

# Radiation protection during transport operations



Luc Verpoorten – Federaal Agentschap voor Nucleaire Controle

# Radiation protection during transport operations

Workers exposed during transport operations:

- Drivers
- Airport handlers
- Port handlers
- Warehouse workers
- ....

Note: exposure during preparation/receipt of the packages should be considered in the facilities

# Radiation protection during transport operations

Dose limits for workers:

- ARBIS/RGPRI: 20 mSv per 12 consecutive gliding months

Optimization (ALARA):

- Transport regulations<sup>1</sup>: the carriage of radioactive material shall be subject to a **radiation protection programme...**

<sup>1</sup>e.g. the Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR)

# Radiation protection during transport operations

Radiation protection programmes:

*“Consists of systematic arrangements aimed at providing adequate consideration of radiation protection measures.”*

*“Respect of the relevant dose limits and optimization (ALARA)”*

*“The nature and the extend of the measures to be employed in the programme shall be related to the magnitude and likelihood of radiation exposures”*

*“Provide appropriate training to workers”*

# Radiation protection during transport operations

Radiation protection programmes:

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

*(a) Is likely to be between 1 mSv and 6 mSv in a year, a dose assessment programme via work place monitoring or individual monitoring shall be conducted; or*

*(b) Is likely to exceed 6 mSv in a year, individual monitoring shall be conducted.*

*When workplace monitoring or individual monitoring is conducted, appropriate records shall be kept.”*

# Radiation protection during transport operations

**Companies involved in transport are facing following problems:**

- Every day is different (number of radioactive packages to handle, radiation levels, ...);
- Insufficient measuring equipment available;
- Urgency of the deliveries;
- Economic considerations: e.g. lead shielding behind the driver is at the expense of the loading capacity of the vehicle;
- Lack of supervision during transport;
- ...

# Radiation protection during transport operations

## How can this be managed?

- Dangerous goods transport regulations:
  - Limitations on radiation levels per package;
  - Limitations on radiation levels per shipment;
  - Mandatory training for all persons involved in the carriage of dangerous goods.
- Belgium: the obligation to be recognised as a class 7 dangerous goods carrier:
  - Undergoing a compliance audit wherein radiation protection programme, emergency procedures and training programmes are evaluated;
  - The obligation to have in Belgium a health physics department with a recognised radioprotection expert (internal or external) and at least one internal radiation protection officer;
  - Each carrier shall be subject to punctual inspections, from once every three years to five times a year, depending on the activities of the carrier (graded approach).

# Radiation protection during transport operations

## Limitations on radiation levels per package:

→ Categories of packages, overpacks and containers:



*Transport index: the maximum dose rate determined at a distance of 1 meter from the external surfaces of the package in mSv/h, multiplied by 100.*



# Radiation protection during transport operations

## Limitations on radiation levels per package:

→Categories of packages, overpacks and containers:

**Table 5.1.5.3.4: Categories of packages, overpacks and containers**

Conditions		
Transport index	Maximum dose rate 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 0.005 mSv/h but not more than 0.5 mSv/h	II-YELLOW
More than 1 but not more than 10	More than 0.5 mSv/h but not more than 2 mSv/h	III-YELLOW
More than 10	More than 2 mSv/h but not more than 10 mSv/h	III-YELLOW <sup>b</sup>

# Radiation protection during transport operations

## Limitations on radiation levels per package: conclusion

- (1) There is a maximum dose rate around packages ready for transport;
- (2) The dose rate around a single package is easy to interpret:
  - The more red strips on the label, the higher the radiation;
  - The higher the transport index, the higher the radiation.
- (3) Each driver is instructed to load the packages with the highest radiation most to the rear of the vehicle.

# Radiation protection during transport operations

## Limitations on radiations levels per shipment:

→ Maximum total TI per vehicle for shipments not under exclusive use, depending on transport mode:

*Exclusive use: 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 and shipment are carried out in accordance with the directions of the consignor or consignee, where so required by the regulations.*

TABLE 10. TRANSPORT INDEX LIMITS FOR FREIGHT CONTAINERS AND CONVEYANCES NOT UNDER EXCLUSIVE USE

Type of freight container or conveyance	Limit on sum of TIs in a freight container or aboard a conveyance
<i>Freight container:</i>	
<i>Small freight container</i>	50
<i>Large freight container</i>	50
<i>Vehicle</i>	50
<i>Aircraft:</i>	
Passenger	50
Cargo	200
Inland waterway craft	50
<i>Sea-going vessel<sup>a</sup>:</i>	
(i) Hold, compartment or defined deck area:	
<i>Packages, overpacks, small freight containers</i>	50
<i>Large freight containers</i>	200
(ii) Total vessel:	
<i>Packages, overpacks, small freight containers</i>	200
<i>Large freight containers</i>	No limit

# Radiation protection during transport operations

## Limitations on radiations levels per shipment:

Additional requirements relating to transport by road and rail: the dose rate shall not exceed:

→2 mSv/h at any point on the outer surfaces of the vehicle;

→0,1 mSv/h at any point 2 meter from the outer surfaces of the vehicle.

Additional requirements relating to transport by road (Belgium regulation):

→The dose rate in the driver's compartment of the vehicle shall not exceed 20  $\mu$ Sv/h. Above 2,5  $\mu$ Sv/h the crew should wear individual dosimeters.

