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RADIOLOGICAL IMPACT FROM THE TRANSPORT OF RADIOPHARMACEUTICALS OF THE IPEN

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ABSTRACT

When a package is shipped, people who work, live or travel in the route used for transportation of radioactive materials are irradiated, as well as those who are inside vehicles that travel in the same or opposite directions. Therefore, the proposed work has as main objective to estimate the radiological impact of the transportation of radiopharmaceuticals of IPEN-CNEN/SP to some predefined destinations. The doses were estimated for drivers, from both the operation of driving the vehicle, and the loading and unloading of packages, because these tasks are performed by the drivers. The calculations were carried out from information obtained in the activities of transport of radiopharmaceuticals, such as: number of packaged transported, number of trips, number of workers involved, average time of loading, unloading and transport, in addition to the measures obtained in the monitoring performed in packages and means of transport.

1. INTRODUCTION

When a package is shipped, people who work, live or travel in the route used for transportation of radioactive materials are irradiated, as well as those who are inside vehicles that travel in the same or opposite directions. Therefore, the main objective of this paper is to estimate the radiological impact of the transportation of radiopharmaceuticals from IPEN-CNEN/SP to some predefined destinations.

In order to obtain an assessment of the radiological impact under normal conditions of transport [1, 2], resulting from the transport of radiopharmaceuticals from IPEN - CNEN /SP, four major destinations were identified, namely: the Congonhas Airport (São Paulo), Cumbica Airport (Guarulhos), City of Rio de Janeiro and Belo Horizonte City. These destinations represent the distribution of radiopharmaceuticals of the IPEN - CNEN / SP containing ^{99m}Mo and ^{131}I, related to routes, time spent and people involved in the surroundings.

During the implementation of this study, only packages with the labels of categories II-yellow and III- yellow containing ^{99m}Mo and ^{131}I were considered. These are the types of packages that contribute with almost all doses for the public and workers involved in the loading, unloading and transport, as previous studies [3 - 7].

2. METHODOLOGY

In order to obtain an accurate assessment of the radiological impact under normal conditions of transport, from the carriage of packaged containing radiopharmaceuticals on the IPEN - CNEN / SP for the four major destinations, it was necessary to know some parameters and define others:

- distance between the IPEN - CNEN / SP and destinations;
- average speed of vehicles to different destinations;
- number of workers involved in the transport;
- quantity of packages transported;
- transport index medium of the vehicle and;
- number of packages by vehicle.

The sampling period used was the year of 2008, in this period, 29,825 packages were transported and 1,020 trips were made. Twenty three workers (drivers) were involved in the transport of these materials and all of them were monitored individually, which means they were individuals occupationally exposed. In order to determine the doses received from the packages loading, each worker used a direct reading dosimeter (dosimetric pen). It was considered that the doses they received during the unloading were equal to the doses received during the loading.

For the calculation of workers doses, measures of dose rate in the cabin of the vehicle, the transport index (TI) of each package and the sum of TI of the packages in the consignment were used.

3. RESULTS AND DISCUSSION

Table 1 presents the main information of the values measured experimentally on packages shipped in the year of 2008, containing ^{99}Mo and ^{131}I.

Table 1. Main information about transported packages in year 2008

Number of transported packages with ^{99m}Mo e ^{131}I	29,825
Number of packages by vehicle (average)	29
Number of trips	1,020
Number of workers (drivers)	23
Average dose received by workers in each load operation (μSv)	143
Average dose received by workers in each unload operation (μSv)	143
TI_{total} transported	26,362
$\sum_{TI}$ by vehicle (average)	26.1
TI by packages (average)	0.9

During 2008, from IPEN - CNEN/SP to Congonhas Airport, 365 trips were realized, 12,775 packages were transported and eight workers (drivers) were involved in the transport of these materials. From IPEN - CNEN/SP to Cumbica Airport, 330 trips were realized, 10,890 packages were transported and eight workers were involved in the transport. From IPEN - CNEN/SP to Rio de Janeiro, 229 trips were realized, 4,819 packages were transported and four workers were involved in the transport. From IPEN - CNEN/SP to Belo Horizonte, 96 trips were realized, 1,341 packages were transported and three workers were involved in the transport.

