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ET DE MATHEMATIQUES APPLIQUEES

SERVICE DES EXPERIENCES CRITIQUES
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DCPM n° 15 CEA/DRAGON 1
PART 1

PRELIMINARY REPORT ON THE EXPERIMENT PERFORMED IN MARIUS REACTOR LOADED WITH TELEDIAL FUEL

BY

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I - INTRODUCTION -

The experimental work described in this paper is part of a collaborative programme agreed between CEA and DRAGON PROJECT.

The aim of the programme is the measurement of the relative Conversion ratio in a reactor loaded with Teledial fuel elements.

The results will allow us to check our calculational methods and the assumptions upon which the calculations are based, in the case of a teledial core, which represents a very complicated geometry, specially, due to the presence of the U238 with its resonance.

II - DESCRIPTION OF TELEDIAL FUEL ELEMENT -

The teledial fuel element, made with compacts supplied by DRAGON PROJECT has the following characteristics :

Number of pins per element	8	
Number of compact per pin	7	
Length of teledial element	329 ± 1	mm
Pin radius	5,45	mm
Central cooling channel radius ...	10	mm
Outer cluther boundary radius	22,9	mm
Channel Marius radius	30,55	mm
Outer Teledial radius	25	mm

The Teledial fuel is made of consolidated coated UO_2 particles main characteristics are :

Heavy metal density in compact ...	0,949	g/cm^3
Carbone density in compact	1,49	g/cm^3
Uranium enrichment	3,5	% U_{235}
Mean diameter of the Kernel	807	µm

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III - LAYOUT OF MARIUS REACTOR -

The loading of Marius Reactor for the teledial experimental programm had been decided some times ago, following the calculations made by WOLOCH F. and al [Réf. 1].

Since, however, the fuel elements were not all available at the date of the loading of Marius, it was necessary to repeat some calculations to find the arrangement which, with the fuel locally available, could give a zone of constant spectrum in the central zone of teledial elements in Marius Reactor.

III-1 : Calculational methods for the Reactor loading.

The computer codes used for the planning of the Marius core were :

a) WIMS (for the cells)
b) ALCYON (4 groups-Diffusion) for the reactor.

The following table gives the partition vector for the energy group used :

Group Number	Energie Range
1	0,8 MeV - 10 MeV
2	9,1 keV - 0,8 MeV
3	4 eV - 9,1 keV
4	0 - 4 eV

III-2 : Zones in Marius.

- Teledial zone

It has a diameter of 40.12 and a length of 33 cm. It contains 19 cells whose hexagonal pitch is of 90 mm, channel 61 mm.

- Reference zone

It is composed of a mixture of powder UO_2 3,5 % enriched, with graphite powder. These powders are loaded in an Aluminium tubular can of 330 mm length with a central graphite rod and an external graphite tube the zone is 100 cm long and its diameter is of 109 cm.

It contains 365 cells of a 90 mm hexagonal pitch channel 61 mm.

III-3 : Adjustement and complementary zones.

a) Axialy, after the reference zone, we find a zone loaded with 3,5 % enriched UO2 pins (2 pins per cell, over 66 cm), then the graphite reflector.

b) Radialy, a transitory zone has been studied to avoid perturbations in the central zone due to the higly thermal driver zone (224 mm pitch). This transitory zone is made with a ring of HTR type cells (H90-C61) loaded with 3,5 % UO2 pins (2 pins per cell) and a ring of classical MARIUS cells (224 mm square pitch, channel 110 mm diameter) loaded with a natural uranium tubular fuel.

III-4 : Driver zone

Usual natural or slightly enriched uranium MARIUS fuel is used to reach the criticality by loading the external zone.

III-5 : Comparison of physical characteristics of teledial and reference cells.

The characteristics of the reference fuel element (loaded in the zone surrounding the Teledial zone and containing UO2 powder, 3,5 % enr.) have been chosen so that they are as near as possible to the characteristics of the Teledial fuel.

On the following table are compared the 2 cells :

	Cell Teledial	Cell powder (P) 3,5 % + C	$\frac{\lceil (T) - (P) \rfloor}{T}$
ϕ_3/ϕ_4 EFF	0,8112	0,8114	- 0,02 %
ϕ_2/ϕ_4 EFF	0,6218	0,6177	+ 0,6 %
ϕ_1/ϕ_4 EFF	0,2183	0,2148	+ 1,6 %
$\frac{\overline{\sigma}_{+9}}{\overline{\sigma}_{+5}}$	1,879	1,881	- 0,1 %
RCR	3,845	3,894	- 1,2 %
k_∞	1,42879	1,36434	-

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IV - EXPERIMENTAL PROGRAMME -

IV-1 : The first task of the programme of experimental has been to check the calculations of the neutron spectrum in the central part of the reactor core.

