

## ORGANIZATION OF THE IEAR-1 SWIMMING POOL REACTOR OPERATION SECTION

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At the Instituto de Energia Atômica (IEA), one of the branches of Reactor Physics Division, namely the Reactor Operations Section, is responsible for the operation of the IEAR-1<sup>(1, 2)</sup>. This responsibility comprehends also the operation programation, reactor maintenance and designing and handling of the irradiation facilities. This Section holds basic experiments from which operational data are obtained.

The Section is composed of a supervisor, two physicists, seven technicians-operators and two technicians, engaged in the maintenance of the electronic equipment at the control room. In order to perform maintenance services this Section has a small mechanical shop and an electronic laboratory, besides the fact that it receives assistance, if necessary, from other Divisions of the Institute.

The IEA Health Physics Service has a branch working with the operation Section charged with the Radiological Protection in the Reactor building. This branch has a supervisor and two technicians. This group is in charge of: (1) performing surveys during reactor operations, including air activity measurements; (2) assisting in beam experiments planning concerning shield and equipment localization; (3) measuring radiation levels in operations such as handling of irradiated materials and irradiations in pneumatic rabbits; (4) personnel monitoring; (5) performing gamma irradiations, dosages and handling of the irradiation facilities used.

The obtained data in the surveys and air activity are transmitted to the Operations Section.

The Radiochemistry Division charges a supervisor and a technician to provide the water treatment in the reactor pool. They are responsible also for resin regeneration, filters changes, etc. when necessary, and measure the pH and resistivity of the water. These data are reported to the Operations Section.

All applications for irradiations and experiments are sent to this Section, through the Heads of the Divisions. For simple irradiations, the supervisor and his staff discuss the requirements directly with the applicant. For complex experiments or irradiations that require special care, the hazards and safety aspects are discussed by a Committee. Usually the members of this Committee are the applicant, the head of the applicant's Division, the reactor supervisor and the head of the Radiological Protection Service. For complex experiments, mainly those using new collimating assembly, the application approval depends also from a radiometric survey performed in conditions as similar as possible to that of the actual experimental arrangement.

The procedure for a routine reactor operation starts when irradiations and experiments applications are collected.

During the reactor "operation program" (PO) elaboration and control pannel check out, three technicians, the supervisor and his assistant are needed to perform this task. Then the PO is completed with all the scheduled irradiations and experiments approved for this operation. This PO has to be approved by the operator, reactor supervisor and Health Physics supervisor. This approval is the first item in the check-out list with 57 more items. After completion, this document is signed by the operator, the supervisor and his assistant. These three persons begin the reactor start up, after a general audic warning for all the people present at the reactor building. When the desired level reaches criticality, and after a few minutes needed for instruments stabilization, the reactor is turned under automatic control. From this moment on, just two persons are needed at the control room. During all operations the supervisor remains around. Each 30 minutes, a general instruments' reading is performed, and the values are annotated in the operational data sheet. The pneumatic

rabbit movements and other occurrences are also recorded on this operational data sheet. When necessary compensation of the control rod with one of the safety rods is performed and the data recorded. After the operational program is completed, a general warning is given in the reactor building and the shut down is started. Then the operating crew fills out an instrument final check-out sheet which involves 26 items. When the reactor is shut down, the data on the operation burn up is written down in a log book. Fig. 1 shows the energy spent in the last four years. All the data related with the irradiations and experiments are also recorded.

### IRRADIATION FACILITIES

This reactor can be operated in two different positions. In the main core position, the grid plate is located above the header of the primary coolant loop, and the flow rate through the core is 2600 gpm. The second position is in front of a thermal column made up of graphite blocks placed inside a rectangular steel box of 1.8 x 2.4m. and provided with six channels of removable graphite blocks. The thermal column is shielded by a 16-ton door 12.75" thick (consisting of 11" of steel plates, 1" lead and 0.25" boral plates). The maximum operating power at this position is about 100 Kw; at this power level the reactor does not require forced cooling and the graphite blocks temperature due to radiation heating is reasonable.

The irradiation and experimental facilities, such as the beam holes, are available at the two core positions.

In front of the thermal column position, are located two 6" beam holes. At the main core positions there are six 6" and two 8" beam holes, and two 6" through tubes. Each beam hole can accommodate three different types of plugs. The three different types of plugs are sample plugs, inside which it is possible to irradiate huge samples near the core; electrical plugs for experiments requiring fluid pipes or wires; collimating plug which allows the withdrawal of a neutron beam of 1.5" diameter.

Adjacent to the reactor core are located the terminals of a pneumatic rabbit system with four sending and receiving stations.

