HEALTH PHYSICS ROUTINE AT THE INSTITUTO DE ENERGIA ATÔMICA

Gian-Maria A. A. Sordi

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Gian-Maria A. A. Sordi

COORDENADORIA DE PROTEÇÃO RADIOLÓGICA E DOSIMETRIA
(CPRD)

INSTITUTO DE ENERGIA ATÔMICA
SÃO PAULO – BRASIL

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SÃO PAULO – BRASIL

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HEALTH PHYSICS ROUTINE AT THE INSTITUTO DE ENERGIA ATÔMICA*

Gian-Maria A. A. Sordi

ABSTRACT

We describe our routine Health Physics work at the IEAR 1 reactor and the modifications that are being made

This work includes specific tasks in cooperation with other IEA Divisions and Services.

Further we describe our personal dosimetry laboratory, waste disposal and descontamination laboratory, shielding calculation section, dosimetry laboratory radioactive source and instrumentation calibration

A short description of plans for our new building for the S P R D is included.

Finally we talk about the assistance that we give to those external to the IEA.

I – INTRODUCTION

The growth of the "Instituto de Energia Atômica (I E A)"since its foundation has been exponential

The Health Physics Service has grown together with the I E A because its principal function is to provide technical assistance to the other Divisions and Services in all aspects of radiation protection, personal health, safety of installations and monitoring for contamination

Since the reactor, IEAR-1 is potentially our must dangerous source of radiation, we consider it first. We will briefly describe our rotine precautions, and the modifications being made in the reactor.

This work benefits in particular two divisions, Operation and Maintenance Reactor Division (D.O.M.R.) and Nuclear Physics Division (D F N)

After the reactor we will consider specific projects with other divisions and services; which are presently:

Radioactive Material Productions Service (SPMR)
Radiochemistry Division (DRQ)
Radiobiology Division (DRB)
Industrial Radioisotopes Applications Service (SARI)
Nuclear Metalurgy Division (DMN)

In the thirth section we will speak about projects of general utility This includes itens such as personnel dosimetry, waste disposal, descontamination, shield design, source calibration and instrumentation. As a supplement we will discuss plans for the new Health Physics and Dosimetry Service (S.P.R.D.)

(*) Presented at the FIRST LATIN AMERICAN CONFERENCE ON PHYSICS IN MEDICINE AND RADIATION PROTECTION. SP. Brazil 1972

Finally, we discuss our assistance to outside institutions that request our help Our service includes personnel dosimetry, monitoring of laboratories, cobaltotheraphy units, X ray machines, etc; and shielding calculations for radioactive sources and for laboratories in which they are used

II — REACTOR BUILDING

The IEAR 1 is a water cooled and moderated reactor of the swimming pool type, designed to operate at 5 MW[7] Normal operation at present is at 2 MW, 36 hours per week

Our routine monitoring procedures in the reactor building have changed somewhat since the first criticality on 16 Sept 1957 Early procedures were summarized in 1961 by Hehl[2] and modifications represent attempts to provide better protection and eliminate non essential tests

One change is that laboratories in the reactor building have been eliminated so that within the building there remains only operators personnel, S P R D personnel and those with experiments directly attached to the reactor beam holes (D F N)

These people must wear lab coats, film badges and pocket dosimeters Other dosimeters are employed as necessary for example wrist dosimeters and audible dosimeters in cases of high risk

Acess is controled so that all other persons entering the reactor justify their entrance and are registered by an S P R D technician

These persons are given a lab coat and pocket dosimeter

The protection is done by an equipment that in general is fixed and another that is movable

The fixed equipment used at present includes:

1 — Eight ionization chamber, type "jordans" distributed as follows:

a) Three chambers on the third floor of the reactor building adjoining the swimming pool.

b) Three on the first floor of the reactor (inner yard) where the beam holes are located together with the experimental apparatus of the D F N and with the radioactive material storage area

c) Two in the basement of the reactor one being in the sump for the sinks and rooms of the building as well as of the cleaning of ionic resin and another near the left of the swimming pool directed toward the heat exchanger (primary circuit)

2 — Air-borne continnously monitoring one near the reactor swimming pool and another in the inner yard of the first floor of the reactor

3 — Three spherical neutron dosimeter that detect neutrons up to 14 MeV in energy, placed in the inner yard of the first floor of the reactor

4 — A Geiger-Mueller counter with rate meter and recorder placed in air exhaust of the building, after absolute filters and before the chimney

The Jordan chambers and the remaining air-borne continnously monitoring the latter adjoining the swimming pool are all connected to the scram of the reactor The recorder of the Geiger counter that measure the activity of the exhaust air is placed in the control panel of the reactor

The reactor modification whose aim is to encrease power to 10 MW is going on and is divided in the three following parts

1 – Reform in the ventilation system and in the tightness of the building Is already concluded

