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IONIZING RADIATION DOSE CONTROL FOR WORKERS IN A RADIOACTIVE PLANT

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ABSTRACT

With the liberation of the use of the nuclear energy for peaceful applications, International Commission Radiological Protection, ICRP, founded in 1928, it was created in 1958 a protection system for the ionizing radiation doses undesirable caused to the workers, public's individuals and environment to make possible the introduction of those applications. That protection system is adopted by the International Atomic Energy Agency, IAEA, that publishes recommendations - Safety Series, SS. In Brazil the *Comissão Nacional de Energia Nuclear*, CNEN, publishes regulations in standards. Those international recommendations and national regulations went by adaptations and they need to be applied in that way. The present work uses recommendations of the publication ICRP-75, of the publication SS-115 and regulations of the standard NN 3.01 of CNEN to present, through radioprotection measures, the doses control of ionizing radiation for workers in a radioactive plant that works with unsealed sources. In this way, it is possible to prevent the undesirable doses appropriately and to confirm the received doses.

1. INTRODUCTION

The objective of this work is to present a short historical about the workers' radiation dose control progress and to illustrate how this control can be carried out in a radioactive plant. This study was based in the national and international radiological protection norms.

After liberation for peaceful uses of atomic energy, in 1955, the ICRP formulated a protection program to the human being and their environment, in 1958, introducing a system of limit radiation doses recommendation. The first dose limit standards were presented by IAEA in 1962. It was named annual limits maximum permissible, ALMP, of radiation dose, because it was allowed to work under their numeric values and they reached their acme in 1967 with new publications as much of ICRP as of IAEA. In 1973, the ICRP presented new guideline due to the knowledge that dose of radiation, even few ones, may cause detriments and it recommended to reduce them as low as readily achievable, taking into consideration economical and social factors. The ICRP started denominating ALMP of radiation dose how ALMA, annual limits maximum admissible, that was 50 mSv to effective dose, E, for workers. Once it doesn't surpass 1 Sv during 50 years of work. The permissible maximum was changed to admissible maximum exactly to force the decrease of the doses.

2. METHODS

To reach acceptable values of radiation dose [1], smaller than 1/10 of the ALMA, acted in the Figure 1, the ICRP recommended a first optimizations cycle to reduce the workers' doses individual remainders for 3/10 of the ALMA.

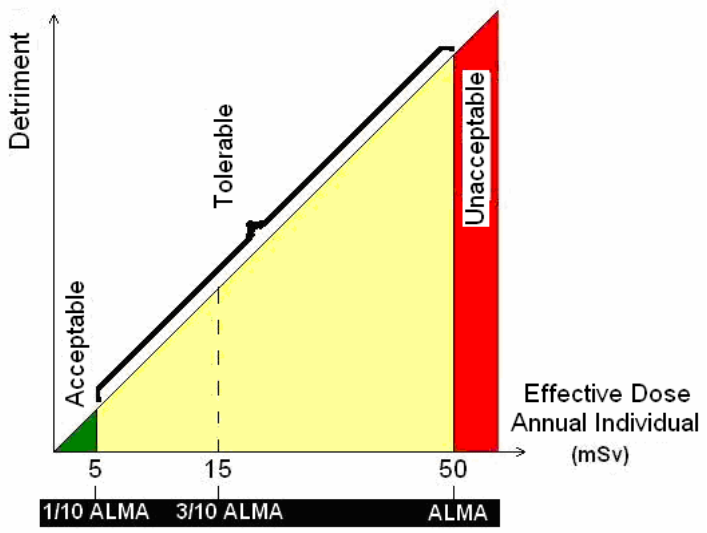

Figure 1. Work regions with ionizing radiation.

The worker's doses control, in that first optimizations cycle, was made with the use of four radioprotection measures:

- Monitoring (of workplace and individual) [2];
- Workers' classification [2;3;4];
- Areas classification [2;3;4];
- Reference levels [2;3;4].

The monitoring in the workplaces involves the measures taken from the workplace. This monitoring is accomplished with preventive character for external radiation, for surface contamination and for air contamination. The monitoring in the individuals involves the measures taken by an equipment carried by the worker (dosemeter) or an equipment for the determination of the amount of radioactive materials that he incorporate or present about his body and the interpretation of these measures. This monitoring is accomplished with confirmatory character for external radiation, for contamination of skin and clothes and for internal contamination. The principles that the monitoring programs must satisfy were in the ICRP-12 publication and in the SS-14 from IAEA, edition 1965, when it was in validity ALMP. With the coming of the ALMA these publications were substituted respectively by the publication ICRP-35 [2] and by the SS-14 from the IAEA, updated in edition 1980. The workers' classification used to be done to identify two groups: A group that received tolerable

doses larger than 3/10 of the ALMA and other group that received tolerable doses smaller than 3/10 of the ALMA. The first group was denominated workers in the working condition A and the second group was denominated workers in the working condition B. For the workers that received doses above the 3/10 of the ALMA, individual optimizations were accomplished applying techniques of help for the decision-making. This way, the doses were reduced for smaller values than 3/10 of the ALMA and the use of the workers' classification started to be unnecessary.

