HEALTH PHYSICS — PROCEDURE WITH THE IEAR - 1 BRAZILIAN RESEARCH REACTOR

PROCEDIMENTO DE ROTINA EM PROTEÇÃO RADIOLÓGICA
NO REATOR IEAR - 1

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INTRODUCTION

The way in which a health physics routine procedure can be stablished, in a novel Institute, is described. This kind of description can be found in a number of publications. The intention is to show how same problems could be solved with improved arranjements, and the minimum equipment needed to this. The description concerns the Institute of Atomic Energy, São Paulo, but is restricted to the reactor area. Besides that we have also, Radiobiology laboratories (animals experiments with radioisotopes), a Van de Graaf acelerator, a radioisotope processing plant, and radio-chemistry laboratories.

The IEAR-1 is a swimming-pool reactor, designed to work continuously in 5 Mw. It is installed in a separate building provided with a basement and three floors, which contain:

Basement - Heat exchanger, resin columns, sump, etc.

First Floor - Beam holes, tubes for deposit of hot materials, areas for research work with the beams.

Second Floor - Equipment rooms

Third Floor - Pool surface, control room, and some laboratories.

The IEAR-1 reactor has been operated in a variety of conditions; during the last months, most of the operations correspond to the power of 2 Mw.

A service in health physics, in order to be efficient, must be as much independent as possible, for every human element of the staff, when collecting data or trying to achieve improvements in the geometry or the technique, might unconsciously expose himself without necessity.

When planning any experiment, the health physics service has an important role, in order to avoid that the arrangements, after being prepared, have some modifications which sometimes are not simple.

In settling health physics procedures the most important problems are: external radiation, air activity, and contamination. Normally the hot operations are those connected with the beam holes, irradiation elements, and pneumatic rabbits.

AIR SAMPLING

Two continuous air monitors are being used: a MAP-1 placed on the first floor, near the beam holes, and a Victoreen monitor, placed on the third floor. The latter has an extension which ends near the pool surface. The reason to this location is due to the fact that, on the first floor, neutron beams from the beam holes are responsible for the activity in the air and, on the third floor, the activity comes from radioisotopes which might eventually exist dissolved in the water. No monitors are provided on the basement floor because this part of the building is closed during the reactor's operation.

The Victoreen monitor scrams the reactor when the maximum permissible concentration is reached. The MAP-1 is not connected with the reactor's scram system, because external radiation not coming from air activity would be detected by the Geiger, so giving a false alarm; when the maximum permissible concentration is reached an alarm bell rings.

As the Brazilian construction materials are rich in thorium the air activity in the building raises gradually, due to the thoron emanation from the walls. So, several points of calibration for the air monitors were obtained by sealing a room and waiting for the air activity variation. A survey of the air activity has been made inside the reactor's building, because it was verified that the room conditions very more frequently as due to the thoron emanation than to the reactor operation.

Besides the monitors, there are Millipore pumps which normally take two air samplings a day, one on the first floor and another on the 3rd one. During the reactor's operation the sampling is carried out every hour, until the equilibrium is reached.

After some experience, the Millipore filters, which are really expensive, have been substituted by cheaper ones and their efficiency determined by comparison. The advantage of the Millipore system is that it can be actually transferred from one place to another, thus allowing air sampling in different areas, as, for instance, in the laboratories or in the radioisotope processing caves. Fig. 1 shows some air sampling data.

Finally there is the reactor's exhausting system, which is connected to the pneumatic rabbits and the hot laboratories. The filter's efficiency and the activity of the expelled air are determined by two Geigers, placed one before and the other after the Cambridge filters. The Geigers are connected to a recorder;

PLACE	INITIATED AT	FINISHED AT	REACTOR'S POWER	AIR ACTIVITY IN $\mu C/cc \times 10^{-10}$
I	10 h 27	11 h 07	2 Mw.	3.75
I	11 h 40	12 h 20	2 Mw.	4.65
I	13 h 20	14 h 00	2 Mw.	8.40
I	16 h 16	16 h 56	2 Mw.	12.10
2	11 h 01	11 h 41	2 Mw.	4.10
2	12 h 15	12 h 55	2 Mw.	4.85
2	14 h 30	15 h 10	2 Mw.	6.55
2	16 h 45	17 h 25	2 Mw.	7.47

FIG. - I

Showing the results of air sampling with reactor on at 2 Mw.
Place I - 3rd floor. Place 2 - 1rst floor.