2 – Reform in the water coolant system of the swimming pool, with the introduction of a decay tank for ^{16}N and a second heat exchanger is underway In consequence we will have two primary and secondary coolant circuits

This part is under construction and we hope to operate at 5 or 6 MW but if necessary we can operate at 10 MW

3 – Reform of the reactor's pool is planned

The normal building air exhaust system (figure 1) have "Cambridge" absolute filters with 99 97% minimum efficiency in removing 0 3 micron particles Also in the case of an accident there is an emergency circuit with active carbon filters, so that the normal exhaust can be turned off and the air passed through the absolute and active carbon filters

To have an adequate safety system so that it is possible to identify immediately an increase of the air radioactive level and the place where it is occuring we have purchased and will install this year the following equipment:

1 – An air-borne continnuosly monitoring with filters to detect iodine that will be placed next to the reactor swimming pool

2 – Four detection sets for the building air exhaust system

One is to be placed in the general exhaust system after the filters and before the chimney and the other three are to be placed in the basement, first floor exhaust systems

3 – Two detection sets will be put in the two secondary circuits of the coolant water to give a fast alarm in the case of leakage in the heat exchanger

Also related to the reactor renovation is the problem of the radiation levels at the swimming pool surface which is discussed in another presentation of this Conferences[4] Under present conditions, with the power increase the radiation level at the reactor surface would be too high

Portable detectors are represented by several survey meters

For beta and gamma radiation we use Geiger Muller detectors, ionization chamber type cutie pie detectors and for fast and thermal neutrons we use proportional counters with BF_3 detectors

Two monitorings are done daily, one in the morning approximately an hour after the reactor starts and the other in the afternoon two hours before the reactor shuts down.

These monitorings are done adjoining the beam holes, working areas for D F N personnel, reactor control room and the reactor swimming pool

Terminating in the first floor of the reactor (inner yard) we have fourteen beam holes with internal diameters of 6 and 8 inches

Twelve of these beam holes have the other end close to the reactor core[5] (figura 2) while two beam holes were placed further away in the direction of the thermal wall If one day the reactor were moved to adjoin this thermal wall, these two beam holes would be utilized instead of the others.

The neutron thermal flux, in the end close to the reactor core, of the twelve beam holes is between 10^{12} and 10^{13} neutrons/cm^2 sec

The gamma exposure is about 10^8R/h We monitor the beam holes that are closed in order to detect possible collimated beams that could come from between the plugs and the walls of the beam holes This space is full of water is test drained to verify that the space is full

Most of the beam holes are opened for the execution of experiments done by D F N personnel

After the exit of the beam hole one puts the experimental apparatus and then a beam catcher The exposure measurement is done out of the beam trajectory In view of this one creates a series of places where the personnel should remain to execute their experiments With the intention of avoiding over exposure of this personnel we monitor these places and we warn the interested party about the exposure levels so that they take the necessary care and thus avoid exceeding the maximum permissible level

Adjoining the swimming pool and in the control room of the reactor the dose coming from neutrons is insignificant In tables 1 and 2 and in Figure 3 we give the average level of radiation dose during 1972 for each place monitored

Still referring to the reactor building, we should mention that we maintain under our control fifty storage tubes for radioactive materials used in the reactor or that await decay

These storages, in a horizantal position, are placed in a wall of the first floor of the building (figure 4) In them we put beam hole plugs, collimators, reflector elements, damaged industrial sources, etc

III – I.E.A. DIVISION AND SERVICES

For each Division and Service that need our collaboration we give technical assistance, equipment, technicians or scientific personnel

Van de Graaff acelerator of 400 KV and generally use target of tritium to produce a neutron beam of 14 MeV For protection measurement we placed in that laboratory a tritium detector, neutron spherical dosimeter and a neutron survey meter identical to those we use in the reactor building

The Radioactive Material Production Service has a chemistry processing laboratory where one produces the radioisotopes, principally used in medicine Among them we mention ^{131}I, ^{198}Au, ^{24}Na, ^{51}Cr, ^{82}Br, ^{32}P, ^{35}S There is still a little production of fission products such as ^{132}I and ^{137}Cs but in quantitities of order of µCi In this room (figure 5) we have a air borne continnously monitoring and a Geiger Mueller survey meter In the external corridor we put a hand and clothe monitoring device In the hot laboratory of this Service and in the semi hot laboratory of the Radiochemistry Division we maintain a rate meter to control personal contamination Even so as a precaution measurement we monitor daily in the S P M R laboratories and in the D R Q laboratories, principally to control eventual contaminations or leakage on the processing cell A copy of the report is sent to the respective division head The radioisotopes processing room is lower in pressure than all the other S P M R areas and the processing cells are at still lower pressure The air that circulate in the room and in the cell is exhausted through special ducts and passes though filters before leaving by the chimney Immediately after the filters we put Geiger Mueller counter with rate meter and recorder to control the elimination of radioisotopes

