

Portuguese Research Reactor (RPI) Exploitation and Operation

Introduction

The main task of the RPI Exploitation and Operation Group was to assure *a safe and reliable operation of the reactor*. With this objective the articulation of the activities of the RPI Operation Group with those of the Modelling and Simulation Group and with those of the Radiometry Group, of the RPI, is of paramount importance.

In the context of this articulation:

- updating of the safety conditions of the reactor equipment and installations, and
- technological assistance to the reactor users.

are dominant aspects.

Operation Summary

The Portuguese Research Reactor (RPI) was operated in a two shifts per day schedule, from 9 a.m. to 12 p.m. In 1998 it was operated 200 days, accumulating a total of 1830 hours.

The reactor was mainly utilised by ITN research groups (Chemistry, Physics and Research Reactor groups) and to a smaller extent by the Faculties of Science of the Universities of Lisbon and Coimbra, to perform 400 irradiations, corresponding to 701 hours of utilisation at full power.

Other operational activities of the group:

(a) Training of new operating personnel

To assure continuous safe and reliable operation of the reactor an essential task is training of the personnel. This is more so, as in other places, most of the reactor operators are approaching retirement age. The training course for reactor operators initiated last year with eleven candidates continued in 1998, mostly with “hands on “ aspects, and it is planned to be completed by September of the current year.

(b) Preparation of irradiations

A good deal of effort was placed in the preparation of irradiations aiming at increase of the reactor utilization, including the production of short lived radioisotopes.

(c) Preparation and reviewing of safety reports

Reviewing safety information concerning aspects of reactor utilization was made or is in progress, namely concerning:

- ▶ The installation of the double axis Diffractometer;
- ▶ The preparation of a beam tube for multiple uses;
- ▶ The reracking and inspection of the 20% enriched fuel (LEU);

(d) Tests in the installation

1. Beam tubes

At present only the 8" and the thru tube are installed. The current schedule calls for the installation in the near future of beam tubes E1 and D1, to be used, respectively for the double axis spectrometer and for multiple applications, i.e., PGNAA, hydrogen determination in steels and BNCT. Tests have been done in those tubes to assure their conditions in respect to tightness and deformations. The tightness was checked by filling the tube with water under pressure up to 2 bar. For the deformations, the internal and external diameters of the tubes were measured at various locations, and clearance between the tubes and their plugs (to be used when the tubes are empty) was also verified.

2. Water level and activity monitoring

The practice of monitoring and controlling both the water level and its activity in positions around the reactor, i. e., in the lining and in the building foundations was continued.

(e) Reracking and monitoring of the LEU fuel

As indicated elsewhere, reracking and inspection of all the LEU fuel assemblies was conducted. This activity was demanded to improve the safety of the arrangement of the fuel in the pool and to prepare for its return to the USA under the RERTR programme.

(f) Return of the LEU fuel to the USA

Negotiations regarding the return of the LEU spent fuel to the USA were initiated. In the context of these negotiations the fuel was also inspected by SR personnel. In connection with this subject several actions regarding the manipulations of the fuel are in progress.

Team

Researchers –	3 (PhD or equivalent)
Reactor Operators –	4
Technicians –	1
Operator trainees -	9 at beginning

Publications

Conf. Commun. –	3
Internal Reports –	4

	10 ³ PTE
Expenditure:	7 272
Missions:	1 666
Others Expenses:	2 148
Hardware & Software:	760
Other Equipment:	2 698

		10 ³ PTE
Funding:		7 272
OE/ITN	OF	6 149
	PIDDAC	1 123

Portuguese Research Reactor - Overview 1997/98

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Abstract

A short review of all the activities related to the safe operation of the reactor is presented. Complete information about the utilization of the reactor and on the modifications and upgrading of the reactor is part of the report. The problems related to the fuel cycle, the maintenance, training and future developments are shortly described.

Communication to: 9th Annual Meeting of EAES-RROG (European Atomic Energy Society - Research Reactors Operators Group), Petten, The Netherlands, 7-8 May 1998.