FIRST FLOOR							
PLACE	BETA-GAMMA RADIATION mr/h	NEUTRONS $n/cm^2/s$		PLACE	BETA-GAMMA RADIATION mr/h	NEUTRONS $n/cm^2/s$	
		SLOW	FAST			SLOW	FAST
I	.05			X	.04		
II	.04			XI	.20		
III	.04			XII	.12		
IV	.04			XIII	.06		
V	.06			XIV	.04		
VI	.04			XV	.05		
VII	.04			XVI	.04		
VIII	.04			XVII	.05		
IX	.05			XVIII	.04		

THIRD FLOOR							
PLACE	BETA-GAMMA RADIATION mr/h	NEUTRONS $n/cm^2/s$		PLACE	BETA-GAMMA RADIATION mr/h	NEUTRONS $n/cm^2/s$	
		SLOW	FAST			SLOW	FAST
I	.05			XIV	.25		
II	.06			XV	.07		
III	.07			XVI	.06		
IV	.08			XVII	.07		
V	.08			XVIII	.16		
VI	.06			XIX	.07		
VII	.06			XX	.09		
VIII	.12			XXI	.19		
IX	.06			XXII	.60		
X	.06			XXIII	.20		
XI	.05			XXIV	.07		
XII	.06			XXV	.50		
XIII	.06			XXVI	.08		

FIG. - 2

Showing the results of a survey with reactor off. The points are choosed in such way to cover all the building.

placed in the control room.

In the case of abnormal activities the dampers can be closed.

EXTERNAL RADIATION

Two surveys per day are made as a routine. These surveys permit to check if the radiation levels are normal, if the sources are well shielded and if there is any factor which could be raising the radiation levels.

Nuclear Chicago survey meters and also Tracerlab cutie-pies are used. During the reactor's operation a survey is made every hour, until the equilibrium conditions are reached and the working areas have been delimited. Fig. 2 shows an example of data collected on these surveys. Besides, there are eight Jourdan chambers distributed on the building, all connected to the control room and to the reactor scram system. Before each operation all chambers are tested.

Besides the delimitation of the working areas all the personnel entering the building must bear a pocket chamber and film badge. It was costumary to pick up the pocket chambers every day and to developed the films every month, but observation showed that the doses detected were lower than the sensitivity of the systems, that is, 4 mr for the pocket chamber, and 50 mr for the film. It was then decided to leave the pocket chamber with the researchers during one week and develop the films quarterly. As to the dosimeters, this procedure showed to be unadvantageous because of leakage. This problem had to be solved by using closed boxes containing silica. The operator, at the end of a work-day, put his dosimeter in the boxes and takes it in the morning. The dosimeters are tested monthly, except when they show a very high exposition. In this case, the tests for calibration and leakage are made immediately. The photographic dosimetry service employs Du Pont 552 packet. This contains two films, one for high range radiation and another for low ones.

The density lectures are made by means of a McBeth Ansco densitometer. Fig. 3 gives a typical individual radiation card showing the results obtained.

Every time a beam-hole is opened, there is a beam-catcher with enough shielding material to stop a beam, when ever the reactor operates at 5 Mw.

The neutron monitoring is carried on with two survey meters from Nuclear Chicago, model 2112 with DN-3 neutron probes. Research is beeing carried out in order to develop a pocket chamber really sensitive both to slow and fast neutrons.

Contamination and Waste disposal

A small laboratory, using classical methods, is available for decontamination.

Presently waste disposal is made by material concentration. Studies are being conducted in order to verify the possibility of burying the radioactive materials, which seems to be the best solution in Brazil, due to its large territory.

Some data on the methods described

ATOMIC ENERGY INSTITUTE

RADIOL. PROTECTION SERV.

1st. QUARTER

2nd. QUARTER

3rd. QUARTER

4th. QUARTER

JANUARY

APRIL

JULY

OCTOBER

FEBRUARY

MAY

AUGUST

NOVEMBER

MARCH

JUNE

SEPTEMBER

DECEMBER

Observations

YEAR: 1961

MONTH	D. D.	OPTICAL DENSITY					DOSE (mrems)			
		CD	OW	CU	PB	PL	M_D	S_D	P_D	L_D
JAN	2-2	.51	1.03	.54	.47	1.00	1050	2250	600	2350
FEB	20-3	.50	.72	.47	.43	.71	1250	1400	700	1800
MAR	10-4	.43	.71	.50	.42	.65	640	1400	500	1250
APR	10-5	.30	.31	.32	.30	.28	300	230	260	160
MAY	21-6	.26	.26	.26	.26	.26	190	≤70	≤70	130
JE	7-7	.39	.44	.40	.39	.42	250	300	160	310
JUL										
AUG										
SEP										
OCT										
NOV										
DEC										

QUARTER FILM				
	M_D	S_D	P_D	L_D
1st.	2900	6100	1600	5800
2nd	200	410	240	430
3rd.				
4th				

D.D.- DEVELOPMENT DATE
CD - CADMIUM FILTER
O.W.- OPEN WINDOW
CU - COPPER FILTER
PB - LEAD FILTER
PL - PLASTIC FILTER
MD - MODERATE PENETRATING DOSE
SD - SUPERFICIAL DOSE
PD - PENETRATING DOSE
LD - LENS EYES DOSE

NAME:

FILM Nº

FIG. – 3

RADIATION CARD

The back-ground inside the building, with the reactor off, is 0.05 mr/h and the normal air activity level is, between 8 and 9 o'clock a.m., $10^{-9}\mu c/cc$ and about 2 o'clock p.m. about $2x10^{-10}\mu c/cc$. This variation is due to the fact that the air conditioned system is turned off during the night; the thoron emanation from the walls, as it was mentioned before, is responsible for the variation. The excessive activity is expelled about 1,5 h after the air conditioned system is on. This variation is shown on fig. 4 as it is obtained from a continuous air monitor, with the reactor off.