# Examples of radioprotection measures during transport operations

## Large port handler at the port of Antwerp



# Examples of radioprotection measures during transport operations

## Large port handler at the port of Antwerp

- 99% containers;
- Small volumes (439 containers in 2019);
- Small number of shipments (43 in 2019, < 1/week)
- Not always permanent staff (dockers pool);
- Little manual operations (only attaching and detaching of twistlocks, and lashing bars on the ship);
- Short exposure times.





# Examples of radioprotection measures during transport operations

## Large port handler at the port of Antwerp

Port handler makes dose assessment (reviewed each year) based on the number of containers handled, their average TI and the exposure times for the different operations:

- Crane operator: due to the distance, no direct exposure
- Visual check of the container (marker) : 30 seconds per container
- Attaching/detaching twistlocks and lashing bars (dockers): 2 minutes per container

This gave following results in 2019:

- Crane operators: no exposure
- Marker: maximum 6  $\mu\text{Sv}$  per year
- Dockers: maximum 350  $\mu\text{Sv}$  per year

# Examples of radioprotection measures during transport operations

## Large port handler at the port of Antwerp

Conclusion: annual exposure is far below the limit for the public, there is no individual or workplace monitoring necessary. Although following radiation protection measures are in place:

- “Take 5” before every shipment where radioprotection principles (time, distance and shielding) are repeated to the concerned dockers;
- Regular checks by the RPO or RPE to verify whether the calculated doses are in line with reality;
- Additional measures in case of the radioactive containers staying on the quay longer than planned (the principle is direct transshipment);
- Emergency procedures.



# Examples of radioprotection measures during transport operations

## Large airport handler at Zaventem



Inside a modern wide-body cargo hold



# Examples of radioprotection measures during transport operations

## Large airport handler at Zaventem

- 99% small packages for medical use;
- Important volumes, number of shipments and total TI
  - More than 5000 packages a month
  - More than 1500 total TI shipped per month
- Permanent staff : small team of occupationally exposed personnel
- Manual operations: dangerous goods checks, loading ULD's, ...
- Exposure times should be kept as low as possible

# Examples of radioprotection measures during transport operations

## Large airport handler at Zaventem

### Radiation protection measures?

- Permanent evaluation of working procedures;
- Installation of bunker with different compartments and 60 cm thick concrete walls to reduce radiation levels;
- In addition to the legal passive dosimeter, the operators also have an electronic dosimeter with different alarm levels (dose and dose rate);
- Internal daily dose constraint: 25  $\mu\text{Sv}$
- Internal yearly dose constraint: 4 mSv
- Internal maximum yearly dose objective: 3 mSv

# Examples of radioprotection measures during transport operations

## Large airport handler at Zaventem

### Results?

- Number of operators (including supervisors) : 22
- Average 12 months dose: 872  $\mu\text{Sv}$
- Median 12 months dose: 930  $\mu\text{Sv}$
- Maximum 12 months dose: 2140  $\mu\text{Sv}$



# Examples of radioprotection measures during transport operations

## Large road haulier



# Examples of radioprotection measures during transport operations

## Large road haulier

- 99% small packages for medical use;
- Important volumes, number of shipments and total TI
  - More than 15 000 packages a month
  - More than 7 000 total TI shipped per month
- Permanent staff: 32 drivers, 5 employees (dispatch and others), 3 warehouse workers
- Long exposure time during transport

# Examples of radioprotection measures during transport operations

## Large road haulier

### Radiation protection measures?

- Internal dose constraint: 10 mSv/y
- Installation of bunker with different compartments and 60 cm thick concrete walls to reduce radiation levels during transiting periods;
- Continuous monitoring of dose results;
- Operational instructions (and tools) to handle the packages
- Allocation of vehicles (length and amount of lead shielding) based on transported TI and length of route;
- Training;
- Future: purchase of electronic dosimeters to evaluate certain routes.

# Examples of radioprotection measures during transport operations

## Large road haulier

### Results?

- Number of operators: 40 (32 drivers, 5 employees, 3 warehouse workers)
- Average 12 months dose: 3087  $\mu\text{Sv}$
- Median 12 months dose: 1500  $\mu\text{Sv}$
- Maximum 12 months dose: 8800  $\mu\text{Sv}$



# Positive evolution over the years

**Among other things due to increasing knowledge within the company about radioprotection measures:**

(1) Introduction of dangerous goods safety advisor:

- In Belgium: separate 5 days course for class 7 radioactive material with attention for radioprotection measures;
- Can be externally but most of the transport companies choose to have this function internally;
- A foreign certificate is also valid in Belgium but most of the important carriers choose for the Belgian certificate.

# Positive evolution over the years

**Among other things due to increasing knowledge within the company about radioprotection measures:**

(2) Introduction of radiation protection officer:

- Should be internally to the company;
- At least 12 hours training;
- Obligation of continuous training;
- Close cooperation with the radiation protection expert;
- Tasks related to radiation protection clearly defined.

# Positive evolution over the years

## Introduction of compliance audits in addition to the one-off inspections:

- Focus no longer on the compliance of single transports but on the procedures in place to guarantee safe and secure transport of radioactive material;
- During compliance audits attention to:
  - Radiation protection measures;
  - Emergency procedures;
  - Training of all involved parties (drivers, dispatchers, warehouse workers, ...);
  - Operational procedures for handling and stowage of the packages in the vehicle.