At the present the new building of S P M R is under construction and we need mention that several time we join with the head of that Service and the responsible engeneer for the project to discuss radiation protection measures

The Radiobiology Division (D R B) section of Radiopharmacy has a labeled compound laboratory Principally one uses the radioisotopes ^{131}I and ^{51}Cr In that laboratory we mantain a hand and clothe monitoring device and a Geiger Mueller survey meter and we do a daily monitoring

A new building is also under construction for the Radiopharmacy section and we have accompanied this project since the start

Our major concerns are to enable construction of a facility funcionally equipped for isotope handling and chemical treatment, together with safety and ease of decontamination

The Industrial Radioisotopes Application Service in 1971, started to use appreciable quantities of ^{82}Br as a tracer for experiences done in rivers and sea

The works is being carried out with the assistance of one or sometimes two S P R D technician. We give them special clothes such as masks, gloves, etc and also survey meters to measure the exposure to radiation

In 1971 we started an effective health physics work in the Division D M N and D E Q because up to that time our work was limitated to attending that division only sporadically, as necessary or as solicitated The planning of this routine service has been slow because of the particular characteristics of these two division; they work principally with alfa radiation The instrumentation is in the stage of conclusion In this conference we will present a work showing the set up of our service in that Division[3].

IV – S.P.R.D. INTERNAL SERVICE

Our personal dosimetry laboratory is in development Until 1970 our personal dosimetry was limitated to the pocket dosimeters and film badge dosimeters In 1971 we started to develop other types of personal dosimeters as the Albedo for neutron and finger ring for the hand

We have introduced urine analisis to determine uranium concentrations This is very useful for the D E Q personal This year we start to introduce thisanalyses also for D M N personnel In this meeting we will present a work about this[3]

We have also started thermoluminescent dosimetry doing a study given in detail about the comparison between film badge, thermoluminescent (several types) and radiofotoluminescent dosimeters. This study will be presented in this meeting[1]

We introduce also audible pocket dosimeters used by the personnel that work in the reactor near the beam holes or that handle radioactive sources and by personnel that work in radioisotope processing

During 1972 we intend to extend the internal dosimetry in an experimental character:

1 – To the Van de Graaff personnel who work with tritium targets; for this we plan to use the D R B liquid scintillator

2 – To the radioisotope chemical processing and label compound personnel using a li-drifted detector and multichannel analyzer that we have on order

Thermoluminescent dosimetry will be used during this year by I E A personnel, together with film badge dosimeters By the start of next year we plan to extend it to all external institution which use our service

Presently we are investigating audible dosimeters The Oak Ridge National Laboratory has given us their dosimeter circuit and our Electronic Service is building some experimental models Depending on the adaptation to our humid and on the cost, they will be made in sufficient quantities for all I E A personnel, at the present 294 In the future they could also be made for external institutions

Film badge dosimetry has been done since the IEA's creation, initially by the Oak Ridge National Laboratory and later by us We will present in this meeting a work about the fading of the film image after developing[6]

We will examine the films badges developed in the last 10 years These films are from nine different lots

Next we give a table showing the distribution of I E A personnel exposures during 1971 These exposures was measured by personnel monitoring film badges produced of Agfa Gevaert

I.E.A. personnel, accumulated exposure in 1971

Interval of Exposure	Number of Emplyees	Percent
Bellow 100 mR	184	62 %
Between 100 and 500 mR	61	21%
Between 500 and 1000 mR	17	5,5%
Between 1000 and 2000 mR	18	6,5%
Between 2000 and 3000 mR	9	3%
Between 3000 and 4000 mR	5	2%

The persons having the higher exposures are connected to the withdraval of irradiated material from the reactor and to the chemical processing of radioisotopes

We continue to use the same system of persoral yearly index cards to keep the film, as presented by Hehl (figure 6), but we also introduce and additional personal index card for the yearly accumulated exposures during all the user's professional life (figure 7)

The S P M R radioisotope production has increased exponentially year to year and consequently the radioactive wastes followed the same pattern The details will be seen in a work presented in this meeting[8] The control methods used up to now have become impractical, forcing us to study new methods

Most problematic are the effluents resulting from the production of Iodine, which must be stored a relatively long period before it is possible to dilute it in our tanks (capacity of 10 000 liters) This year an expert of the International Atomic Energy Agency (I A E A) will come to help us in this job.

