



TRANSPORT OF RADIOACTIVE MATERIALS

Radiation Safety & Health Division
Malaysian Nuclear Agency

Contents

- Introduction
- General procedure moving Radioactive Material (RAM) within and outside premise
- Regulations for Transport of RAM.
- Procedure in transporting and disposing of radioactive and nuclear waste.
- Preparedness and action plan during emergency.
- Record Keeping.

Introduction

- The Radiation protection (Transport) Regulations 1989 derived from Atomic Energy Licensing Act 1984 (Act 304) is legislation enforced by AELB to ensure safe transport of radioactive and nuclear material.
- The regulations cover the movement of RAM outside premise; it is responsibility of the organization to established procedure for safe movement of radioactive and nuclear material within a premise.

General Procedure for Moving RAM

- Arranged, prepared and carried out according to the requirements of the **Radiation Protection (Transport) Regulations 1989**.
- These Regulations, do not apply to RAM:
 - moved **within** the premise;
 - **injected into human body** as part of a medical diagnosis or treatment;
 - **implanted in human body** as a radioisotopic device;
 - used as an **integral part** of a vehicle.

Local rules Movement Within Premise

- Properly packaged and transferred.
- Use a proper container with adequate amount of shielding and labels.
- Liquid form RAM requires double containers to minimize chances for spread of contamination.
- The radiation level on the external surface of a package ≤ 2 mSv/hr.
- Transfer of a package with higher radiation level may require a special approval from a responsible officer.

Movement Within Premise

- Radiation level in the driver's compartment ≤ 0.02 mSv/hr.
- The fixed contamination level on the external surface of a package is within the permissible limit.
- Use the basic principles of shielding, time and distance to minimize the dose received.
- Movement should be recorded in the source inventory

Movement Outside Premise

- Should be done in compliance with the Radiation Protection (Transport) Regulation 1989.
- Requires **License Class D** from the AELB.
- The transportation undertaken in compliance to the regulation is acceptable by all mode of transportation **except by post**, including:
 - *All mode of land transport such as road and rails*
 - *Air transport in compliance to IATA (international Air Transport Association)*
 - *Sea transport in compliance to IMDG (International maritime Dangerous Good Code)*

Regulation For Transport of Radioactive Material

- Principle and Safety requirement
- Type of Packages
- Category of package
- Level of surface radiation and contamination on surface of packages
- Transportation control and storage during transit
- Label on package and carrier
- Safety before and during transportation; and during receiving of package
- Action plan during emergency



**PERATURAN-PERATURAN PERLINDUNGAN
SINARAN (PENGANGKUTAN) 1989**

***RADIATION PROTECTION
(TRANSPORT) REGULATIONS 1989***

[P.U. (A) 456/89]

**Bersama-sama dengan pindaan dan pembetulan
*Together with amendment and corrigendum***

[P.U. (A) 145/91 & P.U. (A) 146/91]

IAEA Safety Standards

for protecting people and the environment

Regulations for the Safe Transport of Radioactive Material

2009 Edition

Safety Requirements

No. TS-R-1



Safety Principles

- Ability to fully **contain** the radioactive contents in **normal** and **accident** conditions of transport.
- Ability to **control of external radiation** from packages.
- Ability to **prevent the criticality** for fissile materials.
- Ability to **prevent the damage of the packages** caused by heat generated by radioactive material.
- Ensure **proper handling and storage** of packages during transportation.

Safety Requirement

- Establishment activity **limits** for content of packages.
- Establishment of standards to ensure **proper integrity and design** of packages.
- Establishment of **category of packages** which reflects control of irradiation and requirement for shielding and sufficient warning signs.
- Establishment of **limits for the contamination** on the surface of packages.
- Provision for control of packages during handling and storage.
- Establishment of **emergency procedures** for packages.