Table 2 presents the main information of the values measured experimentally on transported packages in the year of 2008, from IPEN - CNEN/SP to the four destinations.

Table 2. Main information about transported packages in year 2008

Description	Destination			
	Congonhas	**Cumbica**	**Rio de Janeiro**	**Belo Horizonte**
Transported packages	12,775	10,890	4,819	1,341
Number of trips	365	330	229	96
$\sum_{TI}$ by vehicle (average)	29.3	35.3	19.2	11.4
TI by packages (average)	0.9	0.9	0.8	0.9
TI_{total} transported	11,498	9,801	3,856	1,207
Number of packages by vehicle (average)	35	33	21	14
Number of workers (drivers)	8	8	4	3
Average dose rate in the cabin (μSv/h)	97.8	83.3	64.8	76.7
Average dose received by workers in each load operation (μSv)	143	143	143	143
Average dose received by workers in each unload operation (μSv)	143	143	143	143
Distance (km)	15	40	400	500
Considered time (h)	1	1.5	4.5	6

Table 3 presents the calculated annual doses to workers from the values measured experimentally and are described in Table 2.

Table 3. Annual doses calculated from the experimentally measured values, resulting from transported packages in year 2008 to the four destinations

Description	Destination			
	Congonhas Airport	Cumbica Airport	City of Rio de Janeiro	City of Belo Horizonte
Total dose received by workers in transport operations (μSv)	35,697	41,233	66,776	44,179
Total dose received by workers in the operations of loading (μSv)	52,195	47,190	32,747	13,728
Total dose received by workers in the operations of unloading (μSv)	52,195	47,190	32,747	13,728
Total dose received by workers in the transportation, loading and unloading (μSv)	140,087	135,613	132,270	71,635
Total dose average for each worker by transport (μSv)	4,462	5,154	16,694	14,726
Total dose average for each worker by the loadings (μSv)	6,524	5,899	8,186	4,576
Total dose average for each worker by the unloadings (μSv)	6,524	5,899	8,186	4,576
Total dose average for each worker for transport, loading and unloading (μSv)	17,510	16,951	33,067	23,878
Average dose per worker in the trip: transportation, loading and unloading (μSv)	384	411	577	746
Dose/TI (μSv)	12.2	13.8	34.3	59.3
Number of trips per worker needed to achieve the average annual dose limit (20 μSv)	52.1	48.6	34.6	26.8

Table 4 presents the calculated annual doses and collective doses received by workers from the transport operations, loading and unloading.

Table 4. Annual doses and collective doses received by workers (mSv/year)

Destinations	Annual dose received by the worker (average)	Collective doses received by the workers
IPEN – Congonhas Airport	17.51	140.08
IPEN – Guarulhos Airport	16.95	135.61
IPEN – Rio de Janeiro	33.06	132.27
IPEN – Belo Horizonte	23.87	71.63

4. CONCLUSIONS

The results show that workers involved in the transport of radioactive material are subject to very high doses of radiation, in some cases coming close to the annual limits [8 e 9]. These workers are very likely to receive doses above 100 mSv in five years.

During the development of this work, it was observed that drivers of vehicles carrying radioactive materials use their individual dosimeters improperly. The dosimeters are worn in the front of the body rather than in the back. Actions are necessary to be taken with these workers to remedy these cases. The dose recorded by the dosimeters of these workers are much lower than the dose actually received, because, the dosimeters are protected by the body of the workers. The dosimeters did not receive the maximum dose received by the body, as required by international and national standards.

Finally, this work may be used as a tool for management and planning by companies involved in the transport of radioactive material, they can predict in advance all the necessary infrastructure necessary to carry out the transport of a given number of packages.

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