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PUERTO RICO NUCLEAR CENTER

DESCRIPTION OF REACTOR AND EXPERIMENTAL,

FACIL:TIES AND INFORMATION FOR EXPERIMENTERS.

?OPERATED BY UNIVERSITY OF PUERTO RICO UNDER CONTRACT

NO. AT (40-11-1829 FOR U. 5, ATOMIC EMERGY COMMISSION

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DESCRIPTION OF REACTOR AND EXPERIMENTAL

FACILITIES AND INFORMATION FOR EXPERIMENTERS

Prepared by the Reactor Division of the Fuerte Rico

Nuclear Center,Mayaguer, P. R. Operated by University

of Puerto Rico under Contract No. AT (40-1)-1833 for

J. S. Atomle Energy Coma

February 1965

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Puerto Rfco Reactor - Front and Side Elevations

Reactor Pool = Plan View

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Reactor Room Basenent Floor Layout

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Flux Distribution along Center Line of Beam Tube

Flux Distribution Curves for Core 11 A

Fieal Configuration of Graphite in the Thermal,
Coluen

Neutron Physics Parameters

Location of Gold Foils Used with Pinal Graphite
Configuration

Final Flux Distribution at the Surface of the

Vertical Access Position, Vold in Graphite

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INTROWICTION

This manual has been prepared to provide experimenters

and other scientific personnel with information regarding

the reactor and its facilities. Practical inforeation

Feparding facility size and shape, gama or neutron flux, etes

bas been conpiled in ready reference form for those who use,

of who wish to use, the reactor facilities.

?The information regarding neutron fluxes and gamma dose

rates is representative and is intended to serve only as a

side in planning an experinent.

?A section containing regulations and procedures for

obtaining irradiation services and for performing gross

activity determinations has

so been included.

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DESCRIPTION OF REACTOR AND EXPERIMENTAL PACTLITIES

1. REACTOR DESCRIPTION, (1)

The 1 megawatt pool-type research reactor is a Light-vater moderated, heterogeneous, soltd fuel reactor in which water ia used for cooling and shielding. The reactor core is tmersed in either Section of two-section concrete pool filled with waters One of the sections of the pool contains an experimental stall in which

beam tubes and other experimental facilities converge. The other Section is an open area permitting bulk irradiation. The reactor can be operated in either sections

?The pool {s spanned by « manually-operated bridge from which an aluminum tower supporting the reactor core Ls suspended. Control over the reactor core is exerted by inserting or withdrawing neutron absorbing control rods suspended from control drives mounted on the Keactor core bridge. Additional control 1 provided by the teaperature coeffictent of reactivity. The aluminum tower and movable bridge ere shown in Figure 1.

Heat created by the nuclear reaction {s dissipated by « forced cérculation cooling system. Externally located pumps, « water-to-water heat exchanger, a cooling tower, a denineralizer plant, anda filter complete the water handling systen for the resctor poole

REACTOR SPECIFICATIONS

Poet 20% enriched U-255

in U30g and Al dispersion

MTR type, Al clad fuel

assenblies (18 plates)

Power One aegavart (heat)

Lattice 54 holes on 6 x9

Fectangular pattern

Moderator 40

Reflector 0 and graphite

Shielding HO, Lead, barytes concrete,

?and regular concrete

Cooling Primary loop ~ heat exchanger

Secondary loop - cooling tower

---Page Break---

FIGURE 1 PUERTO SiCo RTACTOR - FRCKT AKD SIDE ELEVATIONS

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Mater Purification

control

Irradiation Facilities

Operating Conditions:

Maxioum fuel plate

sheath tenperature

Primary water flow rate

Coolant inlet temperature

Coolant outlet temperature

core pressure drop

Secondary water flow rate

Secondary coolant inlet

temperature

Secondary coolant outlet

temperature

Demineralizer flow rate

|. EXPERIMENTAL FACILITIES.

The experimental facilities d

ation of materials while affording protection to personnel

Continuous demineralization of

a portion of the prinary flow

4 Boron-carbide shine

rods.