During the first critical experiment at 5Mw (1958) the surveys for external radiation and air activity sampling showed levels higher than the maximum permissible exposition. On the swimming pool surface, for instance, the dose-rate was about 250 mr/h and along the pool sides 80 mr/h. The air activity was $3x10^{-8}\mu c/cc$. Those levels were due to corrosion of some of the fuel elements. After the corroded fuel elements were substituted, the levels decreased and on the surface of the pool the radiation level was 17 mr/h. A greater part of this activity was due to N^{16} and Cr^{51}. A plastic layer was placed 50 cm below the water surface and, in consequence the level was reduced to 4 mr/h, which is a very satisfactory result when compared with those obtained with similar reactors.

On 2 Mw operations, the external radiation level is 0.15 mr/h on the 3rd floor, 0.8 mr/h on the 1st floor and 0.07 mr/h on the 2nd floor. The 1st floor levels depend on the experiments that are being carried on, because radiation scattering is unavoidable when neutron and gamma beams are used. Fig. 5 shows the dose rates obtained in several places. The places chosen for the surveys are those where the operators work. Some of those places may show levels above 2,5 mrem/h which is the maximum permissible ones. The operators then work alternately, so that the radiation they get

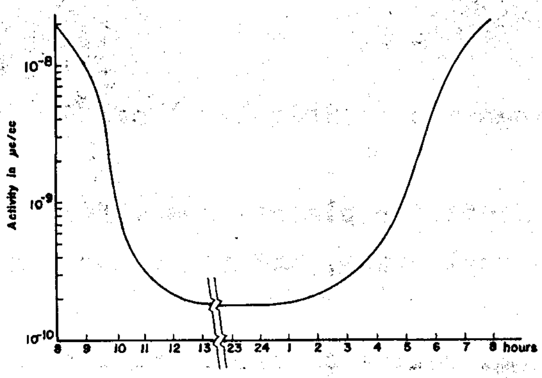

FIG. – 4
The air conditioned sistem was turned on at 8:00 o'clock a.m. and turned off during night.

TIME	PLACE	POWER	BETA-GAMMA RADIATION mr/h	NEUTRONS n/cm²/s SLOW	FAST	DETECTOR
11h05		2 Mw.				GM.-D.N.3
	4	2 Mw.	.30	200	15	458-474
	8	2 Mw.	.50	1,600	60	
	12	2 Mw.	.80	500	35	
	17	2 Mw.	.80	1,500	120	
	18	2 Mw.	4.50	160	80	
	work place	2 Mw.	.40	800	70	
	grade	2 Mw.	.80			
	pool surface	2 Mw.	1.00			
	bridge	2 Mw.	4.50			
11h30	control room	2 Mw.	.20			

FIG. – 5
Results of a survey made during reactor operating at 2 Mw.
The numbers refers to several places on the first floor.

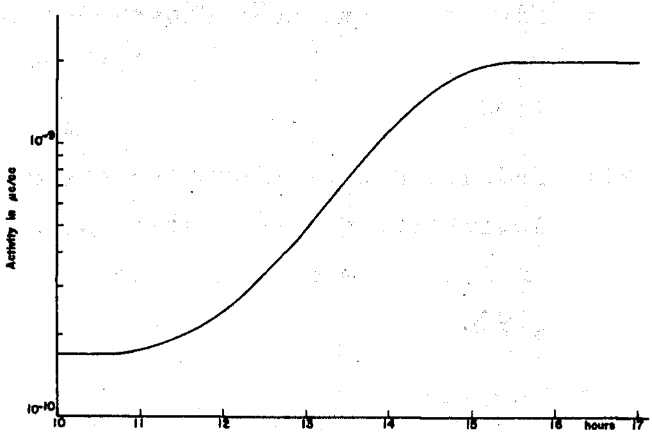

FIG. – 6
Reactor critical in 2 Mw. at 10:00 o'clock a.m.

do not reach the maximum permissible level per day.

On the 3rd floor the places chosen for the survey are the pool surface, the pool sides, and the control room.

The individual radiation cards did not show any level above the maximum permissible rates. The higher levels observed were those of people working on the Radiochemistry Division (processing of radioisotopes) and on Health Physics (assistance to work envolving radiation risks).

The air activity during the operations at 2 Mw reachs, on its maximum, 2×10^{-9} $\mu c/cc$. Fig. 6 shows the air activity variation when the reactor operates at 2 Mw.

REFERENCES :

R.R. Pieroni et Al: Níveis de Radiação Observados com o IEAR-1 Operando em Potência. Publicação IEA nº 34 (1960).

R.R. Pieroni et Al: Radiation Intensity Levels and Air and Water Activities Observed With the IEAR-1 Swimming Pool Reactor at 5 Mw. Publicação IEA nº 16 (1958).