Types of Package

Design of Packages depending on :

- Categories of RAM
- Activity of RAM

Categories of RAM

Radioactive material	Definition
Special Form RAM	<ul style="list-style-type: none"> • Either an in dispersible solid or a sealed capsule containing RAM • High degree of physical integrity – highly unlikely any contamination hazard
Excepted material	<p>Small quantities of RAM – if released it will course insignificant hazards. The limits ($10^{-3} A_1$ or $10^{-3} A_2$ for solids and $10^{-4} A_2$ for liquids)</p>
Low Specific Activity (LSA)	<p>RAM its nature has a low activity per mass Categorized: LSA-I, LSA-II and LSA-III</p>
Surface Contaminated Object (SCO)	<p>A solid non radioactive but has RAM distributed on its surface Categorized ; SCO-I and SCO-II (differentiated by the level of fixed and non-fixe contamination</p>
Fissile material	<p>U-233, U-235, Pu-238, Pu-239, Pu-241 or their combinations Exclude natural uranium or depleted uranium:-</p> <ul style="list-style-type: none"> • Not been irradiated • Irradiated in thermal reactors

Types of Package

Package	Criteria for Transport
Excepted	<ul style="list-style-type: none"> • Performance of qualifying test – not require • Radiation level on the surface - $\leq 5 \mu\text{sv/hr}$
Industrial - IP-1, IP-2 and IP-3	<ul style="list-style-type: none"> • LSA-I (without any limit) • LSA-II, LSA-III, SCO-I, SCO-II (below 100 A₂) • Require – free drop test and stacking test • Radiation level at 3 meter from unshielded material – $\leq 10 \text{ mSv/hr}$
Type A	<ul style="list-style-type: none"> • RAM less to A₁ (special form) and A₂ (non-special form) • Design to maintain the integrity –from normal, rough handling and mishandling • Subject to qualifying test
Type B B(U) or B(M)	<ul style="list-style-type: none"> • Withstand most accident condition • More stringent qualifying test • Design and test needs an approval from AELB
Special	<ul style="list-style-type: none"> • For fissile material • Depend to nature – limits and type of package (A,B, Industrial..)

Category	Sub-category	Examples of Contents
Low Specific Activity (LSA)	LSA-I	Natural uranium and thorium ores and concentrates. Unirradiated natural or depleted uranium and thorium.
	LSA-II	Contaminated vials. Hospital waste. Decommissioning waste.
	LSA-III	Evenly distributed solid waste
Surface Contaminated Objects (SCO)	SCO-I	Equipment which has been used for processing radioactive material
	SCO-II	Equipment which has been used for processing radioactive material

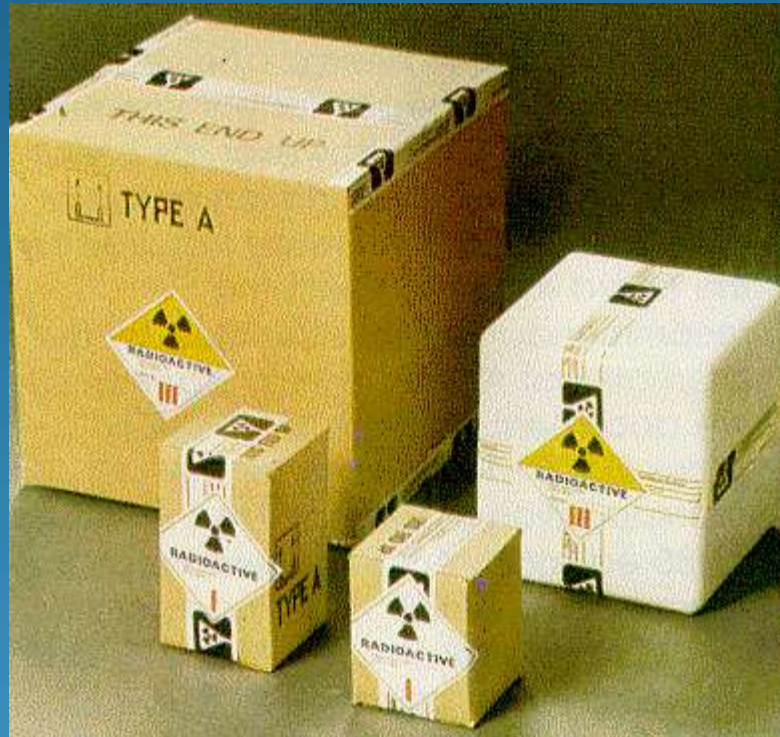
Design and test requirements for the transport of radioactive materials

Type of test	Type of packaging					Type A	Type B
	Excepted Packaging	Industrial Packaging					
		IP-1	IP-2	IP-3			
Water spray test						X	X
Free drop test			X	X		X	X
Compression test			X	X		X	X
Penetration test						X	X
Mechanical test							X
Thermal test							X
Water immersion test							X

