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I - INTRODUCTION

The ISIS facility forms part of OSIRIS assembly which is operated by the Commissariat à l'Energie Atomique at C.E.N. Saclay, since 1966.
The installation includes :

- reactor OSIRIS, a 70 MW pool-type reactor especially devoted for irradiation of fuel elements and structural materials. In fact, the high fast and thermal fluxes attainable allow to strongly enhance the irradiation effects.Lately (1979), conventional UAl fuel was replaced by low enriched 7 % UO_2 fuel (CARAMEL plates).
  Main characteristics in the irradiation regions are :
  . fast flux (E > 1 MeV) 2. 8 x 10^{14} n/cm^2 s
  . thermal flux = 3. 10^{14} n /cm^2 s
  . gamma heating : 8 W/g inside the core
  2 W/g at the outer parts
- 2 hot cells, equipped for positioning and removal of irradiated samples. The cells are connected to the reactor pool through a channel which allows under-water transfer of radioactive devices.
- the ISIS facility

II - THE ISIS REACTOR : DESCRIPTION

The following general principles have led to the design of ISIS :

- the core is as similar as possible to the OSIRIS core. Hence it can be loaded either with fresh fuel elements or with fuel elements already irradiated in OSIRIS, at various burnup values.
- the licensed power (700 KW) is sufficient to allow every kind of measurement to be performed on experimental mock-ups and devices and it is also sufficient for a correct inter-calibration of power, e.g. by thermal balance.
- the water-loop of the core is entirely independent of the pool, to the aim of making homogeneous poisoning easier by soluble poison : the water amount to be poisoned is thus limited to about 6 m^3.
- the facility is connected through a channel to OSIRIS, so that the irradiated devices can be easily taken from one core to the other.

The reactor is set up in a pool 4 x 4 x 7 m. The core is separated from the pool by a watertight duct which yet is open to the air. The duct is provided with a seal which can be moved to allow transfer of irradiated fuel and devices. As in OSIRIS the fuel in the core is arranged in a 7 x 7 matrix surrounded by a Zircaloy shroud. The main features of the fuel are given in Table 1.

III - APPLICATIONS

The general principles outlined in § II have proved to be very suitable to the actual use of the assembly. ISIS has been extensively used both as a mock-up and as a neutron source.

The main points are summarized as follows :

- Best simulation of OSIRIS core : it is made possible by the use of either fresh fuel or irradiated one. The same U^{235} mass content for the two reactors involves, for the same power, the same average thermal flux level.
- Maximum power level : it is rather high for a mock-up (700 KW) This allows a direct power intercalibration between the two reactors by thermal balance : a method which indeed ensures the best overall comparison. Another advantage is the availability of fast flux levels sufficient for performing measurements with a great number of detectors and fission micro-chambers which have a rather poor sensitivity.

A sufficient γ-heating level allows the measurements to be performed directly in ISIS since this type of measurement is quite representative of OSIRIS, once the power intercalibration has been correctly done. Classical differential calorimeters are used.

- Use of soluble boron : the boric acid in the core loop allows to counter-balance the overall available reactivity between the position of control rods at criticality with no poison, and fully withdrawn rods.
- Use for core investigations : the Table 2 summarizes, on the whole, the measurements performed.
- Use for dosimetry purposes : dosimetric measurements are carried out either on the irradiation device itself, or, more frequently, on a neutronic mock-up. The status of OSIRIS core is simulated as closely as possible. In particular, measurements are performed both for a control rod situation representing the average situation in OSIRIS during the cycle, and for several rod configurations in order to foresee the time evolution of the flux.
  The power intercalibration between OSIRIS and ISIS is performed by means of self-powered detectors located in the same region in the mock-up and in the reactor, or also through thermal flux measurement by means of fission chambers put in the same region in ISIS and OSIRIS.