For the next years we must consider an increase in production caused not only by the external market of the I E A , but also by internal consumption because, at the present, the two principal producing services are undergoing expansion A building is being built specially for radioisotope production and another for the Radiopharmacy Section

The descontamination work developed until now has followed the pattern of growth of the I E A. The techniques used in the descontamination processes are the conventional ones, with only a few changes during the years, when the literature showed us that a technique had become the preferred. We have a project to develop during this year concerning the study of descontamination techniques for instrumentation, utensils, areas, walls, etc as well as clothes and persons

We plan to do a general survey of the techniques used, and then submit them to tests to verify their effectiveness, that is, we should do a comparative critical study of all of them

As a second part we will try to improve them or to develop new techniques

Since the IEA's creation we have had no accident that resulted in high exposure for IEA personnel or in high cost for descontamination

The biggest accident that we have had was with an Iridium industrial source of 3 Ci

This source was made with Iridium in compacted powder and encapsulated in steel.

During its calibration and introduction in to the shielding it developed a leak that at the time, 12:15, it was not detected

Only in the afternoon was the contamination detected, and the first actions taken In the accident site the exposures measured with a ionization chamber, (cutie pie type), were 6 mR/h of gamma ray and 240 mR/h of beta rays

The second place of major contamination was the elevator, with 3 mR/h of beta radiation, and the third the entrance door to the reactor building, where our most sensitive survey meters reading down to 0,01 mR/h detected nothing

The identification was done by smearing, with analysis by the analyzer we proceeded to the descontamination the next day a Saturday, when there was no normal work in the I E A The ground floors of the reactor building and the adjacent building were treated On the day of the accident we also monitored all personnel of the two building and we verified that some of them had a light contamination on their shoes On the same day all powdered sources were eliminated New ones have been made with metallic Iridium

The section of shielding calculations is developing its routine activities, giving assistance to the I E A divisions and services that need this kind of protection and also to external Institutions For example, for the reactor rebuilding program we calculated the thickness of concrete that must be put over the nitrogen decay tank that will be installed during the second stage of the project

Also being calculated are the lead thickness necessary for storage or transport of radioactive sources, industrial or otherwise We also perform calculations for the D F N of the beam catcher necessary to absorb the radiation beam leaving the beam hole after passing the experimental apparatus

Related to dosimetry, we have purchased and absolute ionization chamber (Attix model) which we plan to put in operation as soon as its laboratory building is ready, hopefully this semester At the start, in addition to it using to calibrate industrial sources, we will use it to calibrate our instrumentation, because it has an intercomparison chamber to extend the energy range

At the present our instruments are principally calibrated through four French calibrated sources with activity errors of 3%, one 100 mCi and another 10 Ci of ^{60}Co and also one 100 mCi and another 10 Ci of ^{137}Cs These activities refer to the date of delivery, about three years ago All are of the industrial type

The industrial sources made by D O M R are calibrated with one of our instruments, in turn calibrated with these sources At the present, for easier movement, better protection and less waste of time they are being calibrated with an ionization chamber built by our D O M R and immersed the swimming pool of the reactor This chamber was initially calibrated with the French sources

Finally we mention that we are working on the preparation of a plan for the future S P R D building This plan should be ready to be submitted for approvel by March This is not an easy job because the routine development of the S P R D is dependent on the development of the I E A , and on external demand If we plan a small building we are risking that it become inadequate in the next few years, but if we build a big building, depending on the development, it might become inhabited by ghosts

V – JOBS DONE FOR EXTERNAL ENTITIES

Whenever solicited we give Health Physics assistance to external Institutions One of the services that we offer is external personnel dosimetry with film badges At the present we have more than eight hundred users belonging to more than twenty firms

At present we do not have laws that require personnel dosimetry for each worker who has the possibility of exceeding a determined level; this means that these users have solicitated our services spontaneously, being conscious of the necessity of this kind of service

High exposures recorded by the film badges are very rare, and generally happen in Institutions that have many employees and many film badge users

It happens, however, that in all cases that it was possible for us to investigate, the high exposures were not taken by the users Rather they put the film in front of a source without remaining near by themselves

We don't konw the reasons that lead these persons to do this Maybe they want to have proof of our effectiveness

A fact that leaves us more apprehensive is that those responsible in the firm do not pay attention to these incidents and do not investigate the reasons

Other firms, conversely, are excessively worried about personnel dosimetry This is the case, for instance, with a big industrial firm with only a small number of film badge users They pratically only use radioactive sources, as level detectors

The exposure level of their personnel never has exceeded the film badge back ground, this is, 10 mR

Once a monthly film badge from one of their personnel presented a exposure of 35 mR As is generally known, exposure below a hundred mR measured by a film badge must be viewed with doubt, because the fluctuation in the density, due the film's condiction before development, gives a big error

Some time later the firm sent us the plan of an oven, the room where it was installed, and also the adjacent room, with all the details, informing us that the oven was controlled by a radioactive source and asking us if the exposure taken by the mentioned person could be due to his remaining beside the oven at a certein distance for half an hour By fate, the result of the calculation gave us 35 mR We sent the firm the calculation as well as the result