Training of new operators for the Portuguese Research Reactor

Coordinators: A.J.G. Ramalho, F. Cardeira, J.G. Marques

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Abstract

A two year training course for new operators was started in October 97. The first semester was composed of classroom instruction and laboratory training with the assistance of several researchers from ITN and DPSR*. The topics included:

- Fundamentals of Nuclear Physics (E. Martinho).
- Radiation Detection and Measurement (J. Salgado, I.C. Gonçalves).
- Fundamentals of Reactor Theory (J.G. Marques).
- Reactor Kinetics (F. Cardeira).
- Principles of Shielding (A.J.G. Ramalho).
- Heat Transfer (C.R. Carlos).
- Reactor Technology (F. Cardeira).
- Nuclear Safety (A.J.G. Ramalho, F. Cardeira).
- Radiological Safety Principles and Procedures (A. Bettencourt, P. Rocha, M.R. Teixeira, B. Martins, J. Alves, A. Severo, R. Trindade, L. Portugal, F. Carvalho, A. Oliveira, R. Reis).

The second semester was composed of on the job training in specific aspects of the RPI, given by the Operators of the RPI and the Exploitation Group. Topics covered, inter alia:

- Check out of the control system and of the instalation in preparation for the startup of the reactor (M.C. Marques, R. Barreiros, R. Carvalho, J. Roxo, F. Cardeira)
- Participation in the maintenance (routine and annual) of the control system.
- Participation in the maintenance of auxiliary systems.
- Assistance to experimental work, including dosimetry, sample preparation for irradiations, monitoring the water quality and level in the lining, etc.

* Formerly part of the Ministry for Environment. Part of ITN as of January 99.

Nuclear Reactors and Safety

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Abstract

Interaction of neutrons with matter. The chain reaction and principles of nuclear reactors. Neutron diffusion. Neutron moderation. Reactor kinetics. Changes in reactivity. Selected topics in reactor and fuel cycle technology.

Course given at the Faculty of Sciences of the University of Lisbon for the MSc students in Applied Nuclear Physics (one semester)

Advanced Experimental Physics

J.G. Marques

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Abstract

Alpha detection. Beta detection. Charged particle spectroscopy. X-ray and Gamma detection and spectroscopy. Neutron detection and spectroscopy. Application of radioactive isotopes in diagnostic and therapy. Reactor-produced isotopes. Accelerator-produced isotopes. Nuclear techniques in Applied Nuclear Physics: Mössbauer Effect, Perturbed Angular Correlations, Neutron Scattering.

Course given at the Faculty of Sciences of the University of Lisbon for the MSc students in Applied Nuclear Physics (two semesters).

Current Work

Reviewing and Updating Safety Documents:

◆ Safety Analysis Report

The RPI Safety Analysis Report is being reviewed and updated, specially to take into consideration the refurbishment and modernization work done between 1987 and 1990.

◆ Reactor Operating Procedures

The Operating Procedures, which complements the Safety Analysis Report, are essential documents for the operation of reactors. Improvements resulting from the reviews will be implemented and a compilation will eventually be made in an internal publication of the Institute.

◆ **Reactor Emergency Plan**

An Emergency Plan is being improved and updated.

Other activities

Continuation of the 1998 work, in particular:

◆ **Shipment of the LEU fuel to the USA**

Preparations for the shipment of the spent fuel assemblies to the USA shall be prepared during 1999.

◆ **Training of new operating personnel**

As referred above the “hands on” training of four new operators will go on during this year. Furthermore, other operating personnel is being trained in other tasks necessary for a better reactor exploitation.

◆ **Installation of new equipment**

Beam tubes for neutron diffractometer and for multiple applications will be prepared.

Training of new operators for the Portuguese Research Reactor

Coordinators: A.J.G. Ramalho, F. Carneira, J.G. Marques

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Abstract

The above mentioned two-year training course for new operators continues with on the job training in specific aspects of the RPI, given by the Operators of the RPI and the Exploitation Group. Topics being covered:

- ▶ Check out of the control system and of the installation in preparation for the startup of the reactor.
- ▶ Reactor startup and reactor operation.
- ▶ Specific lectures and demonstrations on reactor calibration.
- ▶ Participation in maintenance tasks.
- ▶ Assistance to experimental work.