At this aim a series of flux distribution measurements have been performed on the Teledial, the Reference and the transition Zones [the fuel element in this zone is made by two UO2 pins (3,5 % enriched)]. The Reaction rates have been measured axially and Radially, each 90 mm for a total length of one meter, using :

a) $\frac{Pu\ 239}{U\ 235}$, $\frac{U\ 238}{U\ 235}$ (fissions chambers)

b) Natural Uranium Foils

c) Au an Cadmium covered Au Foils

The chambers and the foils have been irradiated in the measuring channels of Marius Reactor (see fig. 3) with the exception of the Au foils irradiated in the Central channels of the fuel elements.

IV-2 : Measurement of Relative Conversion Ratio and of Fast Fission Ratio.

The Relative Conversion Ratio (RCR) and the Fast Fission Ratio (FFR) have been measured axially in two compacts of a pin of the central teledial element and radially in the first and in the second circle of the teledial zone.

These measurements have been repeted to increase the accuracy.

IV-2-1 : Measurement of RCR

The measurement consists in comparing the ratios $\frac{\text{Atoms of Pu 239 produced}}{\text{Atoms of U 235 destroyed}}$ for a sample of fuel irradiated in the teledial zone and a equal sample irradiated in a thermal spectrum (in our case in the thermal column of Harmonie Reactor).

The sample used for the RCR measurement is the central part of a compacts irradiated in a Teledial element on Marius Reactor : the sample irradiated in Harmonie is mady by loose particles.

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The technique consists in measuring the following ratio :

$$\frac{\text{activity of Np 239}}{\text{activity of U235 fission products}}$$

the γ activity of U235 fission products is measured on particles separated from their matrix.

To count the γ activity of Np 239 the fuel is reduced to liquid (with HNO_3^{β}) and them is possible to proceed in two ways.

a) Measuring the rate of Np 239 decaying on a γ coïncidence spectrometer by counting the coïncidences between γ of 106 keV from a β emission from an excited level of Pu239 and a X-ray of 104 keV (from internal conversion of γ rays of 273 keV originating from another excited level of Pu239) alternatively.

b) Measuring with a Germanium Lithium diode the 273 keV of Np 239 separated by chemical method.

IV-2-2 : Fast Fission Ratio (F.F.R.)

The method consists in irradiating simultaneously two uranium foils : one containing depletum uranium and the second one natural uranium.

The foils have been located in the teledial element between two compacts. The F.F.R. is given by the ratio of the γ activities of the fissions products of the two foils above 511 keV (this threshold is high enough to eliminate the counts due to the Np 239 decay).

We have measured with U238 and U235 fission chambers to link the fission rates and the fissions products. We have located in the graphite of the teledial central element a U238 and a U235 fission chambers together with a couple of uranium foils for the F.F.R. This experiment should give us a correlation between the number of fissions and the produced fission product.

V - CONCLUSION -

The programme of experiments described in this pajer has been completely performed. Some preliminary results are presented in the second part of this report [DCPM 15 / CEA.DRAGON 1 part two].

- REFERENCES -

[1] Layout of the Teledial Experiment in MARIUS
by F. WOLOCH and G. SCHLESER - F. MORIER - G. LANGLET
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by Y. BARBIER - E.R. BATECHELOR - J-P. PRAIZEY - G. ROUSSEAU
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[3] Coating of 3,5 % enriched UO_2 from propylene for the Teledial Physics Experiment in MARIUS.
by J-P. THOMAS - J-P. PRAIZEY - A-C. BEDDALL
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[4] Notes on a Discussion at Cadarache for the layout of Teledial experiments as planned under the DRAGON/CEA collaboration.
by G. SCHLESER.
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[5] Code ALCYON
by G. GAMBIER
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[6] Experience Teledial - Programme de mesures
by J-C. ESTIOT
SECPR/ECM/72/102