1 stainless steel regulating

rod

fery

6" beam tubes

8° beam tudes

Poeunaeic rabbits

?Thermal coluan

Dey gatma factlity

10°F

900 oP

00°F

107.6°F

1 pst

700 ceM

a6r

95.0°F

20 om

icribed below furnish means for

Embedded in the concrete walls of che stall area at core level

are the beam cubes

locations are sown in Figure 2.

doors and plugs afford access to the ex

tro pneumatic rabbit loops are provi

@ Tub

?two S-inch diameter and four 6-inch diameter beam tubes 1

ind a 4 by 9 foot thermal coluan. The respective

?At the outer pool surface, shielding

rimental units. In addition,

ace

4m horizontal planes outward from the reactor core. The basic tube

---Page Break---

wath WMG ~ ToOd

ae MBIA NVId

2.8:

---Page Break---

Assembly consists of an enbedded stainless steel sleeve, retractable slunisun Liner, and a set of interior shielding pluge of canned barytes concrete and lead. Provisions are nade for Fleading the beam tubes with devine sti: satate

(be) Paeumatic Babbécs.

This facility 4s « constant-exhaust system of concentric alvainun air Hines which carry a sample carrier or rabbit into the igh neutron flux areas at the core.

Automatic timing controls the period of irradiati revereal of the air valving. The exhaust air iz filtered and monitored before discharge to the atmosphere through a stack.

and

() Thermal Column,

The Thermal Column (Figure 3) is a stacked gr

lead asserbly for irradiation experiments with highly thermallzed

A steel and alumtnun chamber is cast integrally with the stall wall and the barytes shield at core level, This chenber is square and extends horfzontally fron the inside wall of the stall to the outer surface of the barytes shield. Forming « part of the embedaent is a circular vertical access chamber extending from the op of the shield downward to the horizontal chamber.

The inner surfaces of the chamber are Lined with boral sheet which reduces activation of the embednent and the adjacent concre Stacked within the boral liner for the length of the horizontal chame ber {4 a closely packed arrangement of graphite blocks.

Fastened over the outer face of the graphite stacking is 2 horal plate backed up by a lead block shield. A square opening in the shield 1s provided for the insertion of a lead plugs A lé-inch thick, 5'=6" square barytes concrete door covers the entire exposed area of the horizontal column at the face of the barytes shield.

Access to the thermal column vertical face is provided by means of

the overhead crane system, which opens the barytes concrete door-

The door 15 pinned against the vertical face by a safety lock bar at

the top of the doors A central square opening allows for the

introduction of a shielding plug. The smaller plug in the door and

in the inner lead shield permits the insertion of soall specimens

for irradiation experiments while the door {5 kept shut.

?The vertical portion of the thermal column is an air chanber

with the opening at the top of the barytes shield closed by « lead

plug and a concrete access cover. Both the cover and plug have

Lifting lugs to permit removal by the overhead service crane.

---Page Break---

"NWNM109 WWBHL- £ 3uNdId

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WHMSHL MUHL NOLLORS TWOILYBA

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A Lead and graphite assembly forms the portion of the thermal colunn between the rear face of the reactor core and the Soner vall of the stall. This assembly consists of an alusinum support frane bolted to the stall floor mounting pads. A lead shield is bolted to the front of the Frame imediately adjacent to the reactor core, and « graphite and lead can assenbly ts fastened directly behind the lead shields

() Gamma Room. (2)

?The Ganma Irradiation Room 1s an integral part of the Feactor pool structure and is adjacent to it at the first Level on the east side of the building. The room is a cube approximately ?six feet square. It has 2 tapering side that terminates in « four Foot square aluminum window (Figure 4). This window {3 the only Partition between the room and the reactor pool and it ts located at a depth of approximately twenty-seven fects

Access to the irradiation facility {s through a five foot thick high-density concrete door mounted ons railroad-type dolly which can be rolled back

performed by placing highly elenencs in a rack agjacent to the aluminum window. Any umber of fuel elements up to eight are placed in this rack, which can be moved by means of an. overhead crane. Removing the fuel elements toa distence of approxinately eighteen feet from the window will bring radiation exposure inside the genma facility below the permissible operational Tevel of 7.3 mr/hre

A factory-calibrated fonization chanber type detector connected to @ micro-microammeter and recorder is being used at, present. Since flux intensity varies according to the distance and Decause the chanber volume 1s fairly large (diameter 3", height 12") it 18 impossible to obtain an accurate meastrenent of the irradiation dose at a given point.

hore greater accuracy on simultaneously irradiated samples

1s desired, individual monitors aust be used. Gamma rey dose rates

from six fuel elenents after one day decay period are of the order

of 15 kilo-roentgen per hour at rero distane,

3. REACTOR DESIGN DATA,

(2) Introductions

The core described in this report is 4 30 element unit tn

4 6 x S array which contains 20 standard (18-plate) fuel elements,

5 partial (18-plate) fuel elenents, and 5 control (9-plate) fuel

elesents. This assortment permits adjustment of core excess

Feactivity by rearrangement of the standard ané partial fuel elenents

to compensate for U+235 burneup and for low cross section fission

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ANOAVT 4OOTS LNSW3SVE WOON YOLOVaY

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product poisoning.

