AIMM

Association for Information and Image Management

1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910
301/587-8202

Centimeter

Inches

MANUFACTURED TO AIMM STANDARDS
BY APPLIED IMAGE, INC.

1 of 1

DECLASSIFIED

(CLASSIFICATION)

DOCUMENT NO.

HW-66300 PT2

SERIES AND COPY NO.

GENERAL ELECTRIC

HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

DATE

April 4, 1961

☒

RESTRICTED DATA
THIS DOCUMENT CONTAINS RESTRICTED DATA
DEFINED IN THE ATOMIC ENERGY ACT OF 1954
TRANSMITTAL OF DISCLOSURE OF
CONTENTS IN ANY MANNER TO AN UNAUTHORIZED
PERSON IS PROHIBITED.

TITLE

PRODUCTION TEST IP-350-C
E-N DEMONSTRATION LOAD AT H REACTOR
(PART II, FLATTENED ZONE STRIPED LOADING)

☐

OTHER OFFICIAL CLASSIFIED INFORMATION

THIS MATERIAL CONTAINS INFORMATION AFFECTING
THE NATIONAL DEFENSE OF THE UNITED STATES
WITHIN THE MEANING OF THE ESPIONAGE LAWS,
TITLE 18, U. S. C., SECS. 793 AND 794, THE TRANSMISSION OR REVELATION OF WHICH IN ANY MANNER
TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

AUTHOR

R. D. Carter

CIRCULATING COPY
RECEIVED 100D AREA

APR 24 1961

RETURN TO

TECHNICAL INFORMATION FILES

THIS DOCUMENT MUST BE KEPT UNATTENDED OR UNDER THE CLOSE SUPERVISION OF AN AUTHORIZED PERSON. NO UNAUTHORIZED PERSON MAY HAVE ACCESS
TO IT. WHEN NOT IN USE, IT MUST BE STORED IN AN APPROVED LOCKED REPOSITORY. WHEN APPROVED
GUARDED AND WHILE IT IS YOUR POSSESSION, UNTIL YOU HAVE OBTAINED A SIGNED RECEIPT FROM
CLASSIFIED FILES, IT IS YOUR RESPONSIBILITY TO KEEP IT AND ITS CONTENTS WITHIN THE LIMITS OF
THE SUBJECT AND FROM ANY UNAUTHORIZED PERSON. ITS TRANSMISSION, AND STORAGE AT YOUR
RESIDENCE IS PROHIBITED. IT IS NOT TO BE DUPLICATED. IF ADDITIONAL COPIES ARE REQUIRED,
OBTAIN THEM FROM THE ISSUING FILE. ALL PERSONS READING THIS DOCUMENT ARE REQUESTED
TO SIGN IN THE SPACE PROVIDED BELOW.

ROUTE TO:	PAYROLL NO.	LOCATION	FILES ROUTE DATE	SIGNATURE AND DATE
R. D. Carter	17352	17608	APR 24 1961	RDC 8-1363
P. D. Carter	17352	17608		

RECORD
COPY

Indefinite Retention

Disposal Date

Authority

Authority

DECLASSIFIED

54-3000-340 (3-57)

AEC-GE RICHLAND, WASH.

(CLASSIFICATION)

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

MASTER

DECLASSIFIED

HW-66300 PT2

DISTRIBUTION

1-2. AEC-HOO Attn: AT Gifford/RL Plum
3. ER Astley/GJ Rogers
4. RS Bell/SL Nelson/RJ Bursey
5. HE Berg
6. WA Blanton
7. RW Bown
8. JH Brown
9. ~~RD Carter~~
10. JCL Chatten
11. MA Clinton
12. DW Constable/JF Jaklevick
13. BR Cremer
14. EJ Filip
15. GC Fullmer
16. WD Gilbert
17. SM Graves
18. OH Greager
19. CN Gross/RG Clough
20. AK Hardin
21. AR Kosmata/RA Chitwood
22. LW Lang

23. AR Maguire/JW Baker/WJ Ferguson
24. DI Monnie
25. WS Nechodom
26. DE Newbrough/JH Ferguson
27. R. Nilson
28. GF Owsley
29. CA Priode
30. T. Prudich
31. RW Reid
32. WD Richmond/JT Baker/DS Lewis
33. OC Schroeder
34. HG Spencer/RR Bloomstrand
35. SL Stewart
36. JT Stringer
37. AP Vinther/IL Huffman
38. CD Wilkinson
39. 300 Files
40. Records Center
41. Extra

Classified By:

GC Fullmer~~RESTRICTED DATA~~

This document contains restricted data as defined in the Atomic Energy Act of 1954. Its transmission or disclosure to unauthorized persons is prohibited.