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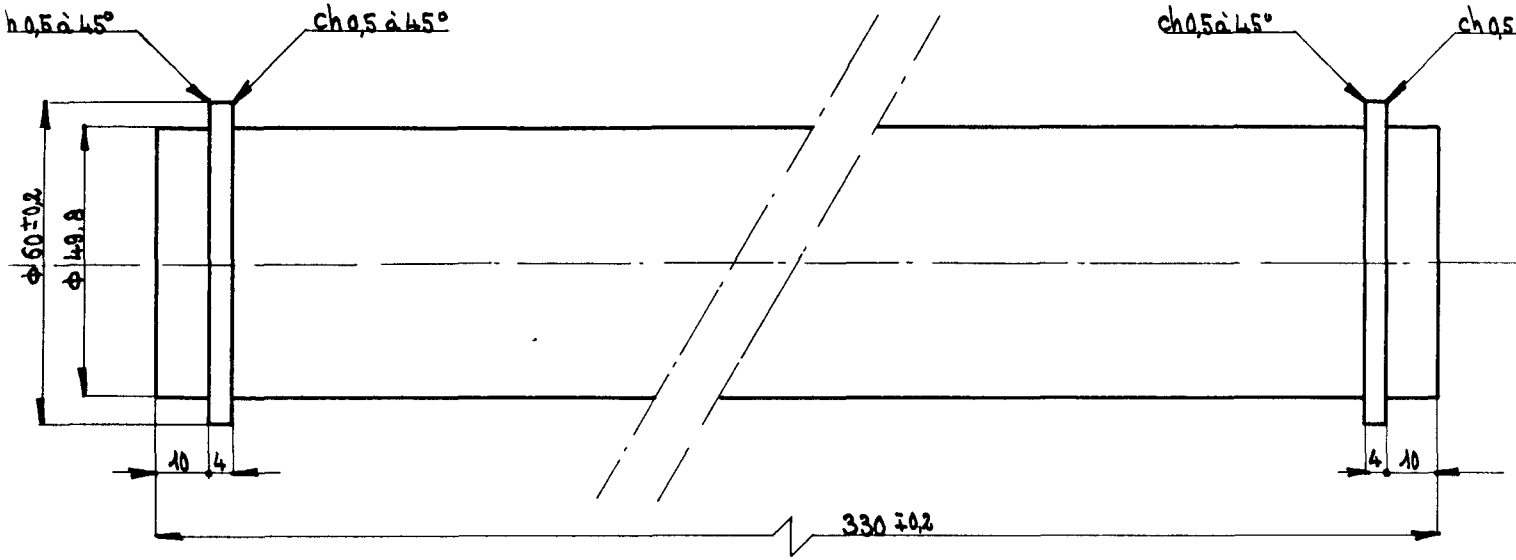
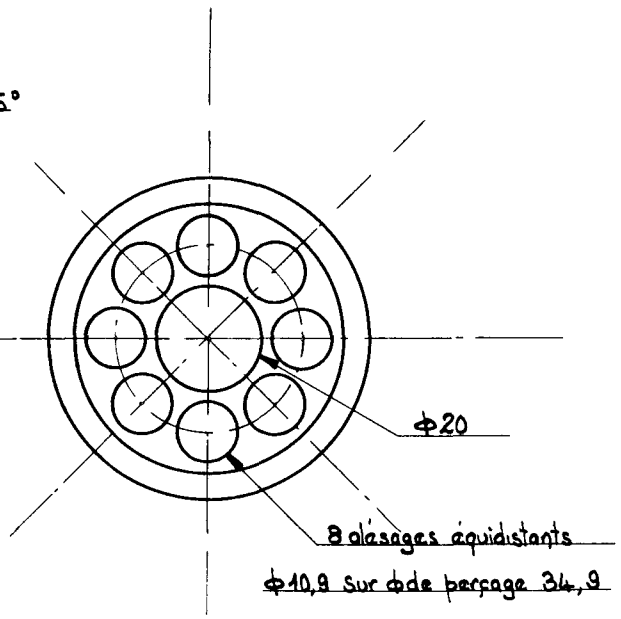
fig 1





Tolérances générales · ±0,1

INDICE	DATE	OBJET DE LA MODIFICATION	MODIFIÉ par	VISAS

MATIÈRE Graphite - USINAGE

TRAITEMT : PROTECTION

SNE "CESAR"