Package Design & Tests

- ***Water spray test*** at 5 cm/hr for more than 1 hour
- ***Free drop test*** from height of 0.3 to 1.2 meter (depending on the package mass)
- ***Stacking (compression) test*** for 24 hours to a compressive load of equivalent to 5 times the mass of the package
- ***Penetration test*** by 6 kg bar from the height of 1 and 1.7 meters
- ***Mechanical test*** simulated for three different nature of drops
- ***Thermal test*** at 800°C for 30 minutes
- ***Water immersion test*** at
 - 15 meter > 8 hours
 - 200 meters > 1 hour

Type A Package



Type A packages are used to transport radiopharmaceuticals

Type B Package



Portable Type B radiography
camera

Type B Package



Large Type B packages are used to transport radioactive cobalt -60

Industrial package



Steel drum can be used as Industrial packages for LSA material

Category of Package

Category of package based on

1. Radiation level at any point on external surface of packaging
2. The potential for nuclear criticality

Category of Package

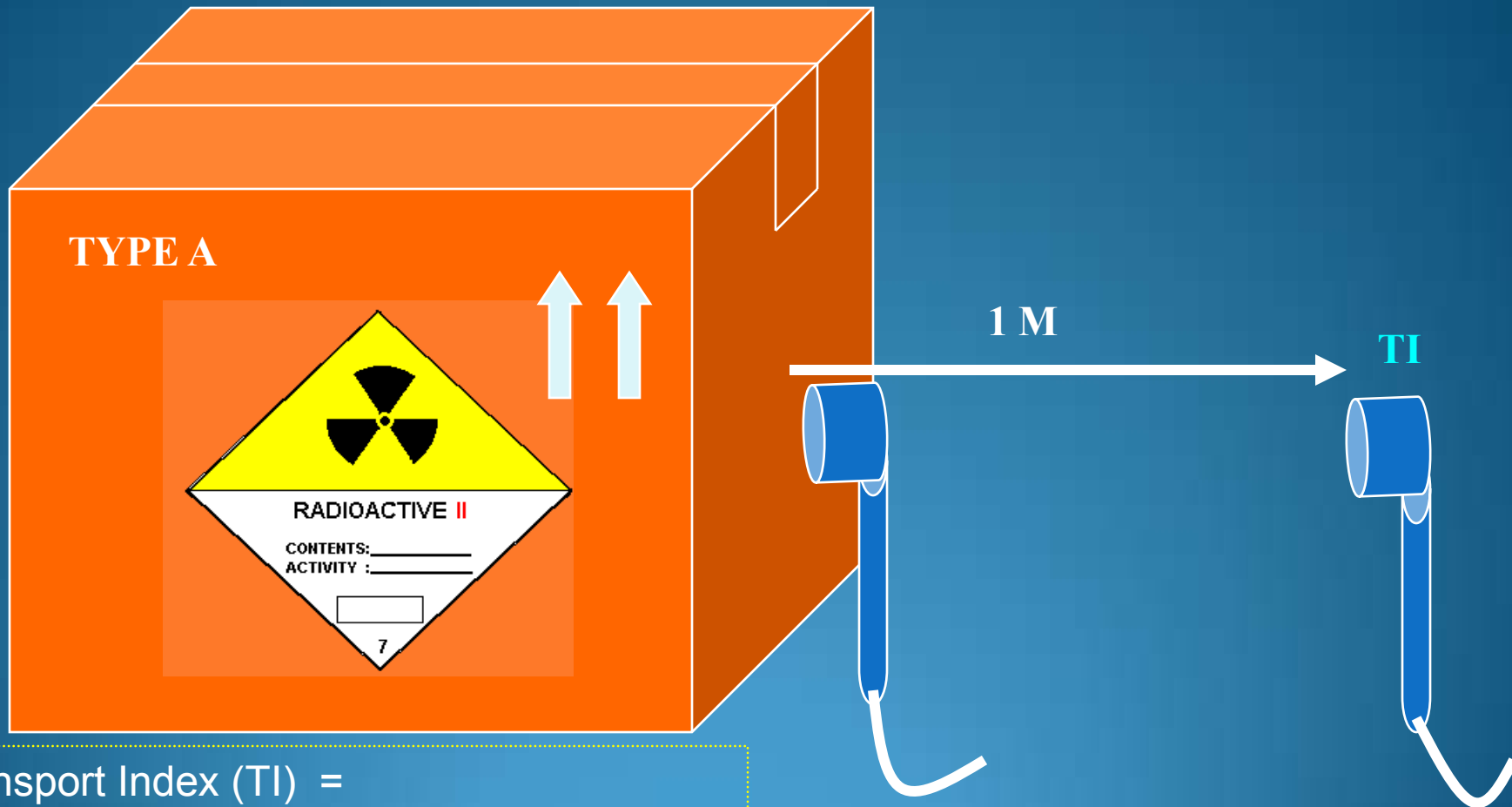
Category of package determined by maximum radiation level at any point on the external surface of package

