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PORTUGUESE RESEARCH REACTOR

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Introduction

The Portuguese Research Reactor (RPI) is the main research facility in the "Laboratório de Física e Engenharia Nucleares". This Laboratory is one of the Departments of Junta de Energia Nuclear the coordinating body of the nuclear activity in Portugal.

The Laboratory is located near the Tagus 4km NE from Lisbon and it was dedicated on April 1961. It covers an area of about 10^5 m^2. At present it employs about 200 people, 30% of them having a University degree.

Fig. 1 shows the organization chart of the reactor and its connection with J. E. N. and the L. F. E. N..

Description of the facility

A short description of the facility is given here, and its general layout is shown in Fig. 2.

a) The building

The building consists of a hall containing a 10 t crane and all the reactor components and an outbuilding where offices and laboratories are located.

Inside the hall, which has a volume of 10^4 m^3 and which is maintained in depression by a ventilation system, we can find:

- the pool where the reactor core is located
- the control room which also contains the controls of the ventilation and monitoring systems
- the pump-room containing the water circulating pumps, the heat exchanger and the demineralizer

- a hot laboratory having two cells, for hot chemistry work, provided with returning stations of the pneumatic system

- a conference room

- a store-room and a small electronics work-shop

- deposits for storage of radioactive substances

Near the building a storage tank for demineralized water, with a capacity of about 350 m^3 , is found.

b) The reactor

It is a conventional pool type reactor (unreflected core) with a maximum power of 1 MW. It was designed by AMF Atomics and J. E. N. under the supervision of Dr. Carlos Cacho, General Director of the L. F. E. N. and it is similar to others built by the same firm(1).

The fuel is assembled in MTR type fuel elements having 12 curved plates, 70 mils thick. The meat of this plates is made of an uranium-aluminum alloy , the former being 20% enriched in U-235.

The reactor is controlled by four shim-safety rods and one regulating rod. The safety-rods are made of B_4C contained in an aluminum can. The regulating rod is in stainless steel.

The position of the control rods is permanently shown in a coarse position indicator graduated from 0 to 100 and in a fine position indicator reading 10^{-4} of the total travel of the rod (24").

The reactor can be operated in two different positions each one located in one of the two sections into which the pool is divided.

The pool has a total capacity of 500 m^3 and the sections can be isolated from each other by an aluminum gate.

c) Water purification system

It includes the usual units. The demineralizer is of the "mixed-bed" type and has a capacity for treating 4.5 m^3/h (20 US gallons/min). The inlet and outlet of the system are located close to the pool surface.

d) Cooling system

The heat is removed from the reactor via a cooling system including a primary circuit and a secondary circuit. The cooling agent for both circuits is

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(1) For example: Avogrado RSI, Batelle Research Reactor, Democritus Research Reactor

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is water respectively the pool water and decalcified water.

The nominal flow rates in these circuits are 3.4 and 2.6 m^3/m, respectively.

e) Monitoring system

The system includes the usual detecting channels namely the gamma area monitoring, air particulates sampling, stack exhaust monitoring and also a fission product monitoring.

The control of all this system is located in the reactor control room.

f) Ventilation system

This system which has a capacity of about 3×10^4 m^3/h was designed to be utilized in 3 different modes, namely normal, abnormal and emergency.

These working modes correspond to situations of no contamination, low contamination, and high contamination of the reactor hall.

The system includes filters both in inlet and outlet and a climatization system.

This system which has electropneumatic type controls, operates, normally, under automatic control and maintains the hall in depression with respect to the outside.

g) Irradiation facilities

Most of the irradiation facilities are located in one of the pool sections . They are:

- 7 beam tubes

  4-6" internal diameter making a 30° angle with the normal to the reactor core

  2-8" internal diameter normal to the reactor core

  1 - through tube, 4" internal diameter
- a pneumatic system
- a hydraulic system
- a thermal column with two accesses
- a 3' x 3' irradiation window
- a spent fuel irradiation facility

Reactor utilization

Up to the present, the reactor utilization has been small. This has been mainly caused by a shortage in trained people.

At present the personnel engaged in the Division amounts to 15 people , 7 of them with University degree. The main utilization of the reactor has been made by this people, however the facility can, of course, be used by other people.

A - Work performed

It includes the 3 main items:

- reactor calibration
- training of personnel
- irradiations

1) Reactor calibration

The results of this work were published recently [1] . Here only a short summary is presented.

- Core loadings

Critical experiments were performed in several core loadings and the worths of fuel elements, placed in adjacent positions to those core loadings, were determined.

- Control rods calibration

Control rods have been calibrated in several core loadings. For the regulating rod the positive period method was used; for the safety rods the drop test and comparison methods were adopted.

It is worth mention the fact that we have observed reactivity inversions for rod movements below 15%, as it was noted for a similar reactor [2] .