These pneumatic tubes are used mainly for short periods of irradiation. Two kinds of pneumatic rabbits are used. One is constructed with aluminum and the other with nylon or polyethylene. Both are provided with felt rings and terminals. The nylon rabbit has low radiation damage resistance. On the other hand it suffers negligible activation and then it is possible to handle it immediately after irradiation. This is very important for short half-life activation analyses. These rabbits could stand several minutes irradiations or a few hours irradiation without damage. It was noted that the main source for radiation exposure was the felt parts. The aluminum rabbits are used for larger irradiation periods. These rabbits return from the reactor core with high activity due to  $Al^{28}$ ,  $Mg^{27}$  and  $Na^{24}$ . The procedure at the IEAR-1 is to open these rabbits after a decay time of about 12 hours or when necessary, it could be opened within a special shield connected directly with the receiving station. With this shield the sample could be removed from the rabbit after a decay of one hour in such a way that the operator exposure is reduced.

One of the advantages of the open pool research is the easy access to the core or the grid plate, and most of the irradiations are performed locating sample holders at the grid plate.

There are five different types of irradiation facilities that could be used:

- EISAT, designed to irradiate telluric acid in aqueous solution. This facility is described in detail in another paper<sup>(3)</sup> to be presented in this meeting.
- EIRA to irradiate materials in higher thermal to fast flux ratio. The material is located inside aluminum capsules closed either by pressure or screwed (provided with a polyethylene gasket). These capsules are fitted in an aluminum rack which is then placed inside a 3" diam. and 2.5m long aluminum tube. In the upper extremity of this tube there is a flange provided with a rubber gasket. Connected with this flange there are two 0.5" diam. and 6.7m length aluminum tubes. The rack support is a small diameter Al tube opened at the

bottom and connected with one of the 0.5" diam. tube. The other 0.5" diameter tube ends directly at the flange. Therefore it is possible, if necessary to circulate water. This water, however, is independent of the pool water. The activity of the water coming from the facility can be monitored. If the monitor indicates contamination, the water is diverted to a retention tank. In order to remove the samples, the flange is easily opened manually, above the water surface, and the inner sample tubes are transferred to a transport shield placed below the water surface. If the samples to be irradiated do not require water circulation the 3" diam. tube can be filled with water up to 30 cm below the flange. In this case, since the hydrostatic pressure is lower, the probability of leaks in the samples capsules is reduced.

EIS is a facility used mainly for fast neutron irradiation. It is an Al box with external dimensions similar to the fuel elements. To assure tightness to the cover, a polyethylene gasket is used. After irradiation this element has to be withdrawn from the pool, placed in a special shield, and then opened to remove the internal Al capsules that contain the samples. This operation is not practical and another facility was designed and is being built to substitute this one. The facility planned as the EIRA and EISAT, is provided with a flange that could be manually opened just above the pool water surface. The rack that contains the sample capsules is lifted. The capsules are then transferred to the transport shield behind a wall-type shield.

The EIP-8 and EIP-20 are graphite reflector elements with a circular hole in their vertical axis down to the bottom. An Al cylinder provided with a cone-shaped upper extremity is fitted in the hole and welded at the reflector element suspension frame. These parts could be left permanently at the core position. The reactivity effect resulting from the substitution of one standard graphite reflector element with one of these, is very small. The part that contains the samples consists of two concentric Al tubes, 3m long. The internal one is the rack that supports the samples and slides within the outer one (liner). With the samples in position, the assembly hanged with a nylon wire could be introduced into the hole. This

introduction is easily achieved with the help of the cone already mentioned. After the irradiation, the two-tubes assembly is suspended at the level of the pool surface and the operator slides the internal tube up to the corresponding sample position, then the capsule can be removed through a hole in the liner located at 1m from the bottom. In this way the sample capsules can be transferred to the transport shield, at about 2m below water surface. There are two models in which it is possible to irradiate capsules up to 0.8 cm and 2 cm in diameter respectively.

TVA is a vertical Al tube 3-in diam. and 10m long. Into this tube, when located at the grid plate, different kinds of racks can be introduced. One of these was specially designed for activation analyses samples that require long irradiation periods. In this case a rotor of variable speed is adapted in order to rotate the rack which contains the sample and the standard tubes located symmetrically with respect to the vertical axis. This facility can be used either with or without water. It has been used mainly for low or medium reactor power level ( $\leq 200$  Kw) due to shielding problems. It is also used for high intensity gamma irradiations.

