Consideration on the assessment of the environmental consequences and impacts during transport of radioactive materials (RAM)-A Safety Case

Gheorghe Vieru, AREN, Bucharest, ROMANIA

Abstract: The transport of Dangerous Goods-Class #7 Radioactive Material (RAM), is an important part of the Romanian Radioactive Material Management. The overall aim of this activity is for enhancing operational safety and security measures during the transport of the radioactive materials, in order to ensure the protection of the people and the environment. The paper will present an overall of the safety and security measures recommended and implemented during transportation of RAM in Romania. Some aspects on the potential threat environment will be also approached with special referring to the low level radioactive material (waste) and NORM transportation either by road or by rail. A special attention is given to the assessment and evaluation of the possible radiological consequences due to RAM transportation. The paper is a part of the IAEA's Vienna Scientific Research Contract on the State Management of Nuclear Security Regime (Framework) concluded with the Institute for Nuclear Research, Romania, where the author is the CSI (Chief Scientific Investigator).

Keywords: Transport, RAM, Environmental, Impact, Security.

1. INTRODUCTION

The IAEA defines nuclear security [1] as *"the means and ways of preventing, detecting and responding to sabotage, theft and unauthorized access to or illegal transfer of nuclear material and other radioactive substances, as well as their associated facilities"*. The IAEA works closely with Member States (MS) to establish and enhance the measures needed to control and protect nuclear and radioactive materials, as well as to prevent illicit nuclear materials trafficking [1].

On April 2010 the 47 MS attended the Nuclear Security Summit issued their Communiqué of the Washington Nuclear Security Summit, stating the they "reaffirm the essential role of the IAEA in the international nuclear security framework and will work to ensure that it continues to have the appropriate structure, resources and expertise needed to carry out its mandated nuclear security activities, in accordance with its Statute and its Nuclear Security Plans".

In the modern world the terrorism has renewed attention to security issued, prompting a profound re-thinking in the international approach to nuclear security. As a consequence Romania, as a MS, joined to the new realities in according with the IAEA Nuclear Security Plan.

Taking into consideration the above mentioned, the paper presents a methodology for risk assessment of the State Management of Nuclear Security in transport of Radioactive Materials (RAM) in Romania [2].

In the Figure 1 is presented the main routes for the transport of RAM.

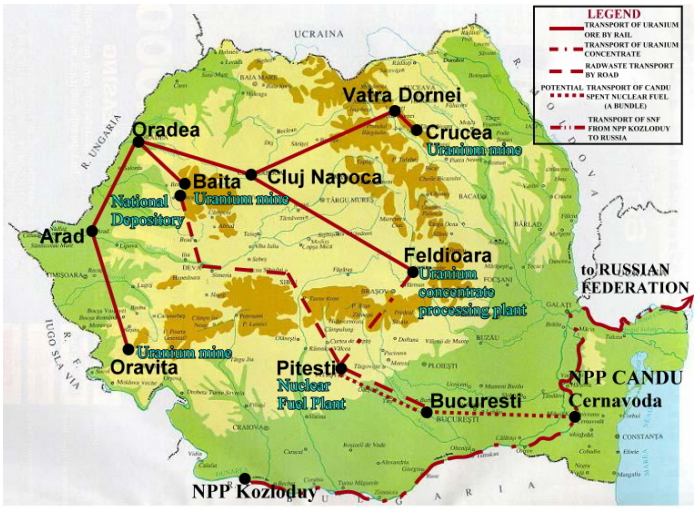

Fig 1. The Main Routes of RAM Transportation in Romania

2. DESCRIPTION OF THE METHODOLOGY TO BE USED

In order to determine a methodology to assess the radiological consequences due to a potential malicious act possible to be happen during the transport of RAM in Romania by using the INTERTRAN II and RADTRAN II computer codes [3].

