed to move only during day time.
- ix. A security plan explaining different measures should also be prepared.

## **9. Security Arrangements during Transport**

Security measures during all phases of movement of a radioactive source depend on the type and activity level. Higher the risk involved associated with a

source, greater efforts would be needed to strengthen security measures. Accordingly, IAEA has defined four security groups (A, B, C, D)<sup>[5]</sup> which are based upon the categorization of radioactive sources<sup>[6]</sup> along with other factors such as a possible threat by a person or a group with malicious intent. The categorization of a source is based upon D-values<sup>[6]</sup>. A D-value is simply the specific activity of a source which if not under control can cause severe deterministic effects. Table-2 presents safety and security classification of radioactive sources.

**Table-2 Safety and Security Classification of Sources**

Activity Ratio (A/D)	Source Category	Security Group
$A/D \geq 1000$	1	A
$1000 > A/D \geq 10$	2	B
$10 > A/D \geq 1$	3	
$1 > A/D \geq 0.01$	4	C
$0.01 > A/D \geq$ Exempt/D	5	D

*For example, a Blood/Tissue Irradiator containing a radionuclide: Cs-137 having a typical activity of 260 TBq is to be transported The D-Value assigned to this radionuclide is 0.1 TBq. The ratio of  $A/D = 260/0.1 = 2600$ , accordingly the radioactive source is assigned to Category 1 and Security group A. In situations where several sets of sources with various radionuclides are involved, the concept of 'aggregations of sources' should be applied<sup>[6]</sup>.*

To deter malicious acts, specific security measures may be applied in accordance with "IAEA –TECDOC-1355"<sup>[5]</sup> The transportation of Security Group A sources should satisfy the performance requirements for security for this group. In addition, they should also satisfy the recommendations that are to be issued in further IAEA publications on security in transport.

As an example of these performance objectives for a Security Group A sources, the transporter should carry out the following measures:

- i. Background checks on trustworthiness of the transport organization and operatives;
- ii. Deterrence through use of transport packages locked and sealed and in a dedicated transport unit, which is locked;
- iii. Timely detection through radio communication between the personnel in the vehicle and a security office or organization; installation of a satellite tracking device
- iv. Response through security trained transport operative;
- v. Emergency plan developed to deal with emergencies in transit

Depending on the threat assessment, additional guards or a response force should be arranged.

## 10. Radiation Protection Programme

A Radiation Protection Programme should be established by each licensee for the transport of radioactive material<sup>[4]</sup>. The nature and extent of the measures to be employed in the programme should be related to the magnitude and likelihood of radiation exposure involved during transportation. During transport, protection and safety should be optimized in order that the magnitude of individual doses, the number of persons exposed, and the likelihood of incurring exposure should be kept as low as reasonably achievable, economic and social factors being taken into account.

The radiation dose from transport activities should not exceed 6 mSv in a year. For occupational exposures solely arising from transport activities, where it is assessed that the effective dose:

- i. is most unlikely to exceed 1 mSv in a year, neither special work patterns nor detailed monitoring nor dose assessment programmes nor individual record keeping should be required
- ii. is likely to be between 1 to 6 mSv in a year, a dose assessment programme via work place monitoring or individual monitoring should be conducted
- iii. is likely to exceed 6 mSv in a year, individual monitoring should be conducted. When individual monitoring or work place monitoring is conducted, appropriate records should be kept.

## 11. Training

The workers involved in the transport of radioactive material should receive appropriate training concerning the radiation hazards. The workers should also have sufficient knowledge regarding packing of radioactive material, marking and labeling of radioactive material, loading and unloading of radioactive material etc.,

## 12. Segregation during Transport and Storage in Transit

The packages of radioactive material should be segregated sufficiently from workers and from members of the public and from other dangerous goods during transport and during storage in transit. A driver transporting the consignment should be categorized under public. The following values for dose should be used for the purpose of calculating segregation distances or radiation levels<sup>[4]</sup>

- i. for workers in regularly occupied working areas a dose of 5 mSv in a year
- ii. for general public a dose of 1 mSv in a year

The radioactive material should also be sufficiently segregated from undeveloped photographic films. The basis for determining segregation distances for this purpose should be that the radiation exposure of

undeveloped photographic film due to the transport of radioactive material be limited to 0.1 mSv per consignment of such films.

The radioactive material should be safely and securely stored during transit. During transit, the material should be placed away from working/occupied areas. The transit area should be marked with tape/rope and radiation warning sign should be visibly posted. The appropriate security measures should also be carried out when radioactive material is temporarily stored in transit sites.

