ACCIDENT IN A CRITICAL FACILITY: PHYSICAL DOSIMETRY

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INTRODUCTION

On September 23rd 1983, while a change in core configuration was taking place in an experimental reactor, the RA-2, at the Constituyentes Atomic Center - Buenos Aires - Argentina - an accidental criticality excursion occurred. This accident caused, 48 hours later, the death by overexposure of the operator, and lower doses to the people who were in the commanding room and in the surrounding laboratories.

The absorbed dose to the people involved in the accident and the air absorbed doses in several points outside the facility are shown. An enumeration of the methodologies used for the dosimetric evaluation is done.

DESCRIPTION OF THE FACILITY

The reactor is a critical ensamble of variable configuration with fuel elements of uranium enriched at 90 %; it works using light water as moderator and reflector and it has a 0.1 W nominal power. It is placed into a cylindric aluminium container with a diameter of 2 m and a height of 1.5 m,with a top surface free to reach the core for assembling operations.

The accident occurred just when it was going to be changed the configuration core of the facility. This operation was carried out, as usual, manually by the operator (A), who was leaning on the edge of the container. Figure 1 schematically shows the facility, composed by the reactor, the commanding room and the annexed laboratories to carry out measurements. The figure also shows the location of the 14 persons who were present in the facility when the accident occurred and they are referred to from A to N.

PHYSICAL DOSIMETRY

In order to carry out the dosimetric evaluation it was necessary to use alternative methods because none of the persons involved had their personal dosimeter.

The data were obtained by measuring the induced activity of Na-24 in the body or in blood samples, induced activity of P-32 in hair and activation of personal elements like rings, chains, keys, sweaters, etc., measurements of rate of absorbed dose after the event, and absorbed dose obtained from the personal dosimeters that were hanging on the panel, marked number 3 in fig. 1 and from area dosimeters that are shown in fig. 1.

The methodology used to estimate the absorbed dose, consisted in the use of different evaluation methods based on:

1) using the values of the sodium activation in blood, sulphur in hair and the characteristics of the critical facility (1);
2) knowing the thermic, epithermic and rapid component of the neutrons fluence and applying conversion factors fluence dose in equivalent tissue (2);
3) applying an AERE-R 7487 (3);
4) using the relation between gamma and neutrons absorbed dose (4,5);
5) determining the hardness factor (R) from P-32 measurements in hair and Na-24 in body.

$$D = D_{rapid}\,(1+R)\text{, considering } R = \frac{D_{thermic} + D_{intermediate}}{D_{rapid}}$$

6) measuring the rate of gamma absorbed dose, estimating the components of the gamma dose due to fission products and to prompt radiation, including in this last component, the gamma radiation coming from neutronic captures (6,7);
7) modelling an homogeneous estimated cylindric source based o the core's accidental configuration.
8) defining a transference factor: relation between the gamma absorbed dose measured in a certain place of the facility and in a place of the core.

ESTIMATION OF THE ABSORBED DOSE IN THE PERSONS INVOLVED AND IN THE SURROUNDINGS OF THE FACILITY

In order to evaluate the dose absorbed by the operator (A), all the methodologies mentioned above were applied.

The total absorbed dose in the whole body was obtained adding gamma and neutron components. The weighted neutron fraction in total body was estimated to be 22 Gy, while gamma the fraction in total body was assigned to be equal to the maximum dose in trunk, that is to say, 21 Gy. So, total dose absorbed in whole body was estimated to be 43 Gy.

The dose value obtained belong to the average of the differents methods applied, with a maximun dispersion rate of 30 %

The distribution of the neutron absorbed dose in differen parts of the body are shown in table 1.

The dose in different organs, applying the conversion factors of fluence in free air to organ dose (8) was also estimated. The obtained values are shown in table 2.

The absorbed doses in whole body for the other persons involved are shown in table 3. Errors of measurements are not shown in the tables because they are negligible considering all the other error sources such as: location of each person in the moment of the accident, orientation in the space, time of permanence in each point, etc.

The air absorbed dose in the surroundings of the facility are shown in figure 1.

CONCLUSIONS

From the data of the absorbed dose in the reactor's operator, it was estimated that he was positioned at the time of the critical excursion was leaning on the reactor container with his right arm extended over him, and with his body and head a little turned to his left.

From the measurements of the rate of the gamma absorbed dose taken after the event and from the estimations carried out, we conclude that there is a contribution to the absorbed dose of the persons B and C due to sky effect.

There is a good correlation between the dose obtained by the physic dosimetry and the dose estimated by clinic and biological dosimetry (9).

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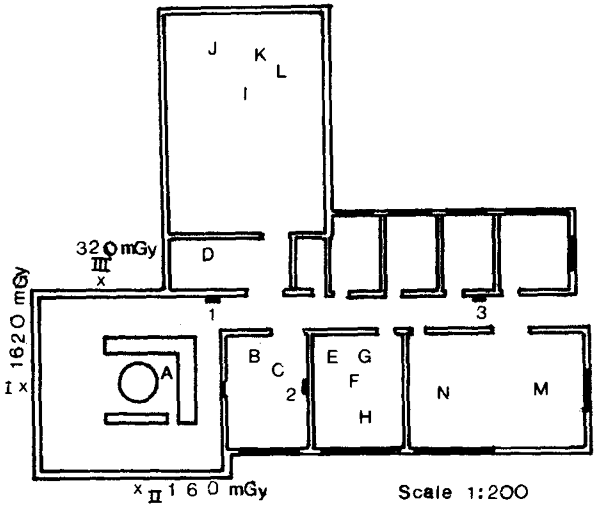
Figure 1

RA-2 Facility



Scale 1:200

A-N: Location of the persons.

1-2: Area dosimeters.

3 : Panel of personal dosimeters.

I-III: Air absorbed dose.

Table 1: Neutron Absorbed Dose Distribution in body surface

Area	Neutron absorbed dose (Gy)
mustache	22
head,right side	23
head, left side	18
nape	5
trunk	26
right axilla	16
left axilla	8
pubes	8

Table 2: Organ Neutron Absorbed Dose

Organ	Neutron absorbed dose (Gy)
right lung	20
left lung	6
red bone marrow	8
testes	4

Table 3: Total absorbed dose

person	Gamma component (mGy)	Neutron component (mGy)	Total (mGy)
B	130	147	277
C	124	124	248
D	96	83	179
E	100	96	196
F	82	63	145
G	90	81	171
H	90	81	171
I	5	6	11
J	3	3	6
K	3	3	6
M	1	1	2
N	1	1	2