3. IDENTIFICATION AND THE EVALUATION OF THE POTENTIAL RISKS DUE TO THE TRANSPORT OF RAM

3.1 TRANSPORT BY ROAD

In Figure 1 are shown the main routes for transport of the RAM in Romania. In order to evaluate the dose resulting from possible road accidents involving these radioactive shipments, based on the frequency of occurrence of accidents of specified severities the IAEA computer code INTERTRAN II has been used.
On the other hand for rail transport a probabilistic risk assessment method (PRA) has been adopted [4] for this work aimed to quantify the potential radiological consequences and the expected probability of occurrence of such sequences. Data to be used as input data to the computer code INTERTRAN II has been provided by postulate possible accidents scenarios [2] such as: transport hazards (fixed impact hazard, mobile impact hazard), malicious acts, potential threatens , accident frequencies by road.

Based on these there were calculated road accident probabilities such as:

probability of impact only: 0.421×10^{-5} per journey;
probability of impact and fire: 1.50×10^{-8} per journey;

It is also assumed that, following an impact and a malicious actor a terrorist attacks, the content may become available for dispersion.

The collective doses assessed are as follows:
dose to public along route: 0.25x10-5 person.Sv.y-1;
dose to public during stops: 0.37x10-8 person.Sv.y-1 ;
dose to truck crew: 0.47x10-5 person.Sv.y-1;
The total annual collective dose is: 0.72037x10-5 person.Sv.y-1;
The associated latent cancer fatality risk is estimated at 0.77x10-8 y-1.

3.2 TRANSPORTS BY RAIL

There are different kinds of operation contributing to the overall risk, such as: rail transport, rail road transfer activities handling and misoperation activities, etc. Transport and handling of possible accidents [3] or potential malicious acts may occur and pose a potential risk for the public and the environment.
Because the occurrence of such accidents is statistical in nature, the probability risk assessment (PRA) has been adopted in order to quantify the potential radiological consequences and the expected probability of occurrence of such accidental or potential malicious acts or terrorist attacks sequences. The potential radiological consequences have been calculated by using INTERTRAN II computer code.
The calculated radiological risks include [5]:
- RAM exposure to the public and transport personnel from routine (incident free) transport of the very low level radioactive material (uranium ore);
- transport accident and consequences of the potential malicious acts as well as terrorist attacks resulting in radiation exposure of the population and contamination of the environment.

The accidental sequences include steps such as: characterization and the type and quantity of shipment; determination, selection and description of the type, severity and probability of occurrence of transport and handling accidents; assessment of potential radiological consequences for the spectrum of wealth condition encountered along the rail route, consequences of potential malicious acts, landslide, etc.
The IAEA computer code INTERTRAN II has been used to determine the collective dose to population and transport personnel and the preliminary risk assessment results are:

- crew: 1.34×10^{-5} person Sv/y;
- members of the public: 1.78×10^{-5} person Sv/y;
- TOTAL: 3.12×10^{-5} person Sv/y

Radioactivity releases are not expected to occur in close proximity to a possible accident site at a probability level as low as 10^{-7}, i.e. a chance of 1 in 10 million for the total volume of the RAM to be transported. In case of the malicious acts, sabotage or terrorists attacks the radioactivity releases can increases significantly.

4, TRANSPORT OF SPENT NUCLEAR FUEL BY ROAD- A Safety case

A CANDU spent fuel bundle from NPP CANDU Cernavoda is intended to be transported, by road, to INR Pitesti (see Figure 2).

Fig 2. SNF route transportation from NPP Cernavoda to INR Pitesti

The scope of this transport is to be determined and analyzed the behaviour of the Romanian CANDU manufactured fuel (bundle) during burning. In order to evaluate the risk and the radiological consequences of routine as well as accident frequencies and radiological consequences due to the transport, the INTERTRAN 2 code has been used.

The assessment considers a possible future transport operation and specific details would be confirmed prior to a decision to undertake the movements. It is necessary to make assumption for the purpose of this assessment. An alternative route, for example, could include hazards excluded from this analyze. It is assumed also that the package will be transported on suitable trailer and the speed of the vehicle will be limited at 30 km/h (8.33 m s^{-1}). On the other hand, it is likely that factors such as operational controls and arrangements (high standards of driver training for example) will reduce the probability of many accident scenarios.