Another occurrence that is worthwhile to tell is that a firm one day solicitated us to give it the accumulated exposure taken by one of its X ray machine operators The person had never had exposures higher them the film badge background Reason of the solicitation: that operator contracted tuberculosis and took the case to the courts thinking that the disease was provoked by the radiation

Another type of service that we do for external Institutions is the survey of the radiation levels in the laboratories where there are radioactive sources, X rays machines, cobaltotherapy etc This service is solicitated by the client We do this type of survey in several Hospitals

Related to this type of assistance we have a case that is worth while to tell In an hospital we found an X ray machine, used for chest radiography It was very old, its brand Keleket

The operation high voltage was changeable from 60 to 90 KV, the medium time of each operation was a second and the miliampere level completed unknown Reason: this machine was very old and was not normally in use, but one day it became necessary to use it We called the representatives that repaired the machine but they were not able to repair the ammeter The very representatives had not determined the milliampere level when operating but had informed the Institution that it was possible to operate the machine in that condition

A third assistance that we offer is shielding calculations for rooms of cobaltotherapy, X rays etc

Among these the most unusual was calculation of a complete laboratory for cobalt therapy where the interested person, in addition to giving the necessary data for this type of calculation, informed us that it was his intention to build the walls with diabase Then our biggest problem was to discover what diabase was Finally we found the mean composition of this rock in the Encyclopedia Britannica, and the variation of its density, which depends on its chemical composition, in an article by J J Jakesky, published in Exploration Geophysics After that we could proceed with the calculation

We conclude that the very users are completely uninformed about the possible biological effects of radiation, about the meaning of maximum permissible dose and about the basics of personnel dosimetry

We are sure that in a short time these flaws will be cured because the National Comission on Nuclear Energy has spent several years worring about standards and licencing for the use of radioisotopes, leading us to believe that in a short time it will not be permitted to give radioactive materials to the unprepared person

Table I

SERVIÇO DE PROTEÇÃO RADIOLÓGICA E DOSIMETRIA

NÍVEIS DE RADIAÇÃO

ÁREAS DE TRABALHO

DATA

06/01/72

HORA

OPERAÇÃO Nº

001/71 a 231/71

POTÊNCIA

2 Mw

MÉDIA

LOCAL	BETA-GAMA mr/h	NEUTRONS LENTOS		NEUTRONS RÁPIDOS		DOSE TOT. mrem/h
		Leitura	n/cm².s	Leitura	n/cm².s	
A	0.10					0.10
B	2.06					2.06
C	5.60					5.60
D	7.50					7.50
E	2.42					2.42
F	0.48		11		24	3.88
G	2.04		10		59	7.66
H	18.72		18		252	55.02
I	3.00		22		38	8.48
J	1.50		[illegible]		34	6.34
K	0.70		7		14	2.66
L	0.24		3		5	0.95
M	0.15		2		5	0.86
N	0.12		3		5	0.83
O	4.08		21		83	15.38
P	0.37		12		30	4.71
Q	3.12		7		22	6.22
R	48.75		23		72	53.11
S						
T						

DETETORES

NC 2650 / 613
NC 2660 / 612
NC 2650 / 611
NC 2600 / 5088
NC 2675 / 2035
NC 2646 / T-51
NC 2675 / 205[illegible]
NC 2646 / T-78 [illegible]
NC 2112
DN3 - 474

TÉCNICOS

OBSERVAÇÕES.

RESPONSÁVEL

SERVIÇO DE PROTEÇÃO RADIOLOGIA E DOSIMETRIA

NÍVEIS DE RADIAÇÃO

BEAM-HOLES

MÉDIA

DATA: 06/08/72

HORA: —

OPERAÇÃO Nº: 001/71 a 231/71

POTÊNCIA: 2 Mw

	Beta-Gama mr/h	Neutrons Lentos		Neutrons Rápidos		Dose Tot. mrem/h
		Leitura	n/cm²·s	Leitura	n/cm²·s	
1	0.10		9		37	5.65
2	1.53		19		66	11.05
3 *						
4 *						
5 *						
6 *						
7	0.10		5		14	2.08
8	0.10		2		9	1.37
9 *	0.10		2		4	0.67
10 *						
11 *						
12	0.76		88		730	105.37
13 *						
14 *						

