PRNC108

PRNC lo8

PUERTO RICO NUCLEAR CENTER

Excess Reactivities Associated

with Certain Core Configurations

of the PRNC Research Reactor and

the Proposed Pool Critical Facility

Dr. Aviva E. Gileadi

November 1967

?OPERATED BY UNIVERSITY OF PUERTO RICO UNDER CONTRACT

[NO. AT (401-1833 FOR U.S. ATOMIC ENERGY COMMSSION

---Page Break---

PRNC REPORT 108

---Page Break---

EXCESS REACTIVITIES ASSOCIATED WITH CERTAIN CORE CONFIGURATIONS.

(OF THE PRNC RESEARCH REACTOR ANO THE PROPOSED POOL CRITICAL FACILITY

Dr. Aviva E. Gileadi

+490.

---Page Break---

ACKNOWLEDGEMENTS

The advice and

istence obtained from Mr. C. W. NESTOR of the

Mathematics Division, ORKL = in run;

ing the TWENTY GRAND problems

land From OR. BAL RAJ SEHGAL Of the Reactor Physics Division = BNL

in comput ing the few group cross sections is gratefully acknowledged

herewith.

?The cooperation of the PRNC - Reactor Division in performing the

critical experiments is highly appreciated.

---Page Break---

EXCESS REACTIVITIES ASSOCIATED WITH CERTAIN CORE CONF/GURATIONS

(OF THE PRNC RESEARCH REACTOR ANO THE PROPOSED POOL CRITICAL FACILITY

Dr. Avive E. Gileadi

with certain core configurations of the

computed. The same conputat ional

method and the same input data, when used to compute the excess reactivity

ofa

iven core configuration of the PRNC | HW Research Reactor, yield

results that agree very well (within 2%) with those measured in critical

loading experiments on the sane configuration = thus establishing confi =

dence in the validity of the computations reported herewith. (See py

126 16)

One of the dbjectives is to provide dependable reactor physics data to be in the sa

ty analysis of the proposed PRNC-Po0! Critical Facility.

However the usefuiness of the data presented herewith Is not limited to

the solution of that problem, it is more general than that: The group

constants may be used as input data to» ver

ty of calculations concer~

?ning both the PRNC Res

wreh Reactor and the PRNC Pool Critical Facility,

Including calculations of flux distribution, depletion, perturbation etc

The fuel elements to be used in the proposed PRNC-Pool Critical Facility

identical with those used in the PRNC Research Reactor. They are

NTR-type, 18 plate fuel elements containing 10.67 9 of 20% enriched U305 powder per plate. For the exact description of the geometry and the

imaterials! composition of these fuel elements reference is made to the

Final Hazards? Sumary Report PRNC-37. (see ref. 1)

---Page Break---

?Tho results are presented in the following orde

1, Computed values of few group constants.

2, Computed values of effective multiplication factor (heey)

for @ set of configurations of the PRNC Poo! Critical

Facility.

Comparison of measured and computed kyey values for a given

configuration of the PRNC Research Reactor.

1. Compyted values of Few Group constants

Two, three and four group constants were dete

following regions

12, Standard fuel elenent

b. Partial fuel elesent

+ Center welt

4. Pure water reflector

The group constants ware calculated at the Comput ing Center of Brookhaven Kat ional Laboratory, using the HAMHER-code which was deve- oped at ONL. HANMER contains THERMOS Iibrary for thermal and MUFT

Mibrary for fast microscopic cross sections; the rest of the necessary Input data describe the materials composition and the geometry of the region. NAMMER-conputed few group constants by regions and by energy

Groups are

---Page Break---

1 mev,

---Page Break---

---Page Break---

ssisn suseoco om sey: |

sett | _ sso" | w0so00 19 629° = HEM OL |

Tee Tey wet

|

esesm*

°

| 6mm oss: .

| met ?EzELO"

L

?ész0z0"

oss 190100

6?1100"1 600m 20000"

Legees" 622601" £1000"

uf

NO1930 713K TOULNOD OWMd YOd SLWVASNOD snow 1G CaLN4WO> ua

© nev

---Page Break---

090941 0620610" 0 = 3 S29

we seo cro oy =a

Se

oom ce re

9 689265"! offz20" 061000" AM ESS ~ HOW OL

om cas . mae

1 ?tSses~ Lesh 910100" *8 S29" ~ now E55

[Beste wo tir seve =o

| omsco-z 6ut901° 09¢000" 20M 128° = 50H OF

sdnos6 ase) sesus

YGLVA Suna WOs SLMVLSHOD aNQYD AZ a3LNEHOO-¥IMACH

ome

---Page Break---

2 of Eff iplicatl 1

Effective miltiptication-factors were computed on the Control Data

e 16OK-A computer of the ORNL Mathematics Division, using "TWENTY GRAND",

4 few group, few region diffusion code developed at ORNL.

