CASE STUDY: OCCUPATIONAL EXPOSURES IN THE TRANSPORT OF RADIOACTIVE MATERIAL – REM INDÚSTRIA E COMÉRCIO LTDA. BRAZIL

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ABSTRACT

As part of the optimization process of radiation protection at REM Indústria e Comércio in Brazil, the operational procedures in the transport of radioactive materials were accompanied regularly to evaluate if effective doses could be decreased. The company has 5 drivers and 4 adapted vehicles dedicated to the transport of radioactive materials. These drivers wear thermoluminescent dosimeters throughout 30 days to monitor the radiation effective dose during the practice. Each vehicle has also dosimeters in the driver's cabin. The results of these dosimeters are analyzed and compared with type of transported materials, transport index, routes of transportation and time for each transport. If levels exceed the limited effective dose allowed in Brazilian legislation, actions are taken to minimize the doses.
The first actions taken to minimize the effective doses were written procedures and instructions for the drivers and train them in protection and safety. In general, the effective doses decreased except for 2 drivers.
For these drivers, data of accumulated effective dose for the year 2006 was analyzed and related to material and radiation exposure in the vehicles. It has been detected a need of coordination with radiation protection and logistics, which is responsible for routes of transport, to minimize the effective doses and achieve the goal of 15 mSv per year.

1. INTRODUCTION

According to the Nuclear Energy National Commission (CNEN) there are, in Brazil, 290 nuclear medicine facilities, 150 radiotherapy centers and around 300 industries which use radioactive sources. The increase of radioisotopes consumption in nuclear medicine has been nearly 10% a year and the main radioisotopes production are ^{99m}Tc generators and ^{131}I.

REM has 5 trained drivers which work full time, 5 times per week. Our vehicles are adapted for the transport of radioactive materials: they have a special floor design at the cargo compartment and a lead shield of 2 mm between the cargo compartment and the vehicle cabin to minimise effective doses received by the driver. For customers in São Paulo city and for some cities in São Paulo state (Figure 1), REM delivers the radioactive material, mainly for nuclear medicine, using its vehicles. The shortest way is 10 km (from the production site to one customer in São Paulo city) and the longest way is around 600 km, from the production site to Presidente Prudente, a western city in São Paulo state. Our drivers are responsible for loading and unloading the vehicle with packages, checking transport documents and delivering the material at the customer's site.

In the beginning of the year 2006, it was noticed that the monthly effective doses for the drivers were increasing. Besides, in 2005, the average annual dose for the drivers was 12.8 mSv but 2 of them showed annual effective doses near the limit dose of 20 mSv. The first step done was accompanying the drivers in the itineraries to observe how the transport operations were performed. Secondly, it was written specific loading and unloading instructions and the drivers were trained on them. With these simple initiatives, the effective doses decrease a little.

Figure 1: São Paulo state map

2. THE TRANSPORT IN PRACTICE

REM's drivers have a daily workload of 10 hours, 5 days per week. The external individual monitoring is carried out on monthly basis and the recording level of 0.20 mSv is adopted. Any dose below this value is considered zero.

Each vehicle carries in the driver's cabin a themoluminescent dosimetry which is used on a monthly basis as well.

There are 9 itineraries which are used during the week workload for delivering materials to the customers: one of them is for delivering materials in cities in São Paulo state and the other 8 are in São Paulo city.

IPEN, Instituto de Pesquisas Energéticas e Nucleares, is the producer which site is located in São Paulo city. The production is divided during the week in the following manner: technetium generators and gallium-67 are produced on Fridays, iodine-131, thallium-201 and indium-111 on Mondays, molecules labelled with iodine-131 (for example, MIBG-131) on Tuesdays, iodine-123 and samarium-153 on Wednesdays; fluorine-18 is produced everyday except on Mondays.

In the year 2006, REM transported around 13.000 packages for nuclear medicine centers, all of them Type A packages and with II-Yellow and III-Yellow labels. Table 1 shows the main materials, the quantity of packages and the total activity for each isotope transported in the year 2006.

Table 1: Materials, activity and number of packages transported in 2006

Radiopharmaceutical	Number of packages per year	Total activity
^{99m}Tc	4514	226530.12 GBq
^{131}I	5405	22817.13 GBq
Others	2693	620.41 GBq

3. METHODOLOGY

For each driver, it was summed the effective doses related to the year 2006 for the whole body and the equivalent doses for the right wrist and the number of working days in the year as well (Table 2).

The average effective dose for the drivers in 2006 was 14.2 mSv. The reason for concerning is that 3 drivers have annual effective dose near to 20 mSv.

For each driver and for the isotopes ^{99m}Tc, ^{131}I and ^{18}F it was performed a correlation between number of packages transported in the year 2006 containing the radioisotope and the effective dose. Then, the correlation was compared to the itineraries. For 2 drivers the correlation of ^{131}I and effective dose was 0.72. Surprisingly, another driver, which correlation of ^{131}I and effective dose was 0.30, has a correlation of ^{18}F and equivalent dose of 0.62 (Table 3).

Table 2: Drivers and their effective and equivalent doses

Driver	Total effective dose (mSv)	Total equivalent dose for extremity (right wrist) mSv	Number of working days per year	Average number of deliveries per month
ARM	8.9	11.4	154	263
ASA	11.3	12.6	172	273
AGP	17.9	18.2	124	193
ELS	15.5	17.8	172	285
MG	17.3	19.1	119	148

Table 3: Correlations between isotopes and effective doses for each driver

Driver	^{99m}Tc x Effective dose (mSv)	^{131}I x Effective dose (mSv)	^{18}F x Effective dose (mSv)
ARM	0.48	0.73	0.21
ASA	0.55	0.72	- 0.14
AGP	0.27	0.06	0.06
ELS	0.47	0.30	0.62
MG	- 0.07	0.35	0.39

4. DISCUSSION

Analyzing the data for correlation and comparing to workload and itineraries, it was found out that the drivers ARM and ASA have higher correlation with iodine and worked on the days this radioisotope is produced.

Taking into consideration the high correlation with fluorine for driver ELS, it was revealed this driver transports on Tuesdays the material 18-fluorine and 131-iodine which is produced on Mondays to a city 100 km from São Paulo city.

It was also noticed that sometimes the drivers don't follow operational procedures as it should be. This led us to train them in radiation protection, safety culture and prevention of accidents.

This analyzes make us believe logistics must take turns for drivers and itineraries.

5. CONCLUSION

It was demonstrated that the drivers who work in the days which iodine-131 is produced and transported had the higher effective doses comparing to the other days. This shows us it is urgently necessary to evaluate itineraries and drivers schedules.

It is also important to develop a program of periodic training, which involves topics of radiation protection, safety culture, operational procedures and prevention of accidents.

6. REFERENCES

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