DETETORES

NC 2650/613
NC 2650/612
NC 2650/611
NC 2650/3088
NC 2673/2035
NC 2646 T-57
NC 2673/2036
NC 2646 T-78
NC 2112
DN 3 - 474

OBSERVAÇÕES: * Abertos e ou Bloqueados

TÉCNICOS

RESPONSÁVEL

Table II

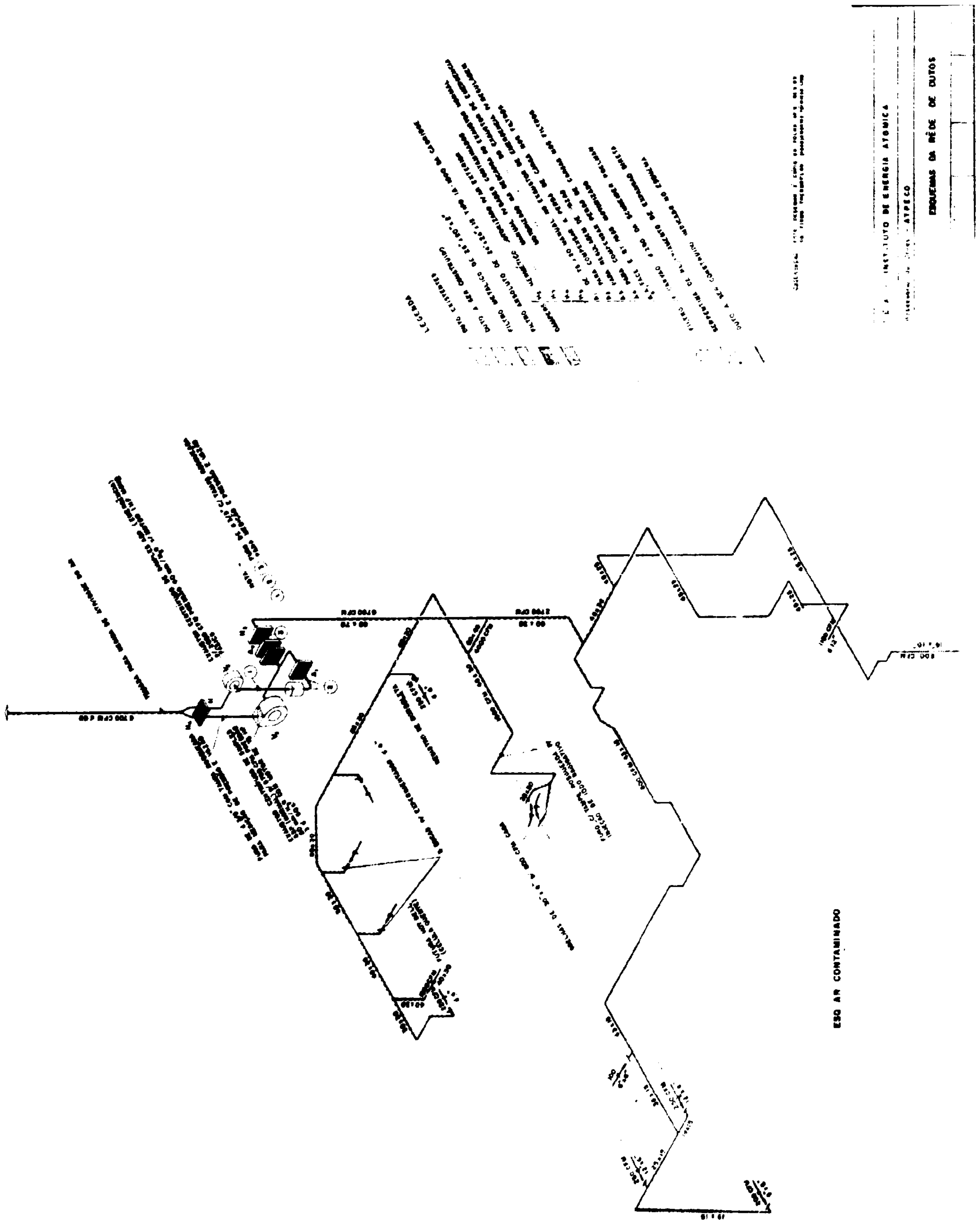
INSTITUTO DE ENERGIA ATOMICA
ESQUEMAS DA RÊDE DE DUTOS
ESQ AR CONTAMINADO

Figure 1

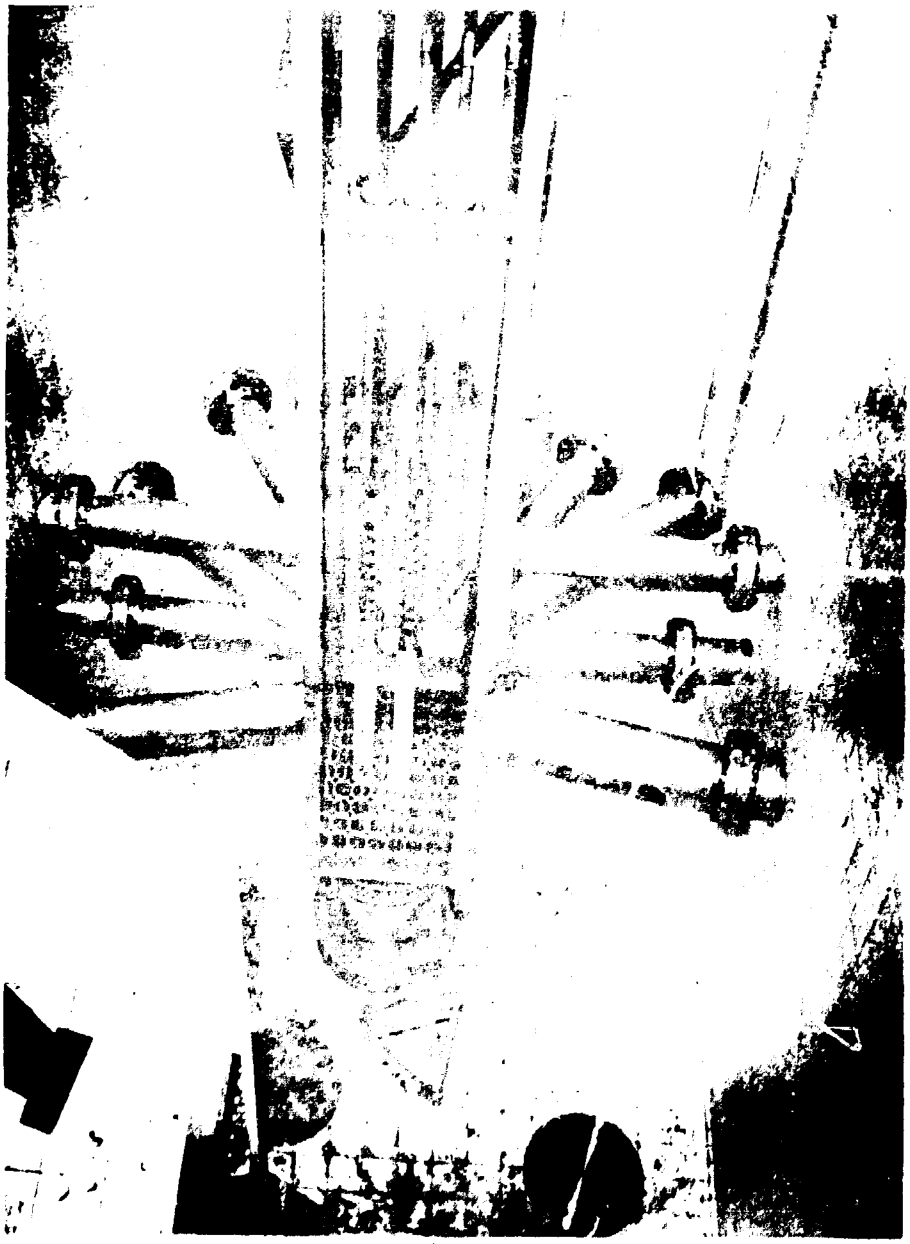

Figure 2

1º PAVIMENTO DO REATOR

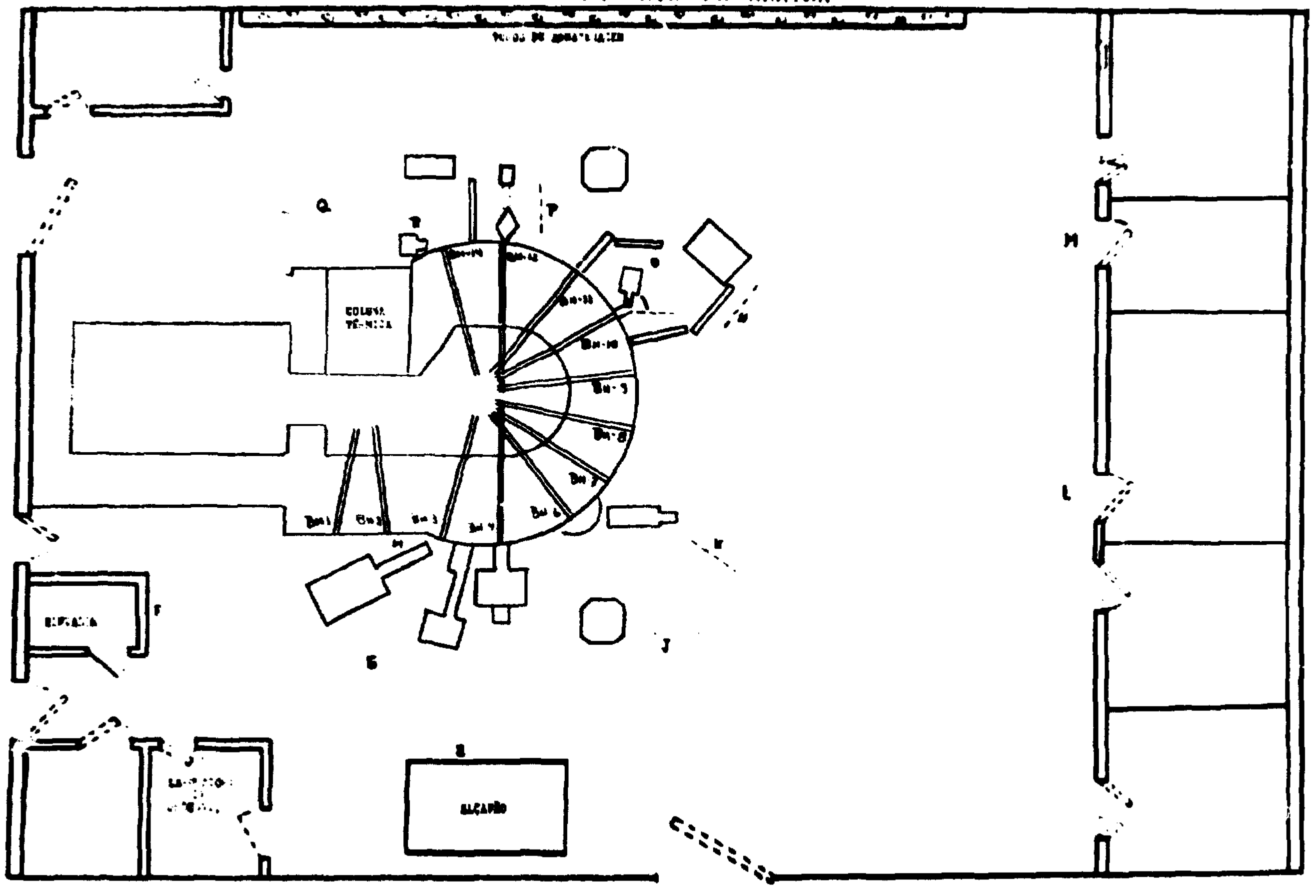

Figura 3

Figure 4

Figure 5

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)				QUARTER FILM				
		CD	OW	CU	PB	PL	M_D	S_D	P_D	L_D		M_D	S_D	P_D	L_D
JAN	2-2	51	1.03	54	47	1.00	[illegible]	2250	600	[illegible]	1st	[illegible]	[illegible]	1600	5800
FEB	20-3	50	.72	.47	.43	.71	1250	1400	700	1800	2nd	200	410	240	[illegible]
MAR	10-4	43	.71	50	42	65	640	1400	500	1250	3rd				
APR	10-5	30	.31	.32	30	28	300	230	260	160	4th				