The core has deen designated as core number LL,

with core ILA representing the stall end configuration and core Ii B

the open pool configuration

The fuel elenents for the PRNC reactor consist of 20%

enriched Us0g compound dispersed in powdered alusinun. The U=235 mass

per standard fuel elenent is 192 grams, the partial and control fuel

elenencs contain 96 grants

(b) Summary of Reactor Parameters.

TABLE 1

CoRE_cuakacteRistrcs

Type

Power Level (initial)

Power Density

Moderator

coolant

Reflector

Open Pool Posteton

Stall Position

Coolant Flow

Avg. At Across Elenent

cold Clean Crieteat

Mass (Core 11 A)

Operating U-235 Mase

Effective Prompt Neutron

Lifetine? (avg.)

Temperature Coefficient

Cave.)

Mass Coetfsetent (avg)

?Avg Thermal Neutron Flux

tn Fuel

4h the power

Heterogeneous thermal

1,000 kilowatts

208 kew/kg U-235

40

20

40

W,0, Lead and Graphite

900 cP?

7.6

4223.5 gre

4799.5 gre

6.0 x 107? sece

5.5 x 107° Brrr

5:25 10° BE) gran v235

12

5.2 x 10"? njen? see

mcursion calculations of the hasards analysis the

neutron lifetime is quoted as 6.1 x 10°) sec

applicable for the U-shaped core undi

?a value whieh is

lying the hazards analysis.

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Fuel Elenents

Number of Fuel Places

Standard Element

Partial Elesene

Control Elewent

Mas

0-235 per Elenent

Standard Elenent

Partial Elesene

Control Element

Number of Fuel Elenents in

Core

Standard Elements 20

Partial Elements 5

Control Elements 3

Gontrol Rode

Number 4 shtmcsatety rods plus

type wectleads plaviey fall

Absorbing Material

Shin-Sefety fod 240+ ca. Liner

Regulating Rod stainiess steel

Reactivity Worth

Sore A Gore 1B

751 OK

&

4 Shim-Safety Rods

+ 88 Oe + 098 A

Toca Wort sak sett a

wat Worth 74 «

Gore Kege (all rods fully inserted

cold clean condition)

Core 11 4 0.91

Core 11 B 0.95

---Page Break---

Experimental Facilities Reactivity Effect (Beam Tubes, air-filled ve water

?4 six-inch diameter beam tubes ~0.58% AK

1 graphite thermal column 10.856% AK

Reactivity ALlowancs

for 1 MW Operation

ae

Equtlibrive Xenon-135 1.40

Equilibrium Sanariun-149 190

Tenperature Effect 104

Experiments (other chan Beam Tubes) 100

Control 130

Us235 Burn-lp and Lew Cross Section

Fission Product Accumulation for 75 M¥D +30

Total oan gK

* This value (4.16%) is less than SO% of Shim Rod value

for core 11 A,

---Page Break---

TABLE 11

+ CORE TT A PARAMETERS.

(a) RATIO OF Og / Je (AVERAGE NEUTRON PLUK 1 t® ELEMENT

TO AVERAGE NEUTRON FLUX IN CORE) FOR DIFFERENT CORE

FO AEMGE NEUTRON FLUX IN CORE) FOR DIFFERENT CORE

PosrTi0Ns .

Position ¢ Hip, Posteson hy,

a 652 ot 77

- 785 2 1.687

3 318 3 1.310

4 +390 ?4 ats

~ 460 ? 002

873, et +390

2 1.000 2 1.063

3 1.496 a 1.523

? 922 4 902

+856 - to

996 Pa 140

~ 1584 2 902

?3 1.805 ~ +830

? Leu ? 834

= +808 352

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qaDLe 12

(>) THERMAL, NEUTRON PLUK AT VARIOUS DISTANCES FROM CORE

THERMAL NEUTRON FLUX AT VARIOUS DISTANCES FROM CORE.

NID FLANE EXTENDING OUTWARD IN A NORTH DIRECTION

?MID PLANE EXTENDING OUTWARD IN A NORTH DIRECTION

» (ea) 4 (open? see

° 5.016 x 101?