- Reactivity perturbations caused by irradiation facilities

Particularly we have been looking for: beam tubes in what concerns the "draining", filling and presence of neutron absorbers; pneumatic and hydraulic systems regarding the introduction and extraction of sample containers , loaded and unloaded with neutron absorbers; the thermal column as for the reactivity gained by moving the reactor from section II to section I of the pool.

- Neutron flux mapping in the core and in the irradiation facilities

It was carried out by the activation of gold foils whose activities were measured by $\beta - \gamma$ coincidence and gamma spectrometry.

- Reactor power measurement at low and high powers

It was achieved by neutron flux measurements in the reactor core and the raise in the water temperature passing through it. These last measurements show that the values obtained are dependent on the thermocouple location and on the control rods position.

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- Reactor performance at 1 MW

This operation was used to make the radiation survey around the reactor under full power operating conditions and to obtain information on water temperature distribution in the pool and on the establishment of stationary operating conditions.

- Prompt neutron lifetime

The results obtained via Rossi α method are in agreement with calculated values and will be published shortly [3] .

2) Training of personnel

As it was already mentioned this is a very important problem. However it has not been possible to adopt at full extent the steps known as necessary.

In what concerns reactor operators it was possible to establish and maintain the conditions for a training programme. However it has been difficult to hire this personnel. For this reason it has been necessary to train in the reactor operation the University graduate people.

3) Irradiations

Apart from the reactor calibration the irradiations have been the determining factor for the reactor utilization at 1 MW. However, even for this purpose the reactor utilization has been small. Among other reasons, the Laboratory development has not reached yet a stage where a large number of irradiations is required.

A programme for radioisotopes production is just starting. Irradiations of samples used in checking the methods of processing I-131, K-42 and Na-24 are being performed.

B - Work under preparation

- Fission detectors construction

Those are small size detectors containing natural uranium and thorium as fissionable material and are being employed in neutron flux distribution studies.

- Transfer function of RPI

A pile oscillator has been made and installed in the reactor. Measurement of the reactor transfer function at low and high power in several core loadings is foreseen.

- Subcritical assembly

The possibility of building a subcritical assembly with natural uranium(pro

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duced in the L. F. E. N.) and water is being studied. In its initial stage that as-sembly will be mainly used for the training of personnel.

- Irradition for production of radioactive sources and isotopes

The production of Ir-192 and Tm-170 is being considered. With the present operating schedule of the reactor it is only possible to produce those sources at low specific activity but which would be enough for the most current uses.

C - Future projects

We include a short summary of the work foreseen to be started within the next 3 years.

This work will include:

- Neutron flux distribution in subcritical assemblies using water as moderator and fed with natural uranium rods of different shapes

- Studies requiring monochromatic neutrons: e. g. cross sections measurements

- Production of radioactive sources and isotopes. We will try to increment the utilization of radioactive sources and isotopes and to establish the conditions for their production aiming to cover the needs of the country

- Work using the pulsed neutron source technique. The initial stage will aim at training personnel

- Training of personnel. We note again the importance of this item to which we hope to give a considerable increment. In what concerns graduate people a theoretical and practical course covering laboratorial techniques and experiments using the reactor will be started next fall.

As for reactor operators we have already a training programme based in what is done in technically more advanced countries.

D - Means for the achievement of the programme

1) Equipment

Means which are rather modest at present will be increased at least to an extent consistent with the above mentioned programme.

Among the equipment necessary consideration is being made of a neutron crystal spectrometer, a "slow choper", a pulsed neutron source, low temperature irradiation and isotope production systems and several tools.

For the accomplishment of the work programmed we count on the support of the other Divisions of the Laboratory.

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2) Personnel

As already noted the number of trained personnel including reactor operators, presently existing in the Division, is very small but we expect that a dozen of University graduates and half a dozen reactor operators will be hired in the next 3 years. All the operators will be trained in the Division; for the graduate people we foresee training periods abroad.

The Reactor in connection with the L. F. E. N. and the Country

The RPI is the only reactor existing in the Country and belongs to the largest portuguese laboratory for nuclear activities.

The Directing Board of the L. F. E. N. has adopted a policy according to which the Laboratory is wide open to all of its possible users namely Government owned and private institutions. This has been so for several reasons namely because the Laboratory is much larger than any other having activities in connected fields, the personnel would be insufficient for a full utilization of the facilities available and because acting this way it would contribute to the general development of the Country.

This same policy is, of course, also valid for the reactor.

In what concerns the reactor utilization by Universities and National Research Centers we must note that it has been small. We believe that this has been so in part because only recently it has been possible to start a small radioisotope production program in part because the portuguese Universities do not give, at present, any degree in nuclear sciences. Indication exists that this difficulty is going to be overcome in a near future and in this case we believe that experiments for training students and research work for Ph. D. degrees can be of importance in the reactor utilization.

