EDUCATION AND TRAINING OF WORKERS FOR DEVELOPMENT OF A SAFETY CULTURE IN A RADIOACTIVE FACILITY

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ABSTRACT

The analysis of radiological occurrence in the Centre of Isotopes (CENTIS) of the Republic of Cuba shows 54 % of registered events happen due to human fails during 1997-2015. Then this requires the promotion of safety culture and the systematic labor of education of staff with responsibilities for protection and safety is the key tool for this purpose. Since beginning, a conceived education system included three basic courses and taking into account the CENTIS' functions as importer, producer, carrier and exporter, are designed courses for all practices and technologic working means. In addition, it is executed every 2 years an updating activity. However, this last activity take place annually and maintain analysis of lesson learned from events, with the combined adoption of measures for avoid their repetition, contribute to increase the adoption of better attitudes for security. The trainers are three specialist of the Radiation Protection Department of this center that have between 10 and 22 years of experience in this plant, received the International Atomic Agency, and participate as teachers in initial courses in 1998 and in the updating courses. Following themes considered are state of the art for studies of biologic effects of ionizing radiations, new national regulations, and operational experiences and in the transport of radioactive materials and those obtained from radiological occurrence and the management of radioactive wastes. The preparation and execution of education should respond to results of assessment of safety culture in the facility for to be able to impact in the significant reduction of the negative paper of the human factor.

1. Introduction

The purpose of this paper is to share our experiences from the education and training system of a radioactive facility in Cuba (Centre of Isotopes (CENTIS)) which is focusing in development of safety culture.

The Culture is a combination of habits and knowledge. Among them, there are beliefs, values, and assumptions of the founders of an organization, learning experiences of group members as the organization evolves (Groups of people who have shared significant problems, solved them, observed the effects of their solutions, and who have taken in new members) and beliefs, values, and assumptions brought in by new members and leaders.

Safety Culture is "the assembly of characteristics and attitudes in the organizations, its managers and workers which assures that, as an overriding priority, safety issues receive the attention warranted by their significance". Safety is understood "as the protection of people and environment against the associated risks of ionizing radiation and also the radiological safety and the security of radiation sources", assuming that they are inextricably linked [1].

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Monitoring the safety culture through indicators identifies trends that are very beneficial for an early alert on potential or imminent deterioration of safety in the organization.

Education and training of staff is an internal action to promote safety culture in our organization itself.

2. Materials and Methods

Taking into account the Regulatory Body regulation and IAEA recommendations [2-3] is created and maintained an education and training system for the staff of CENTIS. The analysis of this for improvement is carrying out with safety performance indicators (SPI) and does not concern the method reported in [4].

3. Results

In the Table 1, show the list of courses executed in CENTIS. The CNSN recognized their competence and elaborated the respective certificates with permanent validity [5-6]. Two conferences on security of radioactive sources and security in the transport of radioactive material were in 2009 for the staff related with the transport and they are not included in Table 1 for the specific of these topics and their realization in another time with respect the training in radiation safety.

Despite, it is required a highest percent of accepted answers of the total points (70%) for the staff related with production and transport, all of persons have obtained good results in tests. For the periodical retraining of staff is introduced the analysis of SPI as a tool for get better the feedback process and training. For assessment the efficiency of these courses following are analyzed the radiological events happened and the occupational exposure.

There is a maximum of five events by year during 2001-2002 and 4 events in the period of 2006-2007; this can be observed in Figure 1.

Can be seen the reduction of this SPI during the rest of the time. In the Table 2 presented the relationship between the behaviour of annual handling activity of ^{131}I, ^{99}Mo and ^{32}P, radionuclides of the main contribution to occupational exposure, and S.

In spite of increasing 1.45 times for the sum of activities of ^{131}I and ^{32}P in the last two years, S has an increment up to 1.78 times. Figure 2 shows S' liaison with the number of monitored workers. The increase of personnel implies the same behaviour of S, but reduces E.

The increment of individual radiation doses ^{32}P contributed to 75.4E-03 man-Sv y-1 in 2003. Besides, it should be observed in this figure the appreciable reduction of the individual exposures determines the decreasing of S during 2006-2008. In spite of this, there is the highest value 98 man-mSv y^{-1} in 2011 due to the increment of ^{131}I activity.

Table 2 allows seeing the highest figure of S is 0.49 times lower than estimated annual collective dose [7]. This is caused by CENTIS yet does not reach to the maximum activity of the basis its design for ^{99}Mo and ^{32}P. The highest contribution to occupational exposure belongs to production of Technetium generators. For the majority of workers (equal or more than 63 %), there is E below 2 mSv y^{-1}.