1 6.057

3 6.440

? 5.810

10 1.966

1s 7.058 x 10"?

20 2.m2

2s Lun

30 4.257 x 10"?

35 Lrse

38 Luis

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DISTANCE FROM CORE (em)

?CORE MID? PU

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Ac TIVATION on BRE Folis

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VATION ON BARE FILS

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BEAM TUBE No.2

Fuk pisthie

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18 24 30

DISTANCES IN INCHES FROM FACE OF BEAM TUBE,

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PicuRt 10 FLUX DISTRIBUTION CURVES FOR CORE IIA,

ae Ana Ana

? +785 ?-a18 ?* 590

VERTICAL SCALE, I UNIT= 2 IN., HORIZONTAL UNITS; ARBITRARY.

1) 3

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FLUX DISTRIBUTION CURVES FOR CORE 1A,

12 ae Y

if f

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Fic

FLUX DISTRIBUTION CURVES FOR CORE 114.

---Page Break---

FLUX

Fea

934

Fos

352

VERTICAL SCALE, i UNIT=2IN, HORIZONTAL UNITS; ARBITRARY,

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THERMAL NEUTRON FLUX x 108

10 is

DISTANCE FROM CENTER, INCHES

Fig.l4-FINAL FLUX DISTRIBUTION AT THE SURFACE OF THE VERTICAL ACCESS

POSITION, VOID IN GRAPHITE. (4)

---Page Break---

5. REACTOR SERVICE REQUESTS.

Persons requesting neutron irradiation service from the

factor Division must.

(a) FALL out one Radioisotope Production card for each set

of samples to be irradiated. (A set {3 understood te

be a group of identical samples irradiated simulea~
Beously.) A "Questionnaire for Reactor Experiment? must
be filled out and submitted to Wealth Physics Division (5)
for each new ?radiation. Use brief form for short,
irradiations.

(0) Deliver card and sample to Reactor Supervisor's office.
Note special instructions on reverse side of catde

Please use the following instructions when filling out
the card.

(1) Sample number - Identification mmber or code of
your sample,

(2) Date ~ bate when sample is submieee

(3) Flux of irradiations - neutron flux desired.

(4) Time in and time out - to be £illed in by Reactor
Division.

(5) Total time = desired irradiation time.

(6) Material and weight ~ specify composition and

Weight of cach sample to be irradiated:

(7) Activation cross section - cross section of material

to produce desired radioisotope,

(8) Hale 1ife - half 160 of desired radiotsocope.

(9) Gatcutaced activity - activity of desired radio=

isotope. Tn cases of activation analysis or when

impossible to make calculations please specify so

make a reasonable estimate,

(00) Expected activity - activity to be expected from all

materials irradiated. (This includes sample conteiners

carrier mterials or undesirable materials which suse

be irradiated with sample.)

WD) Originator + signature of Division Head or Progra

Director requesting irradiation, or his designated

representative,

---Page Break---

(02) Delivered to - sigeature of person to whom

Sample is delivered, This signeture will be

requested by a reactor superviser at the ciae

sample is delivered.

Except in eases in which the neutron irradiation is

4 repetition of # previous one "Questionnaire for

Reactor Experiment muse be filled out and sutmitced

to the Wealth Physics Division at the same time the

Nadiotsotope Production card is submited.

(@) When the service desized is other than a neutron

ircadiation, the "Questionnaire for Use of Irradiation

Facilities (other than Reactor)" qust be filled out

and submitted to the Health Physies Division-

---Page Break---

RADIATION SAFETY RULES.

?The Reactor Division has adopted six radiation safety rules concerning monitoring and shielding. These rules showld be taken into consideration when planning an experiments

(a) Monitoring «

(2) ALL experiments installed around the reactor facilities in the basenent at the present tine should be reviewed to determine the need for constant or intermittent neutron onitoring. All future experiments are to be reviewed for the Possible need of constant neutron conitorings

(2) Gamma onitors suitable for vear at oF near the bands shall be used when handling unshielded radioactive substances of the near-curie order.

(3) Audsbte signal gamma son{tors shall be used near ?operating areas where samples are Loaded or unloaded during an trradiation service. These monitors should produce @ signel which is easily related to radiation intensity (ege, Inereese in Signal rate or signal intensity).

(b) shielding.