Status of the Spent Fuel of the Portuguese Research Reactor

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In preparation for return to the US under the RERTR program, the full inventory of MTR fuel assemblies used in the initial cores of the RPI (20% ^{235}U enrichment, U-Al alloy) was visually inspected and the unique assembly identification was rechecked. Digital photos were taken of the side plates and outer fuel plates. Most of the fuel assemblies are in the reactor pool since 1961 and have been kept in aluminium racks in the pool after their discharge from the core. The water quality in the pool has always been controlled and maintained at a pH in the 5.5-6.5 range and at a conductivity below 1 $\mu\text{S}/\text{cm}$.

Visual inspection of the outer plates did not show any evidence for corrosion. The fission product leakage of every assembly was also determined. To this effect a special container was constructed and installed in the pool to perform individual sipping tests. The fission product leakage rate was determined by the measurement of ^{137}Cs using conventional gamma ray spectroscopy. In the context of this task the fuel was also re-racked into two new racks of 20 positions each, placed in the section II of the pool.

Fast Neutron Irradiation of Electronic Modules for the LHC/CERN

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Some electronic modules to be used in the Large Hadron Collider (LHC) facility at CERN will be located in a radiation field where fast neutron fluences of the order of $5 \times 10^{13} \text{ n}/\text{cm}^2$ will be accumulated over a 10 year period. The effects of such irradiation on the performance of key components and modules will be evaluated during a relatively short irradiation (~60 hr) in the Portuguese Research Reactor. A special container was built for simultaneous irradiation in the pool of the reactor of a set of 11 standard modules. During the irradiation of the circuits on-line monitoring will be done on key parameters. A detailed characterization of the neutron fluxes inside the container is underway.

Production of Short-Lived Isotopes for Diagnostic and Therapy

Collaboration between the Chemistry and Reactor sectors*

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An appraisal of the feasibility of producing short-lived isotopes for diagnostic and therapy at ITN using the Portuguese Research Reactor has been under way for some time. In this context small quantities of ^{64}Cu , ^{153}Sm and ^{186}Re , among others, have been or are being produced in the reactor by the irradiation of targets of the natural elements. Further work is underway in the particular area of handling the radioactive targets and optimizing the irradiation conditions.

* Reactor personnel involved: A.J.G. Ramalho, J.G. Marques, F. Cardeira, A. Kling, E. Martinho

RPI OPERATION in 1998

Month	Number of hours in operation			Number of days in operation	Energy Produced	
	P < 1 MW	P = 1 MW	Total		MWh	MWd
January	104,32	33,85	138,17	15	37,135	1,485
February	179,53	34,70	214,23	18	36,495	1,521
March	132,45	37,17	169,62	19	38,888	1,620
April	24,52	25,15	49,67	5	25,468	1,061
May	15,95	106,40	122,35	13	109,622	4,568
June	132,72	77,35	210,07	19	78,889	3,287
July	29,47	144,25	173,72	22	144,560	6,020
August	19,22	39,22	58,43	11	39,850	1,660
September	78,68	119,10	197,78	20	120,061	5,003
October	134,40	62,62	197,02	21	64,128	2,670
November	135,52	36,73	172,25	19	38,089	1,587
December	104,00	23,12	127,12	18	24,274	1,011
Total	1090,78	739,66	1830,43	200	757,459	31,493

USE OF THE RPI 1998 Departments of ITN

Department	Utilization areas	Time (h)	No. of irradiations
Reactor	Dosimetry at RPI	26,72	20
	Determination of elements	2	1
	Thermal Column: BNCT and PGNAAs studies	3,92	4
	Hyperfine interactions studies	1	4
	Tests of irradiation conditions	1	1
	Other	0,25	3
	Sub-total		34,89
Chemistry	Determination of elements (NAA of various samples):	452,34	331
	▶ Studies for the preservation of rocks		
	▶ Studies of the origin of stoneware		
	▶ Pollution studies		
Tests of irradiation conditions	100,95	19	
Sub-total		553,29	351
Physics	Sources for industrial application	63,8	8
	Gems coloration	44,31	4
	Training actions	1,95	1
Sub-total		110,06	13
TOTAL		698,44	397

External Institutions

Institution	Utilization areas	Time (h)	No. of irradiations
F.C.T. Un. Coimbra	Sources for studying perturbed angular correlations	2,56	3
TOTAL		2,56	3