Category	Maximum Radiation Level		Transport Index (TI)
	At surface	At 1 metre	
Category I – White	0.005 mSv/hr	None	Negligible
Category II – Yellow	0.5 mSv/hr	0.01 mSv/hr	≤ 1
Category III – Yellow	2 mSv/hr	0.1 mSv/hr	≤ 10
Category III – Yellow under exclusive use	10 mSv/hr		No limit

Radiation level at any point on the external surface for overpacks

Types of Packaging	Category of package	Limit of Radiation level
Excepted package	Excepted package	$<5\mu\text{Sv/h}$
Type A Or Type B	I- WHITE	$<5\mu\text{Sv/h}$
	II- YELLOW	$<0.5\text{mSv/h}$
	III-YELLOW	$<2\text{mSv/h}$
Overpack of packages	-	$<2\text{mSv/h}$
Package or overpack of exclusive use	-	$<10\text{mSv/h}$

CATEGORY/TRANSPORT INDEX



Transport Index (TI) =
maximum dose rate (mSv/hr) at 1 metre
from the package surface x 100

ON THE
SURFACE

AT 1M

Contaminated surface	Applicable limits in Bq/cm ²	
	β and γ emitters	α emitters
Excepted package (external)	0.4	0.04
Package other than excepted package (external)	4	0.4
Overpack, freight containers or conveyance carrying excepted package (ext. and int.)	0.4	0.04
Overpack, freight containers or conveyance carrying other than excepted package (ext. and int.)	4	0.4
Freight containers or conveyance carrying unpack RAM (ext.)	4	0.4

Label on package and carrier

Label on packages

- I-WHITE
- II-YELLOW
- III-YELLOW
- III-YELLOW with Transport Index (TI)
- Placard to label carrier
- Placard on conveyance and maximum radiation level of conveyance.

Label



Label I-WHITE

Label



Label II-YELLOW

Label



Label III-YELLOW

Label (example)