Four groups were us

The core configurations chosen include the pro=

¥ Posed basic configuration of the Pool Critical Facility as well as

: certain other configurations of the sane facitity obi

ined by a

ing

fone, two, three or four standard fuel elements to the basic configura-

tion, Into the corner positions. Some of these configurations were

Instrumental In determining the excess reactivity associated with the accident, agreed upon In the case of the PRNC-Poo!

Critical Facility as inadvertently dropping

tendaré fuel element

Into a corner position.when the core Is alrandy critical in its basic

configuration.

?The configuration cat

1d NCONTROL CASE" refers to the actual configuration

\ Of the PRNC Research Reactor used in a critical loading experiment.

TWENTY GRAND calculated effective multiplication constants, together

with the configuration diagrams are given in figures | - 5.

---Page Break---

Pecos

LEGEND

BBB sre.0mo rue. [wate nersscron

¢ EEE cowmo. ve.

. E1gue 1

CORE CONFIGURATION A, COMPUTED Kegs = 1.0143652

---Page Break---

LEGEND

BBB srmonen ree [J wien nessccton

EER conraon ven

EguRE 2.

CORE CONFIGURATION 8, COMPUTED kay = 1.0212336

---Page Break---

%

OPS

eS

BBB stavonwo ruer [J wares nervecron

---Page Break---

Leceno

BBQ seo rue (te rercecron

FEES) comrnon wer

EIGURE 4. CORE CONFIGURATION D, COMPUTED Kygy = 10341291

---Page Break---

LEGEND

+ BRP samo ruet conrnot weue

: PARTIAL fUEL (1 saves aercecroa

FIGURE 5. CONFIGURATION ?CONTROL CASE?

couputeo °2029783

ROSES Reve 22

---Page Break---

3. Comparison of Measured and Computed Dats for the ?CONTROL CASE:

Im order to check the overall validity of these computations a con-

parison wes made with experimentally determined results. A set of

critical loading experiments were performed n the PRNC-Research Reactor

Core in the open pool position and the excess activities were determi-

?ned with the aid of a calibrated regulating rod and one calibrated shimrod, The regulating rod was calibrated by the stable period method and the shiarod by the trading method.

Integral calibration curves of the regulating and of the shinrod are shown in Figures 6 and 7 respectively.

Figures 8 through 11 show the core-configurations for which # critical

loading has been performed.

---Page Break---

?ibe

20304

ROD POSITION (% OUT?

' REGULATING ROD CALIBRATION CURVE

INTEGRAL RODWORTH VS ROD POSITION

8030100

Figure 6

---Page Break---

20 30 3080

6070

ROO ?POSITION (%)

PARTIAL ROD CALIBRATION CURVE OF SHIMROD #3

INTEGRAL RODWORTH VS ROD POSITION

---Page Break---

CONTROL CASE ~ MEASURED

---Page Break---

Figure 10: CONF IGURATION H

SH) SH-2 SH=3 Sia RR

100. 100. 100. 100, 36.49

?ditions of one standard fuel

element in lattice position 50

0 the "CONTROL CASE" core results

Jn 33. excess reactivity - as it

can be read off from the cal bration

curves.

+ Rod positions at criticality

<| SH-1 SH-2 SH-3 SH-b RR.

D

100. 100. 23.9 100. 100.

Addition of the last fuel element

SZ

v\)

?amounts to an addition of $1.75

Ry

Of reactivity = as can be read

Off the calibration curves of the

regulating rod end shinrod #3.

XY

Ex,

ete

>

x]

---Page Break---

-i8-

The discrepancy between measured and computed kerf values in the ?CONTROL

CASE is .0029, which is very satisfactory especially if one takes into

?account that the computations rafer to # clean core and the meesurenents

were performed on a core that has had an operating history of approximately

80 megawart days.

Conclusions,

1. From the close agreement obtained between measured and computed values

We conclude that using the BNL-HAMHER code for generating few group

Constants and the ORNL-IVENTY GRAND code for determining the effective

multiplication factor leads to valid computed results. in an attenpt

to corrobora

this conclusion further calculations are being made on

2. We have seen that for configuration A of the proposed PRNC Poo!

Critical Facitity we obtain a computed kye¢ = 1.014 corresponding to clean cold excess reactivity of

this value

by substituting partial fuel elements for sone of the standard elenents

preferably In the center of the core.

3. The excess reactivity associated with the postulated maximum credible

?accident 1s computed as the differance between the kyy's of cases

Aand 8.

OK * 0,0068684 ~ 90g

---Page Break---

aise

References

1. Hazards Sumary Report for the Puerto Rico Nuclear Center

, Research Reactor, 1965, PRNC 37.

2. TWENTY-GRAND Program for the Numerical Solution of few Graup

Neutron Diffusion Equations in Two Dimensions = by K. L. Tobias

£7. 8, Fowler Feb, 1962, ORNL 3200

---Page Break---