The relationship between the maximum annual value of dosimetric magnitudes and their respective dose constrains can be observe in Table 4. It should be observed that a new recommended limit for Hp(3) is adopted [8]. In 1996 and 1997 it is indicated as not controlled (NC) for Hp(3). The highest values appear in year 2000 for E, 2006 for Hp(0.07) and in 2003 for Hp(3). It should be appreciated that dose constrains are overcame in these two first moments.

A worker of the group of Inspection and Trial made all of the elutions of generators and received E higher than the limit as average for 5 years [9]. The workload was redistributed and a shielding of lead with 5 cm was situated. In the second case, the procedure of intervention in hot cell with ^{131}I was analyzed. There was an incorrect manipulation for part of worker and this is the cause of the highest value of Hp(0.07).

The Cuban Regulatory Body established its point of view on safety culture [10]. In that document appears 10 basic elements of the safety culture among them there are following culture on the continuous learning, report and communication on safety. With our education and training activities, allow to improve the conduct respect safety of the staff in CENTIS.

Number	Year	Course	Time (hours)	Participants
1	1998	Elements of radiation protection	40	21
2		Basic course of radiation protection for workers	60	31
3		Radiation safety for the transport of radioactive material	5	20
4	1999	Radiation safety for staff with safety and protection responsibilities	60	11
5	2002	Current in radiation safety aspects for workers and staff with safety and protection responsibilities	60	52
6	2005	Current in radiation safety aspects for workers and staff with Safety and Protection Responsibilities	96	60
7		Current in radiation safety aspects for the staff related with the transport of radioactive material	60	11
8	2007	Current in radiation safety aspects for workers and staff with safety and protection responsibilities	96	53
9		Current in radiation safety aspects for the staff related with the transport of radioactive material	40	9
10	2008	Current in radiation safety aspects for the staff related with the transport of radioactive material	40	9
11	2009	Current in radiation safety aspects for the staff related with the transport of radioactive material	40	16
12		Current in radiation safety aspects for workers and staff with safety and protection responsibilities	96	9
13	2011	Current in radiation safety aspects for workers (including them related with the transport of radioactive material)	20	57
14	2012	Current in radiation safety aspects for workers related with the process of production	20	30

Number	**Year**	**Course**	**Time (hours)**	**Amount of participants**
15	2013	Workshop on Safety Culture and Good Practices	32	30
16	2014	Workshop on waste water management in the radiopharmaceuticals production	20	30
17	2015	Current in radiation safety aspects for workers (including them related with the transport of radioactive material)	60	30

Tab 1: CENTIS' radiation safety courses.

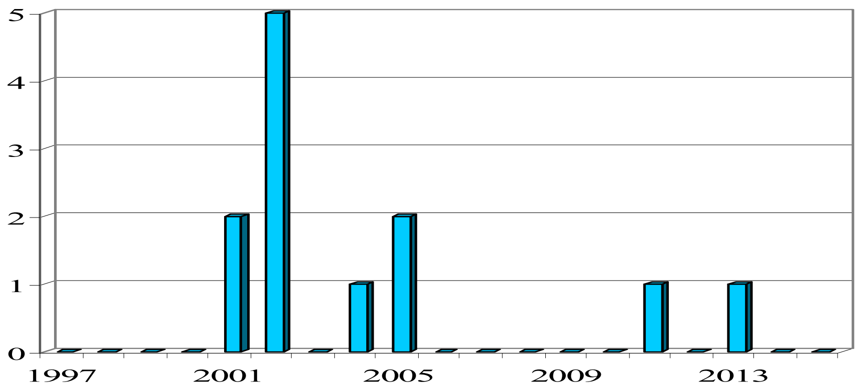

Fig 1: Amount of radiological incidents by year in CENTIS.

Year	**Activity ^{131}I (Bq y^{-1})**	**Activity ^{99}Mo (Bq y^{-1})**	**Activity ^{32}P (Bq y^{-1})**	**S (Man Sv y^{-1})**
1996	Not handled	3.20E+11	Not handled	0.025
1997	7.33E+11	5.92E+11		0.016
1998	4.90E+12	5.39E+11		0.039
1999	4.87E+12	6.60E+11	1.19E+10	0.030
2000	4.84E+12	5.35E+11	**3.64E+11**	0.054
2001	4.88E+12	1.38E+12	3.43E+11	0.036
2002	4.60E+12	1.59E+12	2.35E+11	0.063
2003	3.94E+12	1.49E+13	2.35E+11	0.075
2004	4.71E+12	2.73E+13	1.93E+11	0.026
2005	4.08E+12	2.77E+13	9.75E+10	0.035
2006	3.28E+12	2.29E+13	5.45E+10	0.022
2007	4.91E+12	2.52E+13	8.27E+10	0.017
2008	4.33E+12	2.32E+13	2.03E+11	0.018
2009	5.76E+12	4.01E+13	2.24E+11	0.042
2010	7.09E+12	3.19E+13	3.17E+11	0.055