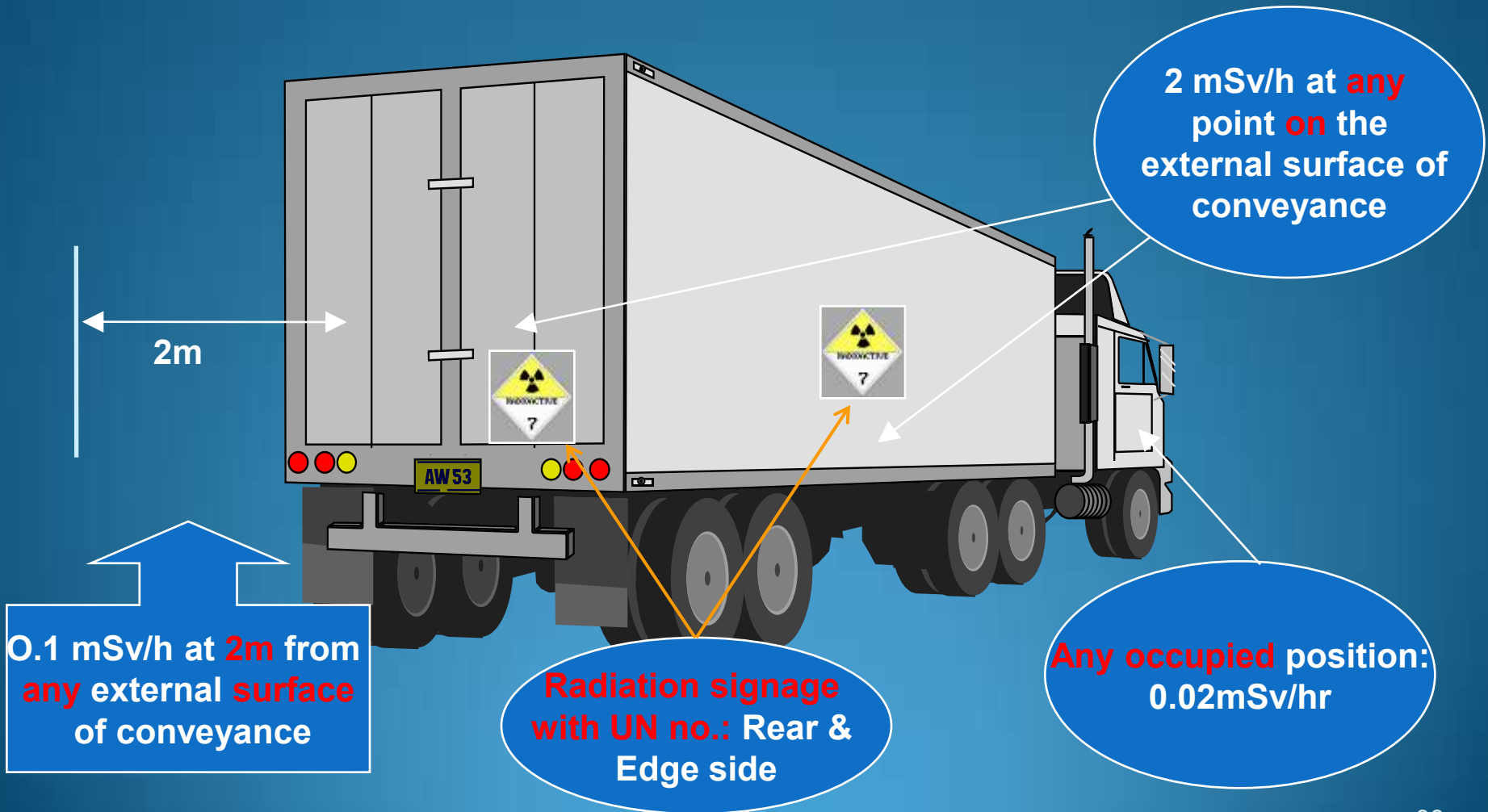
Label III-YELLOW with
example of Transport Index
(TI) 4.7

Placards

- **Displayed on conveyance** carrying RAM packages except Excepted Packages.
- Labels used on packages can also be used as placards provided their **minimum size must be 25 cm**.
- In the case of a rail vehicle, on the external side of each of the two lateral walls.
- In the case of a road vehicle, on the external side of each of the lateral walls and on the rear wall.
- In the case of a tank or a large freight container, on the external side of each wall and each end wall in a vertical orientation.



Maximum Radiation Levels for Conveyances



Markings on Packages

- Each package shall have legible and durable mark on the outside which includes:
 - Gross weight of the package if it is **more than 50 kg**.
 - **Package design** type i.e. either Excepted Package, IP, Type A, Type B(U) or Type B (M).
 - **Identification marks** assigned to the package design by the authority.
 - A **serial number of the packaging** to identify its conformance to the approved design by the authority.
- Packages are also required to be marked with the word “Radioactive” on their internal surface. The warning shall be clearly visible upon opening the packages.

Requirement And Control During Transport And Storage In Transit

Transportation control

- Shall be done in compliance with Radiation Protection (Transport) Regulation 1989.
- Package, overpacks, freight conveyance and tanks shall be segregated during transport and transit:
 - from places occupied by workers and members of the public and from undeveloped photographic film.
 - from other dangerous goods during transport and storage.

Transportation control and storage during transit

Storage during Transit

- Shall be segregated during transit (as mentioned in the previous slide).
- The total number of category II-YELLOW and category III-YELLOW packages, freight containers, overpacks or conveyance in any one storage area does not exceed 50.
- Where the total number (package) exceed 50, storage shall be such as to maintain a spacing of at least 6m from other groups.
- The above requirement does not apply to transit of LSA-I material.

CONSIGNMENT / PACKAGE

RADIOACTIVE MATERIALS (RAM)

+

PACKAGING



Safety Requirement Before Transportation

Consignor Responsibility

- Ensure that the package is properly chosen, design, fabricated and tested according to Transport Regulations.
- Ensure the package is properly categorised, labelled, marked and packed.
- Obtain approval from the authority (design and fabrication aspects)
- Ensure the contents is prescribed
- Prepare transport document e.g declaration statement, written emergency procedures and inform the carrier and consignee.