#### REACTOR UTILIZATION

The research reactors have been used mainly for: (1) Reactor Physics experiments; (2) Neutron Beam experiments; (3) Radioisotope production; (4) Training; (5) Activation Analyses; (6) Shielding experiments; (7) Material testing; (8) In pile loops; (9) Radiation Chemistry, etc... Spent fuel elements or even some reactor cores have also been used for gamma irradiations. In the most developed countries, research reactors have been designed and built specially for some of the above-mentioned purposes. Therefore their reactor utilization programming is uniform and relatively simple. However, in under-developed countries, when a research reactor is brought to operating conditions, due to reasons we do not intend to mention here, there is always the necessity to cover a broad programme of utilization. Under these aspects, the IEAR-1, being a 5 Mw swimming pool reactor is extremely versatile. This versatility, however, brought some intricate problems related with the reactor operations schedule. The

LEAR-1 has been utilized mainly for<sup>(4)</sup> radioisotope production, neutron beam experiments, training, activation analyses and, after the operations, the reactor core is used as a gamma source.

Occasionally, it has been used for other purposes such as radiation effect studies, gamma heating measurements and development on radioisotopes production methods. During the operations all the possible operational data were gathered. Nevertheless, special operations had to be run for this purpose. Frequently, during the same week, besides the routine high power operations (8 hours at 2 Mw two days a week) for radioisotope production and beam experiments, it is necessary to operate the reactor at 200 Kw for beam alignment and other calibrations of beam hole experiments, or even to irradiate special materials at the TVA facility. Some weeks, it is necessary to operate the reactor at low power for training experiments or calibrations. Besides this variety of reactor operations, the gamma irradiations have to be performed. Different types of seeds, grains and animals like rats, insects and other biological materials had been irradiated using the beam holes, tangential holes and the TVA facility. The handling and dosage of the facilities and the irradiations themselves involve a considerable time and manpower. Normally, a weekly reactor operation program is: Monday: 8 hours at 2 Mw; Tuesday: 8 hours at 2 Mw; Wednesday removal of the irradiated samples and execution of gamma irradiations; Thursday and Friday low and/or medium power level operations.

Exceptionally the reactor operates four days a week at 2 Mw. Some papers involving neutron beam experiments<sup>(5, 6, 7)</sup>, activation analyses<sup>(8)</sup>, training<sup>(9)</sup> and data on radioisotopes production<sup>(10)</sup>, will be presented to this Study Group Meeting and therefore will not be discussed here.

#### SOME HEALTH PHYSICS DATA DURING ROUTINE REACTOR OPERATIONS

##### Air Activity

For this determination, a continuous air monitor and portable pumps are available.<sup>(11)</sup> The continuous air monitor is

placed in the third floor and connected to the reactor's scram system. The reactor scrams when the monitor indication reaches  $10^{-8}$   $\mu\text{c}/\text{cc}$ .

Special attention is given to the variations in air activity due to Rn and Thn emanations from the walls. This is important because in some cases this activity is higher than the one due to the reactor operation.

The specific air activity with reactor off is  $10^{-10}$   $\mu\text{c}/\text{cc}$ . When the reactor is operating at 2 Mw, it is raised to  $5 \times 10^{-10}$   $\mu\text{c}/\text{cc}$ . Now, if the circulation is turned down the air activity can be raised up to  $10^{-8}$   $\mu\text{c}/\text{cc}$ , depending from the ambient temperature.

Levels higher than these ones, were obtained just in 1958 when the corrosion of the fuel elements was detected<sup>(4, 12)</sup>.

A system for exhausting the contaminated air is available. This system exhausts the air from the pneumatic blower, from the caves of the laboratories located in the reactor building and from vicinities of the beam hole experiments.

The air is monitored before it is expelled by two geigers tubes placed one before and one after the filter; in this way it is possible to measure the filter efficiency and the air activity. Normally the higher levels are obtained when the blower is turned on.

### External radiation

Relating external radiation, a survey is made covering the first floor (beam holes) and the third one ( control room and pool surface).

Table I shows the radiation levels of a typical survey with the reactor operating at 2 Mw.

TABLE I

Position	$\dot{\gamma}$ (mr/h)	Neutron flux (n/cm <sup>2</sup> .s)	
		Slow	Fast
Control room	0.2		
pool surface	5		
pool grid	1.5		
1	5		
2	1		
3	0.6		6
4	1.5		10
5	0.5		
6	0.1		
7	0.3		
8	30	120	110
9	10	140	150
10	2	20	40

8, 9, and 10 represent places around neutron velocity selector experiment and 3, 4 and 5 around single transmission in hydrogenated material experiment. Besides this periodical survey, a general determination of radiation levels is made by a remote area monitor system involving 8 ionization chambers covering strategic points within the reactor building.

Personnel monitoring

The operators wear pocket chambers and film badges. Both detectors are sensible to gamma radiation and slow neutron.

The fast neutron dosimetry is the most difficult and also the most important. In the case of a reactor, a fast neutron exposition is possible only in beam experiments. In this case an evaluation of personnel fast neutron exposition can be made in the following way: (1) determine the gamma dose to fast neutron flux ratio in the operator's position; (2) multiply the gamma dose determined with pocket chamber and films by the factor (1).