MAY	21-6	26	26	26	26	26	190	170	170	130					
JE	7-7	39	44	.40	39	42	250	300	160	[illegible]					
JUL															
AUG															
SEP															
OCT															
NOV															
DEC															

DD - DEVELOPMENT DATE
CD - CADMIUM FILTER
OW - 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

Figure 6

INSTITUTO DE ENERGIA ATOMICA									
	INSTITUIÇÃO: INSTITUTO DE ENERGIA ATOMICA								
	DATA DE NASCIMENTO: 17 de fevereiro de 1939								
	OBSERVAÇÕES:					Du = Dose uniformemente profunda Ds = Dose superficial Dp = Dose profunda Dc = Dose no cristalino			
INÍCIO:	DOSE ACUMULADA (mR)					DOSE ACUMULADA (mR)			
ANO	Du	Ds	Dp	Dc	ANO	Du	Ds	Dp	Dc
1963	870	1550	705	1430	1968	11914	14794	10586	14180
1964	2340	3665	2030	3494	1969	14956	19214	13557	18132
1965	4432	6295	3980	5969	1970	16058	21037	14637	19772
1966	8327	10675	7321	10010	1971	18746	24242	16877	[illegible]
1967	9457	12055	8221	11360					
NOME: JOÃO DA SILVA RODRIGUES						CÓDIGO: A-131			

ANO	DOSE ACUMULADA (mR)				ANO	DOSE ACUMULADA (mR)			
	Du	Ds	Dp	Dc		Du	Ds	Dp	Dc
S.F.R.D. - SETOR DE DOSIMETRIA FOTOGRÁFICA									

Figure 7

RESUMO

Descrevemos nosso trabalho de rotina de Proteção Radiologica no reator IEAR 1 e as modificações que estão sendo feitas

Esse trabalho inclui serviços específicos prestados em outras Divisões e Setores do IEA. Alem disso descrevemos nosso Laboratorio de Dosimetria Pessoal, Laboratorio de Descontaminação e Disposição de Residuos, Seção de Cálculo de Blindagem, Laboratorio de Dosimetria e Calibração de Fontes Radioativas e Instrumentos

Incluímos uma rapida descrição dos planos para o novo predio do S P R D

Finalmente, falamos sobre a assistencia prestada a outras instituições que não o IEA

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