Modelling and Simulation

Introduction

The objectives of the work carried out concerned the safety aspects associated with the operation and exploitation of the Portuguese Research Reactor (RPI) and also a few research topics related with RPI.

Actions undertaken:

- The establishment of operational limits and conditions of the Portuguese Research Reactor
- Some experience in the calculations concerning the RPI has been transmitted to several potential successors in the calculation activity, namely Dr. José Marques, Dr. José Barradas and particularly Dr. Alfred Stadler. The latter has been trained in a substantial part of the work but he has not persisted until the end, and this made it impossible to achieve the objective fully.
- Relevant calculations having to do with RPI utilization:
    - ◊ Monte Carlo calculation of fast neutron and gamma radiation spectra inside a lead hollow cylinder arising from a planar source of fission neutrons and reactor gamma photons
    - ◊ Effect of the epithermal neutrons on the interference from uranium fission in the determination of molybdenum by instrumental neutron activation analysis
    - ◊ The support to the RPI users concerning the neutron flux distribution for the N2-P1/5 core configuration

Concerning the radioactive waste disposal study, some preliminary results were obtained concerning the sensitivity of U (see report ITN/RPI-R-96/44) to the various parameters.

Research Team

Researchers – 3 (3 PhD or equivalent)

Publications

Journals – 1

Proceedings – 1

Internal Reports: 2

Special publications – 10

Expenditure:	93
	10^3 PTE
Missions:	0
Others Expenses:	92
Hardware & Software:	1
Other Equipment:	0

Funding:		93
		10^3 PTE
OE/ITN	OF	93

Calculation of Epithermal Neutron Doses in Research Reactors

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Abstract

A methodology for calculating the total absorbed doses in samples irradiated in nuclear research reactors which permits to know the contribution of each of the radiation field components (i. e., thermal, epithermal and fast neutrons, and gamma radiation) has been recently described. The epithermal neutron spectrum was then considered to vary as the inverse of the neutron energy (1/E spectrum), which is only valid as a first approximation. The present work improves that methodology by considering the epithermal neutron spectrum as varying according to $1/E^{1+\alpha}$, where α is the parameter which accounts for the deviation from the 1/E law. Average kerma factors are calculated for various elements and nuclides, for values of α between –0.1 and +0.2, this interval covering practically all the experimental conditions of interest. The dose rate due to epithermal neutrons is found to decrease as α increases, except for samples containing, mainly, ^{6}Li, B, N and/or Cl.

Kerntechnik **62** (1997) 184–186.

Calculation of Fast Neutron Spectra from a Plane Source of Fission Neutrons in Various Diffusing Media Using the Monte Carlo Technique

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Abstract

Certain experiments involving irradiation of samples in nuclear reactors, specially those for studies in biology, chemistry, physics and materials science where alteration of properties are to be induced by fast neutrons, require the knowledge of the neutron spectrum, particularly in order to calculate the doses absorbed by the samples on the basis of averaged kerma factors. Aiming at a general characterization of the fast neutron spectrum at the irradiation facilities of the Portuguese Research Reactor — a 1 MW pool type reactor, with fuel elements of MTR shape —, in a way which does not depend on the core configuration and on the irradiation conditions, the following simplified calculation was carried out: (1) the face of the reactor core has been considered as being an uniform plane source of fission neutrons, and (2) using the MCNP–4A code, the spectrum of fast neutrons has been calculated at several distances along the central axis normal to the source, considering various combinations of diffusing media (light water, beryllium, and graphite) of various thicknesses.

Proceedings of the *International Conference on Neutrons in Research and Industry*, ed. George Vourvopoulos, SPIE (The Society of Photo-Optical Instrumentation Engineers) **Vol. 2867** (1997) 461–464.

Operational Limits and Conditions of the Portuguese Research Reactor

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The organizations involved in ensuring the safety of nuclear research reactors, and the protection of the public, the site personnel and the environment, have a number of responsibilities which are interrelated. Some of the more important of these responsibilities are the performance of the safety analysis and the production of the Operational Limits and Conditions (OLC) as well as other safety related documents, and their review and assessment. This document is the result of the review and reassessment of OLC for the Portuguese Research Reactor (RPI). The document (1) describes the main design features of RPI related to the safe operation of the reactor; (2) specifies the safety limits and the safety systems settings, and the parameters to which they apply; (3) specifies the limiting conditions for safe operation; (4) establishes surveillance requirements on items subjected to safety system settings and limiting conditions of operation, including the requirements for inspections, operability checks and calibrations, and the frequency and the scope of tests; and (5) specifies the administrative requirements for the reactor facility.

ITN/RPI–R–97/46 (1997) (in English)

Current Work

Monte Carlo Calculation of Fast Neutron and Gamma Radiation Spectra Inside a Lead Hollow Cylinder Arising from a Planar Source of Fission Neutrons and Reactor Gamma Photons

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Certain experiments involving irradiation of samples in nuclear reactors, specially those where alteration of properties are to be induced by fast neutrons, may require the reduction of the dose due to gamma radiation. In order to maximise the neutron doses absorbed by the samples, a Monte Carlo calculation of fast neutron and gamma radiation spectra inside a lead hollow cylinder arising from a planar source of fission neutrons and reactor gamma photons is being carried out. The effect of the lead wall thickness and of the neutron diffusing media adjacent to the reactor core on the spectra is being observed.

Effect of the Epithermal Neutrons on the Interference from Uranium Fission in the Determination of Molybdenum by Instrumental Neutron Activation Analysis

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The presence of uranium in samples interferes with the determination of a number of elements by instrumental neutron activation analysis, in particular due to the identity of some ^{235}U fission products and radionuclides formed by radiative capture of neutrons on those elements. The extent to which the interference may affect the accuracy in the determination depends on the ratio of the concentrations of the element to be determined and of the uranium in the sample, as well as on the irradiation conditions. This work aims at studying the effect of the epithermal neutrons on the interference from uranium fission in the determination of molybdenum by INAA.