As already mentioned the reactor is also open to Private Organizations. However it must be noted that this kind of utilization, similarly to what happens in other countries, has been small. At present we start seeing some private industries interested in using isotopes produced in the reactor though not yet in a large scale.

Cooperation with other Institutions

a) National Institutions

Up to now and with limited exceptions all the cooperation has been given to projects developped in the L. F. E. N.. We hope that the cooperation with portuguese institutions will become closer after the radioisotope production program has reached a more advanced stage. With this we intend to show how useful this particular tool is for scientific and technological research.

b) Foreign Institutions

The cooperation between the reactor and other countries or international organizations is performed through the organization to which the reactor belongs. Consequently it would profit from the Agreements existing between J. E. N. and other countries or international organizations. At present there is no research work in progress or planned in cooperation with any other nuclear research center. As an example of such cooperation, which would be really welcome, we might mention a research contract with a foreign country or an international organization.

A foreign expert, at the expenses of IAEA, has been in Portugal for a year in order to help the establishment and starting up of the research program. We hope that it will be possible to proceed this same scheme with another expert in similar conditions.

We might also mention the help received from other foreign laboratories accepting some of our trainees. At present we have 2 trainees abroad and we hope to send some other out as soon as those come back to the country.

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[2] PEDRETI, E. and HORN, G., Symposium on Programming and Utilization of a Research Reactors, Vienna (1961) Vol. I, pg. 311

[3] BRUNSON, G. S. and OLIVEIRA, J. M. C., Prompt-neutron Lifetime measurement with an Improvised Time Analyzer in the "Reactor Português de Investigação (RPI)"

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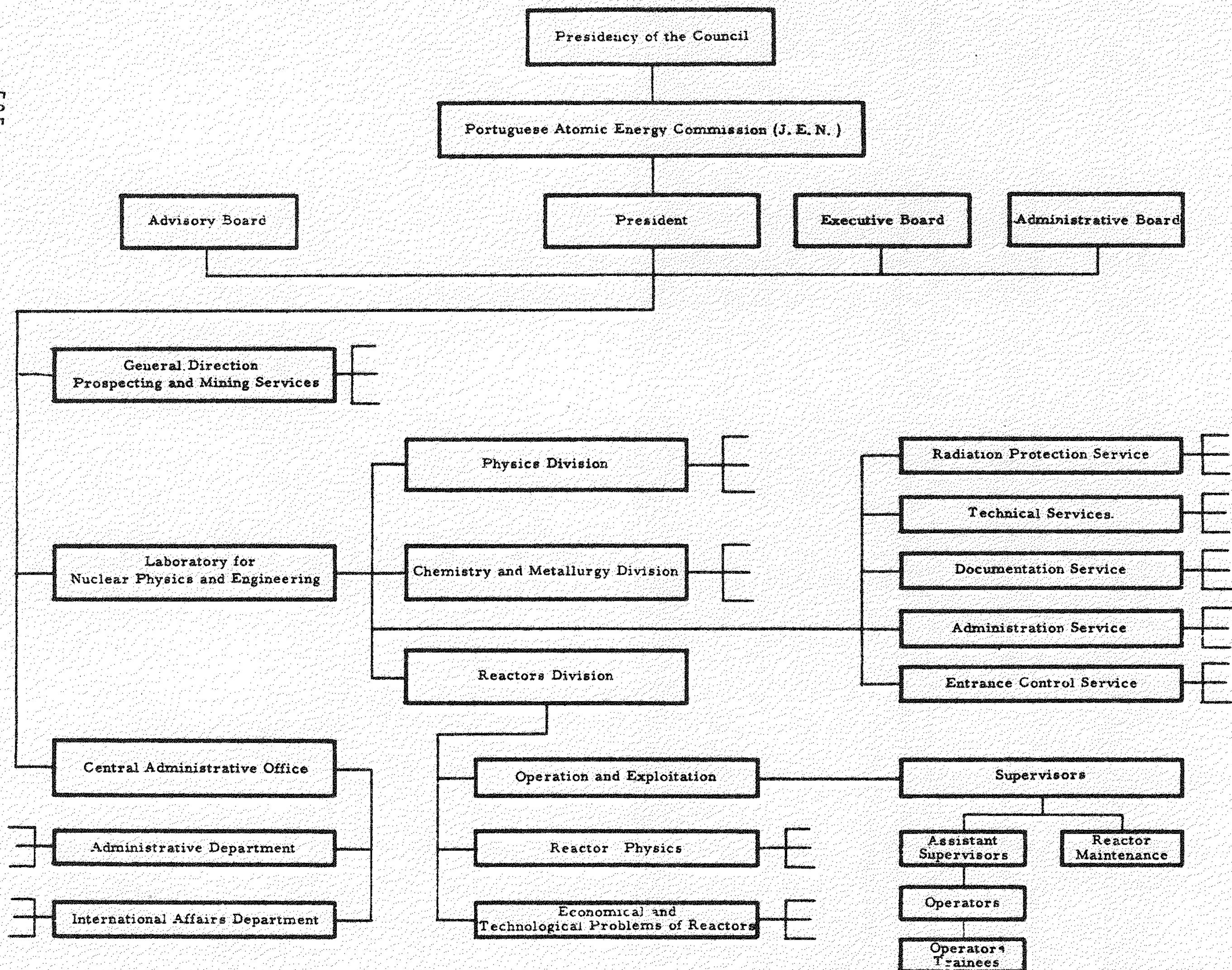