Classification Cancelled and Changed To

DECLASSIFIED

By Authority of WA SnyderCG-PR-2, 1-25-94By J E Savely 2-2-94Verified By J Mally 2-11-94PRODUCTION TEST IP-350-CE-N DEMONSTRATION LOAD AT H REACTORPART II, FLATTENED ZONE STRIPED LOADING

OBJECTIVE

The objective of this production test is to demonstrate the feasibility of a Hanford reactor operating economically as a plutonium-tritium producer to increase the over-all conversion ratio and diversify the useful product output.

This production test has been divided into two parts. The first part/1/ defines the loading of the fringe blanket. This document defines the second part, the loading of the central (flattened) zone with "striped" or E-N charges consisting of enriched uranium (E) pieces interspersed with lithium-aluminum (N) slugs.

/1/ HW-66300, Part I, Production Test IP-350-C, E-N Demonstration Load at H Reactor,
R. D. Carter, 3-22-61

DECLASSIFIED

DECLASSIFIED

HW-66300 PT2

Page -2-

BASIS AND JUSTIFICATION

Future production requirements may be such that the present product would at times assume a secondary role. It is desirable that HAPO prove that other irradiation products can be supplied on scheduled demand at a competitive cost. This has been shown to be possible from a theoretical and preliminary experimental standpoint./2,3/

Because of different types of charges and irradiation times this program has been divided into two separate and distinct loadings: a fringe blanket load and a central striped load. Since the blanket load requires two to three times the irradiation time of the striped load, with the blanket load charged earlier the two would still be irradiated together. The charging of the fringe load first will allow earlier initiation of the test and better reactivity matching. It is for this reason that the production test has been divided into two parts.

The irradiation of the E-N charges will include two metal cycles of three to four months each. Renewal of this charge for more than two metal cycles, if done, will be carried out as a standard operating practice within normal procedures for material allocation requests and production planning and not under the authority of this production test.

The reactivity matching which is necessary to permit both efficient reactor operation and adherence to total control requirements requires that the hot, or operating, pile reactivity of the E-N charged reactor be approximately the same as that for a reactor with a normal (natural uranium) loading at 200 to 250 MWD/T average pile exposure. This exposure in the natural load results in enough pile reactivity to permit optimum control rod patterns and enough excess to permit flux flattening with supplementary control; higher natural uranium exposures require more supplementary control but result in relatively smaller increases in flattening.

To determine that adequate reactivity is available in the hot reactor, and that the desired axial flux flattening is achieved, an initial group of 270 tubes will be charged with the intended E-N charge at least two operating weeks prior to the scheduled charging of the remainder of the flattened zone. The change in hot pile reactivity may then be measured, and any necessary changes in the makeup of the remainder of the E-N charges will be specified prior to charging the rest of the E-N charges.

TEST DETAILS

1. General

The test involves the irradiation of lithium-aluminum (N) material. Since this material is a neutron absorber it is necessary that large quantities of enriched uranium be charged simultaneously to provide reactivity compensation in the reactor in a geometry which will permit optimum operating control. When the pile is charged for the complete test, its loading will consist entirely of lithium-aluminum and enriched uranium except for natural uranium mixing slugs and possibly other neutron absorbers in PCCF tubes. The test can be separated into two distinct parts but the entire irradiation of the striped central charge should be concurrent with the major portion of the irradiation of the blanket load in order to minimize metal loss from reactivity adjustments and to provide operating data for this type of loading. There will be two metal cycles of

/2/ HW-68184, E-N and Blanket Conversion from Analysis of Tubes Irradiated at H, L.W. Lang and W.S. Nechodom, 2-19-61.