In case of fissile material, the following should be considered during transportation and storage in transit;

- i. groups of packages, over packs and freight containers should be limited to a total Criticality Safety Index (CSI) of 50 per group if not under exclusive use and 100 per group if under exclusive use.
- ii. Groups should be separated by at least 6 meter distance

### **13. Undeliverable Consignments**

Where a consignment of radioactive material is undeliverable, the consignment should be placed in a safe location by the relevant concerned personnel of the carrier and inform the consignor/PNRA immediately.

### **14. References**

1. PNRA Ordinance-III of 2001: F. No. 2(2)/2001-Pub, January 22, 2001.
2. Guidelines for the safe use of sealed radioactive sources, PNRA-13001, April 2004.
3. Regulations for Radioactive Waste Management, PAK/915, S.R.O. No. 765 (I)/2005.
4. IAEA, Regulations for the Safe Transport of Radioactive Material, TS-R-1, 1996 Edition (As amended 2003) being issued as PAK/916.
5. Security of Radioactive Sources, Interim guidance document for comment, IAEA-TECDOC-1355, 2003.
6. Categorization of Radioactive Sources, IAEA Safety Standards No. RS-G-1.9, Vienna, 2005.

## 15. Definitions

- (a) "**Authority**" means the Pakistan Nuclear Regulatory Authority established under section 3 of the Ordinance, 2001 ( III of 2001);
- (b) "**carrier**" Carrier means any person, organization or government undertaking the carriage of radioactive material by any means of transport;
- (c) "**Chairman**" means the Chairman of the Authority;
- (d) "**consignee**" means any person, organization or government which receives a consignment;
- (e) "**consignment**" means any package or packages, or load of radioactive material, presented by a consignor for transport;
- (f) "**consignor**" Consignor means any person, organization or government which prepares a consignment for transport, and is named as consignor in the transport documents;
- (g) "**contamination**" Contamination means the presence of a radioactive substance on a surface in quantities in excess of 0.4 Bq/cm<sup>2</sup> for beta and gamma emitters and low toxicity alpha emitters, or 0.04 Bq/cm<sup>2</sup> for all other alpha emitters. **non-fixed contamination**: contamination that can be removed from a surface during routine. **fixed contamination**: contamination other than non-fixed contamination;
- (h) "**criticality safety index (CSI)**" means a number to a package, overpack or freight container containing fissile material which is used to provide control over the accumulation of packages, overpacks or freight containers containing fissile material;
- (i) "**exclusive use**" means the sole use, by a single consignor, of a conveyance or of a large freight container, in respect of which all initial, intermediate and final loading and unloading is carried out in accordance with the directions of the consignor or consignee;
- (j) "**overpack**" means an enclosure, such as a box or bag which is used by a single consignor to facilitate as a handling unit a consignment of one or more packages for convenience of handling, stowage and carriage;
- (k) "**package**" means the packaging with its radioactive contents as presented for transport. The types of packages covered by these regulations, which are subject to the activity limits, material restrictions and meet the corresponding requirements of the Package Design Regulations issued by the Authority, are:
  - I. Excepted package;
  - II. Industrial package Type I (Type IP-1);
  - III. Industrial package Type 2 (Type IP-2);
  - IV. Industrial package Type 3 (Type IP-3);
  - V. Type A package;
  - VI. Type B(U) package;
  - VII. Type B(M) package;
  - VIII. Type C package;

Package containing fissile material or uranium hexafluoride are subject to additional requirements.

- (l) "**packaging**" means the assembly of components necessary to enclose the radioactive contents completely. It may, in particular, consist of one or more receptacles, absorbent materials, spacing structures, radiation shielding and service equipment for filling, emptying, venting and pressure relief; devices for cooling, absorbing mechanical shocks, handling and tie-down, thermal insulation; and service devices integral to the *package*. The packaging may be a box, drum or similar receptacle, or may also be a freight container, tank or intermediate bulk container;
- (m) "**radiation level**" means the corresponding dose rate expressed in millisieverts per hour;
- (n) "**transport index (TI)**" means a number assigned to a package, overpack or freight container, or to unpackaged LSA-I or SCO-I, which is used to provide control over radiation exposure;
- (o) "**vehicle**" means a road vehicle (including an articulated vehicle, i.e. a tractor and semi-trailer combination) or railroad car or railway wagon. Each trailer shall be considered as a separate vehicle.