Fig. 1 Organization Chart.

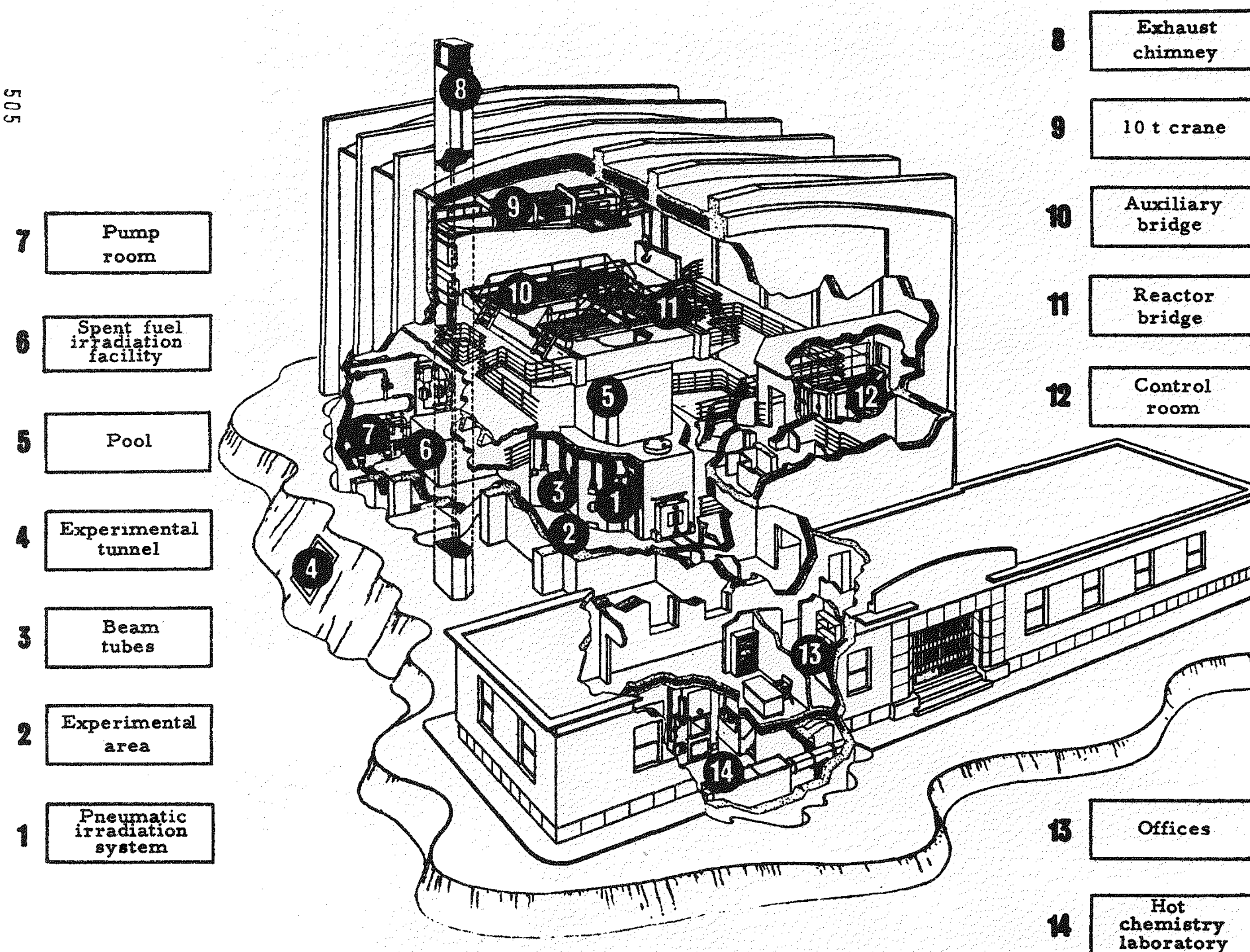

Fig. 2 General layout of the facility.