TABLE 1 CHARACTERISTICS OF THE ISIS FUEL ELEMENTS

	STANDARD ELEMENT	CONTROL FUEL ELEMENT
PLATE TYPE	CARAMEL	CARAMEL
PLATE NUMBER	17	14
FISSILE PART LENGHT (cm)	63	61
FISSILE PART WIDTH (cm)	7.3	5.4
FISSILE PART THICKNESS (mm)	1.45	1.45
U LOADING (kg)	8.7	5.2
NUMBER OF ELEMENT IN THE CORE	38	6
ABSORBING PART OF THE CONTROL ELEMENT		Hafnium

TABLE 2 MEASUREMENTS PERFORMED IN ISIS

CALIBRATION OF CONTROL RODS	- USE OF SOLUBLE BORON - CALIBRATION BY REACTOR DIVERGENCE - USE OF A REACTIVITY-METER
MEASUREMENT OF THE TEMPERATURE EFFECT OF THE MODERATOR	- HEATING OF THE WATER OF THE CORE LOOP
MEASUREMENT OF THE VOID EFFECT	- MECHANICAL ASSEMBLY OF THE FUEL ELEMENT
REACTIVITY EFFECTS	- POSSIBLE USE OF SOLUBLE BORON - MEASUREMENTS BY ACTIVATION DETECTORS : (th. FLUX : Au, Co, Mn) (FAST FLUX : Ni, Cu, Al) - MEASUREMENTS BY FISSION MICROCHAMBERS : U^{235}, U^{238}, Np^{237}, Pu^{239} - MEASUREMENTS BY COLLECTRONS : Rh, Ag
GAMMA HEATING	- DIFFERENTIAL CALORIMETERS "ad hoc"

"IMPROVED" METHODS

Moreover ISIS was operated in support of structural materials programs, as a benchmark for miniaturized damage detectors. Based on electrical resistivity increase after irradiation, the Tungsten and Graphite damage dosimeters have been calibrated versus fluence and temperature in a standard neutron field. This technique leads to direct measurements of DAMAGE/ACTIVATION ratio in experimental devices.

Accurate ($<$ 5%) assessment of nuclear power in OSIRIS fuel experiments is attained by a special facility in ISIS reactor : after a low power irradiation -in a device mock-up- the fuel sample is dissolved and fission products are counted with respect to a standard source irradiated in a thermal column.

IV - ISIS AS A NEUTRON SOURCE

Good adaptability in ISIS operation has led to various devices.

Fuel elements testing by neutron-radiography using a film of cellulose nitrate.

A dry neutron radiography unit is installed on the ISIS reactor. This facility uses on exiting beam yielding a flux of $2{,}5.10^7$ n/cm^2.s in a usable cross section area of 10 x 15 cm at the end of the 4 m long collimator. This beam crosses a 8 m deep vertical pit designed to hold a lead flask loaded with 5 fuel pencils standing side by side in a 4 m long rack.

The lead flask is equipped with a hoisting mechanism which lowers first the fuel pencil rack in the pit and raises the rack step by step in front of the collimator aperture. 30 consecutive pictures corresponding to the 4 m long fuel pencils set are taken.

A special camera using nitrocellulose films as image detector takes place on the travel path of the fuel, behind the collimator window.

It is activated automaticaly by a master clock which controls the exposure time and the number of pictures as well as the repositioning of the fuel before each exposure is done. The nitrocellulose used is the most suitable film for neutron radiography of radioactive materials. It is insensitive to gamma rays and all other radiations except bombardment of heavy particles such as alpha and triton. This bombardment is obtained by means of a neutron alpha converter made on the basis of boron or lithium compound more or less enriched.

After completion of the 30 pictures sequence mentioned above, the film is taken out of the camera and immediately set in the day light on a spool to be developed in a caustic bath. The processing time is fairly short and gives pictures of low density and poor contrast.

The low contrast, generally considered as a disadvantage because of the practice in radiographic films, enables in fact the most possible information to be recorded during one single irradiation. The information will be obtained by multi-stage development of the latent picture, permitting to get successively all the details from the lowest to the highest absorption cross section. In the same way, interesting results may be reached selecting the right fluence for the material to be controlled. In such cases, it will be useful to work with both variable parameters. On the opposite of silver halide film, the prolongation of the irradiation or/and development time doesn't affect the picture size in a sensible way. The obtained finesse is equivalent to that procured by the slowest radiographic films. The low contrast will be compensated by copying the film at every stage of the development on high contrast silver film using an enlarger in order to avoid the scattered light. Owing to the good transparency, direct examinations and optical measurements are possible by mean of optical instruments or, eventually, of polarization filters, directly on the negative nitrocellulose film.

At last should be mentionned following applications :

- Systematic fission chambers calibration for nuclear power-plants
- Improvement of NDT and gamma-scanning methods (short half lives selection...)
- High energy standard gamma beams.