OPTIMIZATION ANALYSIS IN RADIOACTIVE DECONTAMINATION

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ABSTRACT

In activities that involve radioactive material, only those ones which produce benefit even considering all detriment and costs involved can be put on practice, taking into account technical, social, operational and economic factors. However, this is not enough, because it is desirable that the benefit becomes maximum against the detriment and costs. In a practice that involves several alternatives it is necessary to consider the cost of implementation, execution and detriment against the resulting benefits for each alternative. A radiological optimization procedure was performed at IPEN-CNEN/SP for decontamination of glass cups and acrylic holders used during the production of ^{99m}Tc generator. These materials are sent for decontamination, and they usually present dose rates of 0.60 mSv/h. The decontamination method commonly utilized consists of the materials immersion in a 5% NaOH solution during one week. An alternative procedure is an immersion in a 10% HCl solution during one day. Other proposed alternatives would be the decontamination by cavitation in ultrasonic set and radioactive decay. Thus, the purpose of this paper was to demonstrate, by use of analytical techniques of optimization analyses, the best alternative for decontamination of the objects used in the ^{99m}Tc generator production. The analytical method used was a multi-attribute analysis, because it accepts multiple factors. The results showed that among the four different alternatives the option with the highest utility function is the radioactive decay procedure.

Key Words: radiological protection, optimization, decontamination

I. INTRODUCTION

There are three basic principles for radiation protection: limitation of individual doses, justification of exposure and optimization of protection [1]. The practical application of these principles requires the following investigations: an evaluation of the critical group exposure, a cost-benefit analysis showing the benefit versus specific hazards and a cost-effectiveness analysis demonstrating the optimal protection level [2].

In activities that involve radioactive material, only those ones which produce benefit, even considering all the detriments involved, can be put on practice, taking into account technical, social, operational and economic factors. However, this is not enough, because it is desirable that the benefit becomes maximum against the detriment and costs. In a practice that involves several alternatives it is necessary to consider the cost of implementation, execution and detriments against the resulting benefits for each alternative. An attempt was made to optimize the decontamination process of glass cups and acrylic holders used during the production of ^{99m}Tc generator at IPEN-CNEN/SP. The possibilities of substitution of various methods for other were analyzed too. The purpose of this paper was to demonstrate, by use of analytical techniques of the optimization analyses, the best alternative for decontamination of the objects used in the ^{99m}Tc generator processing.

II. MATERIAL AND METHODS

The glass cups and acrylic holders contaminated with ^{99m}Tc and ^{99}Mo during the production of ^{99m}Tc generator at IPEN-CNEN/SP are sent for decontamination, and they usually present dose rates of 0.60 mSv/h. The decontamination method commonly utilized consists of the immersion of the materials in a 5% NaOH solution during one week. An alternative procedure is immersion in a 10% HCl solution during one day. Other proposed alternatives would be the decontamination by cavitation in ultrasonic set and radioactive decay. The multi-attribute analysis [3] for the optimization of decontamination method was used, because it is able to take into account larger numbers of qualitative factors. The essence of this technique is to assign an overall score to each option, and the optimum solution is the one with highest overall score.

III. RESULTS AND DISCUSSION

The methods that have been used are the immersion in a 5% NaOH solution and in a 10%HCl solution. Nevertheless, these techniques produce radioactive and chemical wastes; in addition, they provoke abrasion of objects. Other proposed methods are the decontamination by cavitation in ultrasonic set and radioactive decay. The decontamination by an ultrasonic set does not provoke abrasion, but needs a special detergent, and it produces waste. The radioactive decay does not provoke abrasion neither waste, however it is slow. The Table 1 shows the variables of each option.

Table 1 Variables of each option for decontamination methods

Option	1	2	3	4
Methods	5% NaOH immersion	10% HCl immersion	Ultrasonic set	Radioactive decay
Annual rate S_H (mSv)	2,7	2,7	0,54	0
Product cost (US$)	0.61/week	0.59/week	7.09/week	450.00/year
Worker cost (US$)	30.00	30.00	10.00	0
Detriment Y ($\alpha * S^H$) (US$)	27	27	5.4	0
Annual cost (X) (US$)	1652.94	1651.86	914.00	450.00
X +Y (US$)	1679.94	1678.86	919.54	450.00
Decontamination time	10 days	3 days	1 day	25 days
Waste generation	yes	yes	yes	no
Abrasion of objects	light	heavy	no	no

The analytical method used was the multi-attribute analysis, because it accepts multiple factors. This technique allows to deal with complex multi-factorial problems and to incorporate qualitative factors directly into the analytical process. The aim of optimization is to find the best use of resources in reducing exposures to workers and the population. This should take into account both economic and social factors, such as the efficiency of protection, investments and equity in dose distributions.

In this paper, it was assumed that the disadvantage of any option is directly proportional to the analyzed variables, that is, the utility functions for analyzed variables were linear.

The attributes: annual cost, u (C), and annual dose rate, u (S), had equal importance and their values were only half of the attributes decontamination time, u (T), waste generation, u (R), abrasion of objects , u (D). These results are shown in Table 2.

Table 2 - Multi-attribute utility analysis for the different options.

Option	Utilities					Total utility
	u (T)	u (R)	u (D)	u (S)	u (C)	U (T, R, D, S, C)
1	0.40	0.00	0.50	0.00	0.00	0.225
2	0.12	0.00	0.00	0.00	$9*10^{-4}$	0.045
3	1.00	0.00	0.75	0.80.	0.62	0.613
4	0.00	1.00	1.00	1.00	1.00	0.750

u (T) = u (R)= u (D) = 2/8; u (S) = u (C) =1/8

The final decision remains a prerogative of the decision maker. The results of the multi-attribute analysis showed that the better method for decontamination of objects was the radioactive decay.

IV. CONCLUSION

The optimization analysis clarified that among the four different decontamination alternatives the option with the highest utility function is the radioactive decay procedure, since it caused major positive benefit against the detriment. Clearly, the proposed option is preferred from ALARA considerations, not only on the basis of cost, but also in consideration of the "additional benefits" The radioactive decay procedure was of smaller cost; in addition, it did not generate wastes neither cause abrasion of objects. In this case, both the individual and collective doses to the public and to workers are too small to be a significant factor in the selection of options.

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