Safety Requirement During Transportation

Carrier Responsibility

- Handle the package with care
- Place the package as prescribe during transport and storage in transit
- Transport the package in manner as prescribed by the transport regulation
- Ensure the physical security
- Implement the emergency procedures and inform consignor and regulatory authority in case of accident

Safety Requirement When Receive A Package

Consignee Responsibility

- **Examine** package for **any defects** before opening it;
- **Measure** the radiation and contamination levels if the package has or appeared to have defects, and report to the regulatory authority ;
and
- **Unpack** the package using **method recommended** by the supplier or manufacturer
- **Retain** inspection and testing performed on the package **records**.

Action Plan During Emergency

Emergency response plan is attached to the transport document accompanied the package.

- The driver must be trained to appropriately taking action during accident or emergency, such as immediate action to be taken after accident with or without release of RAM
- Restriction to access to the package – erect barrier, warning sign and notices at safe distance around accident area.
- The responsible RPO should be informed and qualified person to be called to make an assessment of the contamination and steps to be taken.
- The AELB should be orally informed within 24 hours.
- A qualified person shall decontaminate any contamination immediately (Any contamination decision should be based on monitoring assessment).
- The accident report should be prepared together by the consignor, the carrier and the consignee and submit the report to the authority within 30 days after the accident.

Procedure To Transport RAM

- Procedure import/export
- Procedure of acceptance
- Procedure of transportation

Procedure Import / Export

- Class-E license is a license to export/import radioactive materials, nuclear materials, prescribed substances, irradiating apparatus or their waste.
- Import/export permit should be obtained from (e-dagang) – (AELB, DCA, Royal Malaysian Customs)

Procedure Of Acceptance

- The acceptance of the package shall be done in according to the procedure as described to the consignee of package.
- The consignee should be personnel of a company or an organization having appropriate license from the authority.

Procedure Of Transportation

- Require license Class-D for those involve in business of transporting RAM but require no additional license if transporting RAM owned by licensed operators or practitioners.
- The transportation should be carried out in compliance to the Radiation Protection (Transport) Regulations 1989.
- It is important to note that packages having a surface radiation level greater than 2 mSv/h (200mrem/h) shall not be transported by air except by special arrangement
- Air transportation also require the package to withstand temperature difference of -40°C to $+55^{\circ}\text{C}$ and a pressure difference of 95 kPa

Record keeping

The consignor and consignee shall keep the records of the consignment such as the transport document. The consignor shall also keep a copy of design and the results of tests for a reference and inspection by the relevant authority.

The record of monitoring during accident should also be safely kept for a reference and inspection by the relevant authority.

Record keeping

The transport document shall consist of the following information:

- The carrier name and the word “RADIOACTIVE”
- The UN class number “7” and UN number of consignment.
- The appropriate group notation of the consignment such as LSA-I.
- The name and symbol of each RAM the physical and chemical form and the maximum activity.
- The category of package and Transport Index.
- The identification mark of competent authority approval certificate for package and source design.
- Instruction and emergency procedures.

Additional: General Procedure for transportation

- RAM should not be moved from one place to another unless really necessary. It should be carried out in accordance procedure:
 - Appropriate containers or transport casks;
 - Shielding should be used where necessary
 - When transfer RAM into containers, provide adequate protection for the workers
 - In case of unsealed source, handling carried out in a well ventilated enclosure
 - RAM shall not be removed from its original place unless check on the transport containers confirm that external surface are free of contamination and rad. level at specific points r within permissible limits

General Procedure for transportation

- continue:
 - Transport through the easiest and fastest route possible. (Used roller, trolley, etc where necessary)
 - When transport radioactive liquid, gas, powder or other dispersible solids, the container should be placed in another container to prevent spread of any leakage or spillage
 - Only designated person shall be allowed to transport RAM.
 - When carry RAM in vehicle, no person allow to stay in the compartment where RAM placed
 - Fastened transport container to prevent movement which may lead to damage
 - Transport containers shall be arranged such that the radiation level at the driver's compartment does not exceed 20 uSv/hr

Summary

- The transportation of RAM should be in accordance to Radiation Protection (Transport) Regulation 1989.
- The regulation covering air, land and sea transport.
- The regulation to ensure transport workers, public and environmental safety resulted from transferring of RAM during normal and emergency situation.
- The responsibility to ensure safe transport lies to all involve include consignor, carrier and consignee.

Thank You