2011	1.05E+13	3.19E+13	3.12E+11	0.098
2012	1.54E+13	**4.42E+14**	1.68E+11	0.095
2013	1.86E+13	6.79E+13	2.65E+11	0.077
2014	**2.13E+13**	6.77E+13	1.16E+11	0.047
2015	2.02E+13	1.19E+14	1.58E+11	0.057

Tab 2: Annual activities of the main radionuclides and collective doses (S).

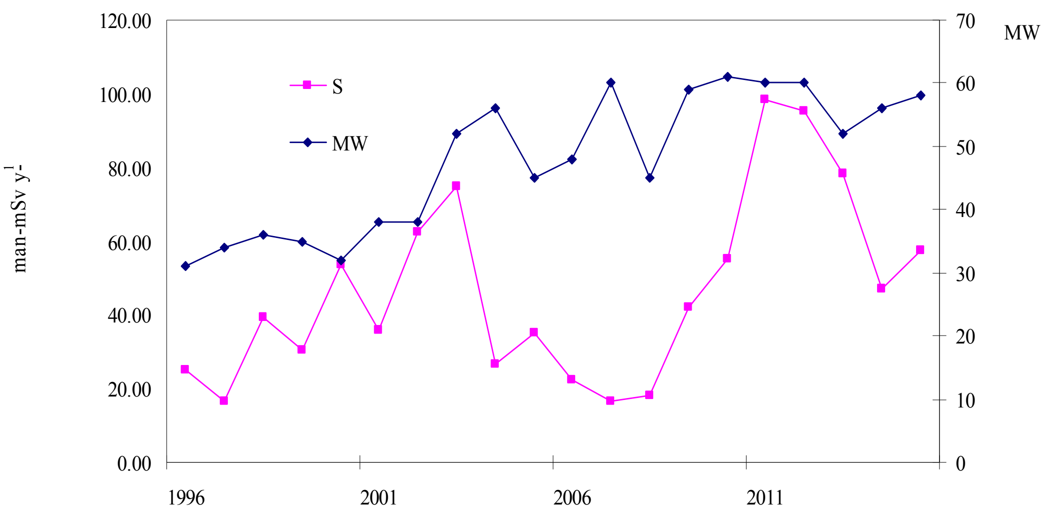

Fig 2: Collective doses and annual monitored workers.

	E (mSv)	Hp(0.07) (mSv)	Hp(3) (mSv)
Dose constrains	12	200	15
1996	4.73	8.15	NC
1997	4.02	8.56	NC
1998	10.27	17.85	2.60
1999	4.85	49.38	4.38
2000	**25.77**	65.43	1.27
2001	3.22	117.97	1.90
2002	7.06	97.94	8.47
2003	5.89	91.47	**12.09**
2004	4.17	73.41	5.14
2005	6.52	145.17	5.89
2006	6.09	**232.71**	3.49
2007	2.96	117.70	3.86

2008	4.28	168.38	2.18
2009	5.32	172.49	4.85
2010	5.14	60.68	3.85
2011	9.13	194.60	12.05
2012	12.56	116.59	9.95
2013	13.23	159.23	7.49
2014	5.46	97.00	6.95
2015	6.68	125.14	8.75

Tab 4: Maximum values of dosimetric magnitudes and relationship with the dose constrain.

4. Conclusions

The education and training system described in this paper allows maintaining the preparation of the staff in radiation safety in accordance with its safety function and the Regulatory Body in Cuba certified it. Assessment of the efficiency and effectiveness of education activities requires analyzing the behaviour of SPI related with occupational exposure and radiological events.

The objective focusing in a safety culture is permanent in our organization since this is a lingering process.

The analysis of SPI behaviour in the training of the staff is a good experience since this allows improvement the feedback process and contribute to perform different aspects related with the optimization of radiation safety. The education and training system is a tool for the achievement of safety culture in the organization and accomplishment and maintaining of the ALARA principle in the diary labor of CENTIS. Culture on the continuous learning, report and communication on safety are continuously improved.

5. References

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