(1) ALL samples whose activity 9 5 r/hr or more shall

be transfered to a lead container under at least two feet of water

Enough shielding shall be provided for use during the transportation

operation so thet radiation intensity does not exceed 200 wr/hr.

at contact.

(2) Samples whose radiation intensity 1s of the order

of 1-5 r/be shall be handied with a rencte handling tool Ceonge 3

feet long) during « transfer operation.

(3) Samples whose radiation intensity is below 1 r/hr.

shall be handled with congs at Least 18" long.

ton

A health physicist will gonitor the transportation ope:

at any tine the radiation intensity outside the lead shield (ae contact) is greater than SO mr/hr. Written peraistion shall be

obtained From H.P.D. when it is desired to remove a sample Eros

fhe reactor building whose expected radiation nt

200 wr/hr. outside the lead shield. The unloading, transfer aad

Eransportation operation shall be performed under the direce

supervision of a health physicist.

---Page Break---

» Specific Activity after

Intermittent Irradiation «

by MAN FLEGENHEIMER, Comisdn Nacional de Energia Atimica, Buenos ier Argentina

?end VIEHAK MARCUS, Israel Atomic Energy Comminion, Rehan, Tel

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?all irradiation periods (and constant Tete 1 @ aye factor 4/1 is equivalent to a

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made at several flux levels, one must irradiation. An. equivalent amount of 1 etmhen 6)

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Theory 1 thin quantity replaces the second 4¢.) unit t the left or tothe righ,

depending om whether ule

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{inHg 7 ae thos converte to factor

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thee is activation crn section jn ?sowmallted activity tems

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Fale Gee curve Dina) (ne A = 0168 se inate «aan spe fr ¢ he

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?ee (00 other conditions chung!) for, + @ tour 0.385 (ina ase eat ie >).

What «final spec activity?? (For 8. Repent stop 4 ©. Subeitte values in? Ea. 9

Nat) Tie = 15 bei for Na 2 = 068 0 Mark the ordinate ofthe D curve ?The vorinaind a-tnte ome

ar, = 105 for 4 Bs (net

?The solution to Probie constant "10D lkewian forall radiation @ = (1 ? e008 Mq-t a ws fa almost whats graphical am ly pera al coulng pt 8 $l Sesmenaneeana erie

?kta follows: 1H. Read the tnfirate the nor

Graphical Procedures constant g} malaot aciity for the last mark D. Find the vale of the Sit term

1. Espen inraation periods as mace. For prem thie valu is lating (00) an the @ curve

Su fo ant coking peo 8 oy a 022 ?au correcting for all saiarquent decay

tes in beth probe 8a = 030, "12, Caelate be from the known (18 ~ 6+ B+ Ox) on the D>

fu, 040, fis = 028 andr = 040). Aus. cromarctom, abundance and fH. Real the value oa the inc

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5 Mark the solinate af the Beurve be aimed separates ant then Ce St the toms (0280,

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8 Adiunt the origins of the tw» A Coopute the fax tartar. in (Al normal! wives. Por the

fects to rigee, then tute the Prsiem i thee ox = 1 ?eral problen tie 0280 x 297

transparent sheet horizontals, avi I. Deter the Boson the fax) 2B/EM

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Moy, 1962 - NUCLEONICS

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QUESTIONNAIRE FOR REACTOR EXPERLIENTS

What 18 the purpose of the experiment?

2. What division and 4:

reaent is sponsoring the experiment?

3, What neutron flux and/or ganaa flux 1s desired?

4, What will be the duration of the experiment prograa?

3s What will be the desired operating time for each irradiation?

©. What are the anounts and kinds of materials which vill be wtthin

the reactor? List both the physical materials and their elemental

breakdown,

What {9 the expected gross activity of the sample?

8 What are the recognized hazards associated with the experinent?

9. What will be the final disposition of the radioactive portions

of the experiment?

To ?Signature of Person

Completing Questionnaire

(Please use additional pages for answering the above questions,

but sign ehis ?and £111 tn the date, Return to Héctor

Barcelé, Head, Reactor Diviston)

---Page Break---

(QUESTIOMUAIRE FOR USE OF IRRADIATION FACILITIES (Other then Reactors)

2. Facility requested (underline those needed):

hot cells, gauna pool, fuel elenent gasa root, gamma field,

gama irradiation, special ect up.

2. Material to be irradiated

5. Radiation dose (s) to be UsedT

4. Approxinate total exposure tine

5. To be used fron %, SESE

Signature Supervisor

Date

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