This analyze is referring to the off-site transport and consider also potential malicious acts, terrorist attacks or protest action.

The package contents: total products activity is approx. 696TBq, (18,800 Ci/bundle), respectively (activity is *945 Ci/k*g metallic uranium). It is also assumed that the true value may be up to *25%* larger than those quoted. Inside the package will be only 1 CANDU spent fuel bundle.
Population Density is required to estimate the consequences of an accidental release of radioactivity, the probability that an accidental release will occur in a particular population density area and the collective doses to the population from the normal transport of spent fuel.
Typical population densities for normal transport dose calculations have been determined to be: a) *urban*: 5,000 peoples/sq, km, b) *intermediate*: 230 peoples/sq.km, c*) rural*: 55 peoples/sq.km.

During incident free routine transport, the package external dose field will result in small radiation doses to exposed workers and members of the public. These doses are estimated using the IAEA computer code *INTERTRAN 2* [3]**.**

RESULTS

The collective doses assessed (assuming 1 shipment/yr, 1 package/journey) are:

Dose to public alongside route	*1.43 x 10^{-3} (Sv/y)*
Dose to public sharing route	*1.78 x 10-3 (Sv/y)*
Dose to public during stops	*2.37 x 10-5 (Sv/y)*
Dose to package vehicle crew	*5.5 x 10-3 (Sv/y)*

The total annual collective dose to member of the public of *3.3 x10-3 person Sv* can be compared with that they receive due to naturally occurring sources of radiation. The total number of the peoples exposed calculated from these areas and densities are about *140,256.* Assuming a risk factor of *0.067* Sv^{-1}, the annual collective dose to member of the public is determined to be 2.3x10E-03.

RISK EXPECTATION VALUES

- The expectation value (or average) of risk, measured in terms of expected number of fatalities per year, is a convenient measure of risk. It suffers from the disadvantage that the averaging is performed over a wide range of consequences. However, the frequency associated with accidents involving more than one fatality is very small in this case and falls off rapidly for higher fatalities.
- The expected number of fatalities for members of the public per year associated with the proposed road transport operation are based on the expected number of fatalities for each scenario in urban, intermediate and rural population distribution and the probabilities of accidents occurring in each region.

The preliminary results are shown below:

- *radiological effects in accidents: 5x10-9;*
- *radiological effects in routine transport: 1.7x10-4*

5. CONCLUSIONS

The transport of RAM in Romania is a very sensible and complex problem taking into consideration the importance and the need of the security and safety for such activities. The Romanian Nuclear Regulatory Body set up strictly regulation and procedures according to the Recommendation of the IAEA Vienna and other international organizations. There were implemented the adequate regulation and procedures in order to keep the environmental impacts and the radiological consequences at the lower possible level and to assure the effectiveness of state nuclear security regime due to possible malicious acts in carrying out these activities including transport and the disposal site at the acceptable international levels. The levels of the estimated doses and risk expectation values [5] for transport and disposal are within the acceptable limits provided by national and international regulations and recommendations but can increase, significantly during potential malicious acts.

ACKNOLEDGEMENTS

The author wants to express deeply thanks to the IAEA Secretariat for the strong support, both technically and financially, under contract, in order to carry out the scientific research

REFERENCES:

[1] IAEA NUCLEAR SECURITY SERIES GUIDE-Security of Radioactive Material during Transport, (2007).

[2] G.Vieru, “Risk and Safety Evaluation in Radioactive Waste Transport in Romania”, RAMTRANS, Vol. 10, No. 2, pp. 105-112, London, UK, (1999).

[3] G.Vieru, “The Identification and the approach of the risk and safety problems associated with the transport of radioactive materials in Romania”, Romanian Nuclear Program, Internal Report, INR Pitesti, Romania, (2002).

[4] G.Vieru, “Safety criteria for the transport and storage of the Radioactive Materials, in Romania”, Romanian Nuclear Program, Internal Report, INR Pitesti, Romania, (2001).

[5] G.Vieru, “The Safety of Transport of Radioactive Materials in Romania”, RAMTRANS, Vol.14, No. 1, pp. 15-27, London, UK, (2003).