The areas classification was done to limit the access and to simplify the workers' classification [3], because the working conditions A were demanded just in controlled areas. The restricted areas were subdivided in controlled areas, when in them there was the worker's possibility to exceed 3/10 of their ALMA and in supervised areas, when in them there was not the worker's possibility to exceed the 3/10 of their ALMA, considering in both possibility of maximum time of 2000 h/year.

The reference levels were values used in the monitoring for the comparison with the values of the measured units. They were reference values recommended by ICRP [3], but not used as rigid boundary-values. However, when the values exceed the reference levels, actions are taken to prevent radiation doses and to guide the course of the radioprotection actions. The reference levels were subdivided by:

- Recording levels: 1/10 of the ALMA, in the time fraction measure. Above this level the values are registered;
- Investigation levels: 3/10 of the ALMA, in the time fraction measure. Above this level the activities are investigated;
- Intervention levels: above the values of the ALMA.

Now, in the second optimizations cycle, to reach the acceptable values of dose, the ICRP [5] restricts the limits control in 5 years intervals, not allowing the in period where the workers' effective doses surpass 100 mSv. With that restriction the value used for the annual doses control starts to be the annual average of the maximum annual limit admissible of the effective dose in five years (20 mSv/year) and it reduces the doses with a system that uses the three radioprotection measures with their updated concepts:

- Monitoring (of workplace and individual) [6;7];
- Areas classification [5 to 8];
- Reference levels use [5 to 8].

2.1 Monitoring

The monitoring is an attendance accomplished through observations of parameters. It is a radioprotection technique that evaluates the control of the exposures of the ionizing radiations and that it must be obtained in an effective and economical way. In the field of the radioprotection, that term expresses the measurement of unit and of parameters for control aims or evaluation of radiation exposure, including the results interpretation [9]. The functions of a monitoring program are divided by:

- Task-related monitoring, applied for a specific task. It supplies data for helping in the immediate decision for give continuation to the task in execution. It can also aid in protection optimization;
- Routine monitoring, associated with the continuous operations, is idealized to demonstrate that the working conditions, including the values of individual doses, stay satisfactory, and to assist to the demands rules. Therefore, he is in a large part of confirmatory nature, because it confirms if monitoring program task-related, in his totality, is satisfactory;
- Special monitoring, of investigatory nature, typically involves a situation, in workplace, where informations aren't sufficient for demonstrate an appropriate control. It is idealized to supply detailed information that can elucidate any problem and to define future procedures.

To each monitoring type, as much of the workplace as individual these three functions are applied.

2.2 Areas Classification

To obtain areas control, the national norms demand: access control, works evaluation, words and radioactive symbols (warning), monitoring, decontaminations and classifications of areas.

Then, for radioprotection administration aims, the officers must classify the work areas according to radiation exposure or radioactive material. According the running standards [9], the classifications are: controlled areas; supervised areas or uncontrolled areas.

An area must be classified as controlled area when it is necessary the adoption of specific measures for protection and safety to keep that the usual work exposures they are in accordance with the optimization requirements and dose limitation, as well as to prevent or to reduce the magnitude of the potential exposures. The controlled areas must be signed with the international symbol of ionizing radiation and a printed text which describes the type of material, equipment or use related to the ionizing radiation. A controlled area, therefore, it is that in the which, in normal conditions of work, including the possible occurrence of incident, it is demanded from the workers that follow procedures very well established, specifically elaborated with the purpose of controlling the exposures to the radiation.

An area must be classified as supervised area when, although it doesn't request the adoption of specific measures of protection and safety, the regular revaluations of the conditions of exposures work must be done, with the objective of determining the classification continues appropriate. The supervised areas must be signaled as such in their accesses [6;8]. A supervised area, therefore, it is that in that the working conditions are maintained under supervision, however, they are not usually necessary special procedures of radioprotection. The definitions of the areas are based on the knowledge and operational feeling [5].

2.3 Reference Levels [5 to 8]

Reference level is a previously determined value for any physical unit used in radioprotection programs that, if it be get reaches or the potential to exist of being, they must begin taking of actions previously defined. Three levels are used:

- Recording level: when the value is exceeded, the result is recorded, while less values that this level are considered null;
- Investigation level: when the value is exceeded, the cause or the implications of the results are examined and the protection must be gotten better;
- Intervention level: when the value is exceeded, the task is interrupted until that the cause or the implications of the abnormality are corrected, for the return to the normality.