ETUI POUR COMBUSTIBLE TELEPHONE

MARIUS - HTR -

CEN - CADARACHE

ECHELLE	DES. PAR	7006 . 13	PL	INDICE
1	Papino G.		/	
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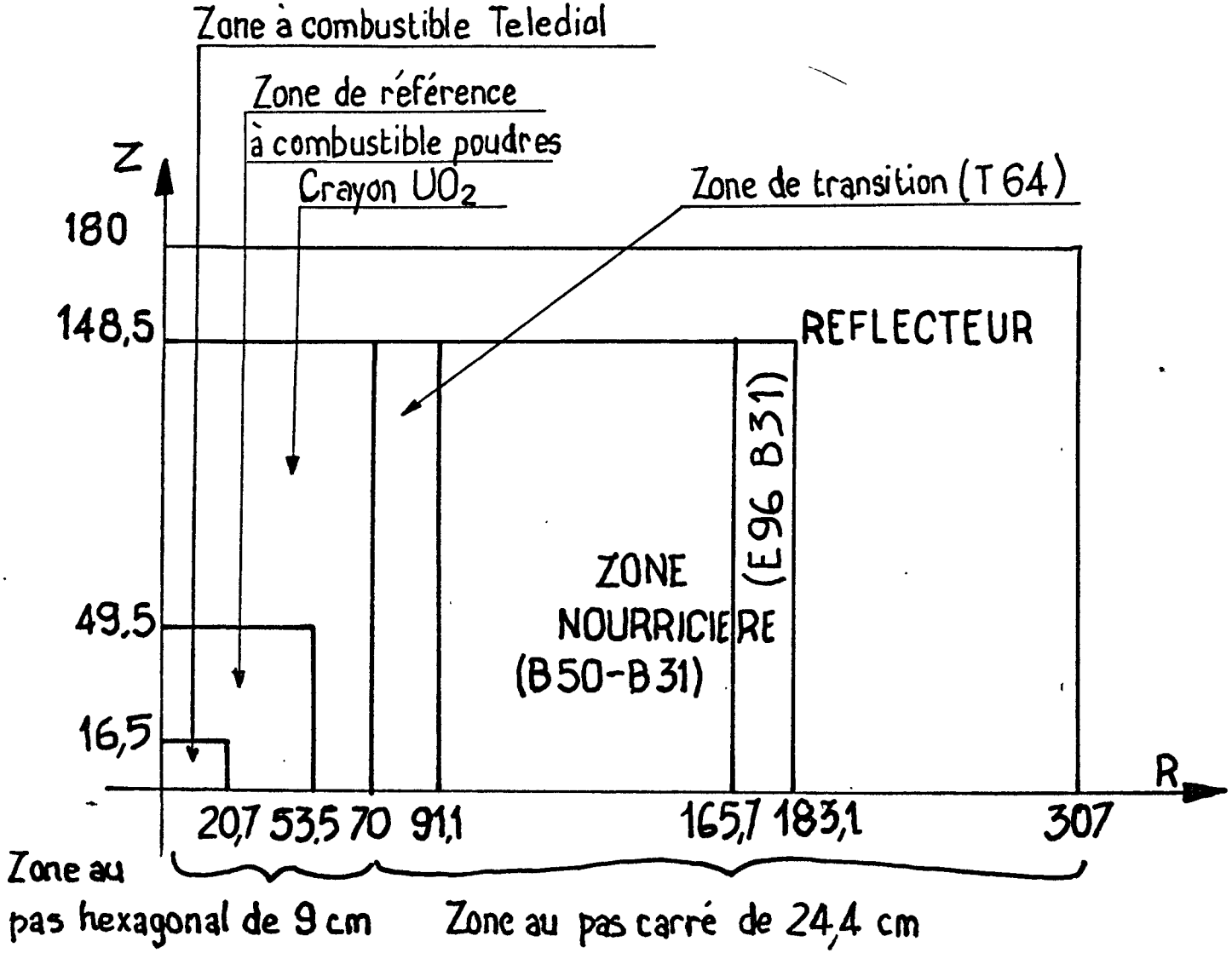
MARIUS III Représentation R Z Echelle 1/20

fig 2



MARIUS III

fig.3

Représentation Radiale

	COMBUSTIBLES 1/2 Pile axiale 0 — 14,5 — 43,5 — 82,5 — 115,5 — 148,5 — 180				Nbre	
1 ZONE	Teledial	Poudres 3,5%	Grappes L=66 G	Crayons 3,5% nu	Poudres 1% Reflect.	19	67
2 ZONE	Poudres 3,5 %		Grappes L=66 G	Crayons 3,5% nu	Poudres 1% Reflect.	72	64
3 ZONE	Poudres 3,5%	Grappes crayons 3,5% L=35		Poudres 1%	Reflect.	36	64
4 ZONE.	Grappes crayons 3,5% L=168.			Poudres 1%	Reflect.	92	64
TOTAL.						219