For the validity of this procedure, the necessary conditions are: (a) all the gamma exposition of the operator must come from this job; (b) the general scheme of the experiment must be kept unchanged.

These imposed conditions are generally achieved for operators engaged in neutron beam experiments. The monthly personnel exposure are all less than 100 mrem, for the experiments that are carried on.

Finally let us see some data about radiation levels in the handling of activated materials in irradiation elements and pneumatic rabbits.

In the handling of EIRA and EISAT, elements that had been already described, 5 mr/h is the average dose rate in the operator's position.

In pneumatic rabbits operations, the dose rate outside the shield is 200 mr/h when the rabbit arrives. During the rabbit passage, the dose-rate is too high, but the duration is extremely short. Dosimeters placed around during that occurrence show an integrated dose of 7 mr.

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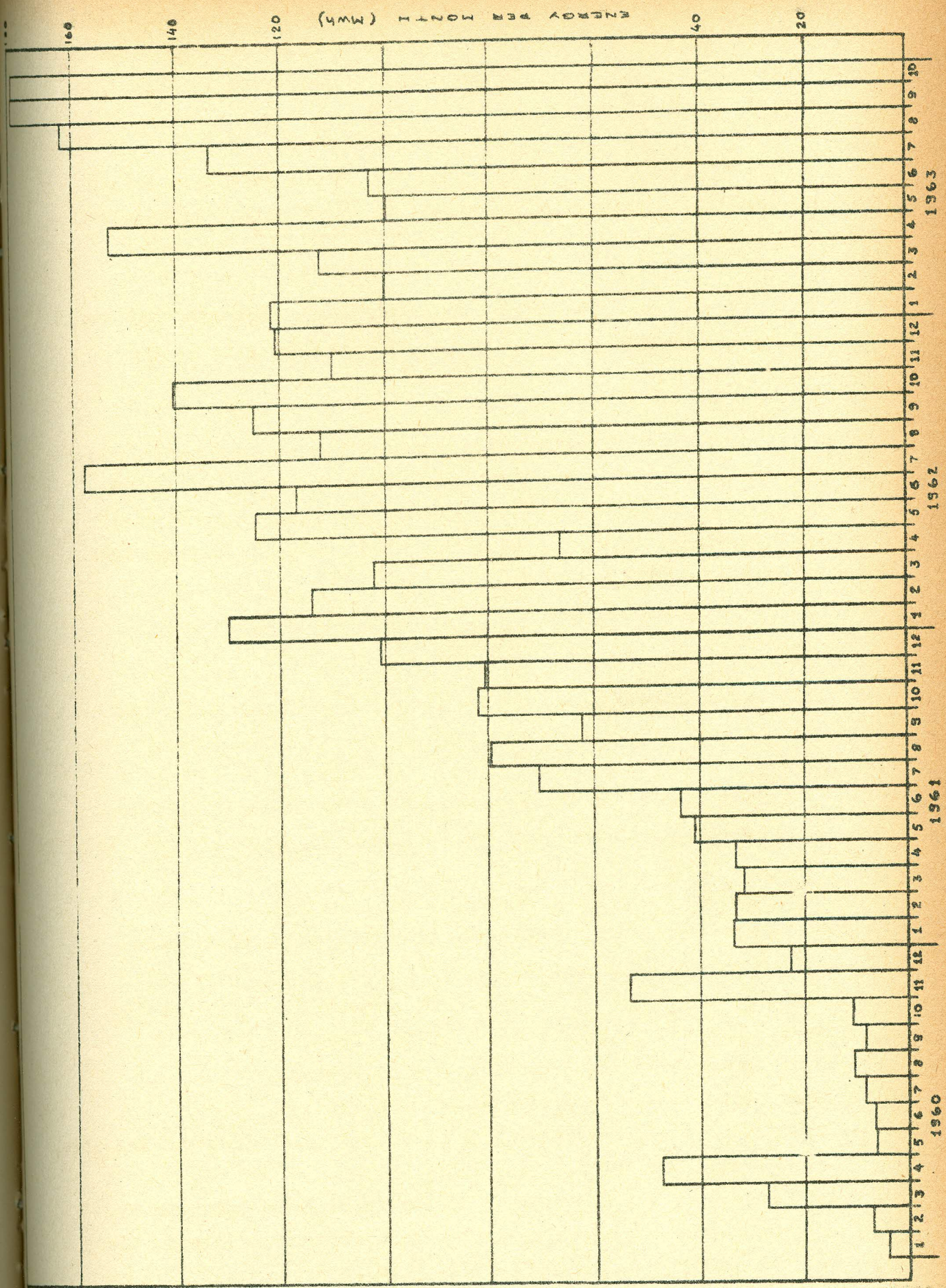


Fig.1 - Reactor energy dissipation histogram