In the workplace, the recording level is used to record the measure of points that can result in annual effective doses greater that 2 mSv in the workers. The investigation levels can be fixed in convenient values for the action of the radiological protection and the intervention levels usually use the values of the ALMA.

In the individual monitoring, the investigation level is used for the workers' investigation that receive annual effective doses above 6 mSv for the IAEA and the ICRP suggest the recording level in 5 mSv a year for the effective dose. The intervention level continues based on the values of the ALMA.

3. DISCUSSIONS AND RESULTS

3.1 Monitoring

3.1.1 Workplace

Fixed detectors and portable detectors:

The obtaining of the values of the doses in the workplaces with the fixed detectors, with routine function, allows an appropriate analysis about the conditions of safety deterioration of the workplace. That monitoring can be done with the aid of recordings of physical access by electronic controls and recordings of video cameras images and it evaluates the effective doses presented in the individual monitoring together with the values of the doses obtained with the portable detectors.

Frequency and chosen points:

Most of the tasks in the plant is not unpublished, is done often. This way, for the routine monitoring to include situations during the tasks, and out of them, it can demand a proportional time of the cycle of tasks.

- With the fixed detectors: The points and the frequency for the obtaining of the values of the doses with the fixed detectors, with the purpose of detecting the beginning of abnormal situations, they can be to every second (on-line), however the frequency for obtaining of the values of the doses with the evaluation purpose is enough of being obtained monthly during the work and out of it, since the tasks are not modified. This way, is obtained the necessary minimum and maximum values for the monthly comparison with the values of the monitoring of individual routine.

- With the portable detectors: For obtaining the values of the doses with the evaluation purpose, the chosen points and a frequency quarterly, they satisfy that purpose. The same frequency but with the audit purpose, to obtain the values of the doses and to obtain the values of surface contamination (used for detect deviations of procedures), it must be increased in the points with different values from background, BG, and in the points with the big standard deviation in relation to the measure, with the objective to best evaluate the standard deviation.

The fiscalization audit the task-related monitoring done by the workers. For daily research works and for the production works made weekly or biweekly, the auditing can be random or with an established frequency that satisfies technical evaluation of radioprotection and administrative of the officer.

3.1.2 Individual

3.1.2.1 Comparison of the values:

- Workplace monitoring and individual monitoring: The comparative study among the **appraised doses** with the detectors of dose rate and the **dear doses** with the individual dosimeters must be done by the radioprotection group always in short periods and in each activity to guarantee radiological protection principles and the good proximity in the forecast of those values.
- Individual task-related monitoring and individual routine monitoring: To reduce the difference between the projected value and the received value, as well as each one of them, corrections are done, for the projected value, in the accountancy of the days really worked, being discounted vacations and change of positions or of workers and for the received value, in the permanence of the dosimeters in the plant during the worker's vacations.

For the good proximity in the forecast of those annual values, the doses control is accomplished monthly by the radioprotection group in the plant with the purpose of interfering in the activities, if necessary.

3.1.2.2 Dismissal of the use of the dosimeter:

The workers that just access the areas classified as having supervised don't need usually of radioprotection procedures for the new concepts. The individual effective doses received in those areas can be inferred based in the results of the monitoring of controlled areas and in the information about the individual's activities in the area that demonstrate that the doses in the radiation fields are inferior to you value small (1 mSv/year).

3.2 Areas Classification

The workplaces classification in controlled areas and supervised areas turn the control of the laboral exposure more effective, because besides demanding specific procedures, it allows to differentiate the workers that have authorization for access. The definitions of the classification consider the obtained values of the monitoring of the workplace, the potential of external exposure and of the workers' incorporation and the probability of transfer of the contamination outside of those areas. The control of the exposure laboral is aided by the control of the workers' access that is accomplished by registered authorization, ratchet of physical access that register names and time of access and camcorders cameras that identify activities, places of access and permanence through their images.

The areas classification and those grouped information assist, therefore the radiological monitoring and the laboral exposure control.

3.3 Reference Levels Use

Now the ICRP [6] uses the same concepts that it used in the definitions of the reference levels [2] with the objective of reaching the acceptable values (5mSv/year) that obeyed to the publication 26 of ICRP, however the control of the ALMA was more restricted with the publication 60 of ICRP. Now the IAEA uses the concepts of the reference levels in smaller reference values, because it considers the average to each 5 years interval of the double of the ALMA (2 x 50 mSv / 5 years = 20 mSv/year) and it recommends to reduce the doses until the investigation level (6 mSv/year). The CNEN adopted the values recommended by IAEA.

4. CONCLUSIONS

This work presented the evolution of the ionizing radiation dose control for workers and it illustrated as this control can be made through measures of radiological protection with its concepts based on norms. In this way we conclude about the necessity of this control demanded by the norms and we can visualize the application of this theory in the practical one, realizing this control.

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