/3/ HW-66999, E-N Economics, R.R. Bloomstrand, 9-22-60

the striped load and one of the blanket layer; supporting enrichment for the blanket layer will require several cycles in the higher power enrichment columns.

A group of 270 tubes in a block 18 lattice units high by 15 lattice units wide will be charged as a representative E-N section with minor modifications at least two operating weeks prior to the scheduled charging of the remainder of the first E-N flattened zone block. These tubes will represent about 18 percent of the total pile reactivity weighting of the active metal and about 25 percent of the E-N reactivity weighting. The reactivity changes due to long-term reactivity gains in the remaining natural uranium will be relatively small this close to goal exposure; any change in the operating reactivity will be almost entirely due to the 270-tube block. Analysis of these changes will permit, if necessary, modification of tube charges in the rest of the E-N tubes and reduce the possibility of poor operation caused by non-optimum pile reactivity. In addition flux traverses will be made, preferably by the poison spline method, to determine the axial flux shape. If necessary, adjustment of N-piece locations in the remaining E-N tubes will then follow.

After two operating weeks, the reactor will be shut down for the discharge of the remaining flattened zone tubes and recharged with E-N. Following the irradiation of the entire central loading of E-N tubes to goal exposure, a second block of E-N tubes will be charged. The E-N charges in this second block of tubes may be further modified for improved operating efficiency based upon data obtained from the initial fuel loading.

2. Loading

a. Blanket Load

The loading for the blanket load was described in Part I of this production test^{7/4/}; it will consist of the outermost pile lattice unit tubes filled with lithium-aluminum, supported by enrichment in the second and third lattice units. E metal in the 4th, 5th, and 6th lattice units will continue to support the central flattened zone at approximately its present diameter.

b. Striped Load

The E-N or striped load will consist of .947 percent enriched uranium (E metal) slugs of six inch nominal length interspersed with the proper number of I&E lithium-aluminum (N) pieces. 3.1 w/o enriched lithium (38.5 percent lithium 6) of four inch nominal length, to obtain the desired pile reactivity conditions. At present, the projected load consists of 40 pieces of E metal and 3 N pieces plus one natural uranium mixer piece in 80 percent of the tubes and 39 E pieces and 4 N pieces plus one natural uranium mixer piece in 20 percent of the tubes. The particular charge makeup, with deliberately staggered geometry, will be specified to H Processing prior to the charging of the E-N load. This loading, however, may be changed at the discretion of the Operational Physics Sub-Section by written notification to the H Processing Manager if subsequent data indicates the need.

Bumper fuel elements may be used in any reactor section in which they appear advantageous.

The N pieces will be spaced initially in each tube such that a number of tubes summed together will show a "smeared" poison distribution with slightly more poison in the center of the reactor than in the ends in a ratio of 1.2 to 1. Weighting of the center with poison will result in a flattened axial flux distribution and thus reduced rupture potential. Operating experience with the initial 270-tube block may indicate modifications in the rest of the first set of charge makeups and further modifications may be required with the second complete loading.

Distribution of poison in the E-N charges will be such that minimum variations in tube power and reactivity will be experienced.

The charging pattern for the E-N load, unless modified prior to charging, is shown in Figure 1. Each variation of the E-N charge is marked with a code number 1 through 5. In order to simplify the charging problem, only two different types of charge makeups have been specified on each row; the pattern repeats every fifth row. The five different charges are lumped together as closely as possible, thus "smearing" the poison charge uniformly over as small an area as possible. The E-N charges, approximately equal in length to natural charges, will use the same standard downstream dummy pattern (SDSDP) as is now used for 32-piece natural uranium charges. The individual charge makeups are:

Code No.	Charge Makeup - Rear-to-Front
1	SDSDP; 2-E; 1-N; 9-E; 1-Mixer; 2-E; 1-N; 12-E; 1-N; 12-E; 1-N; 2-E
2	SDSDP; 4-E; 1-N; 8-E; 1-Mixer; 4-E; 1-N; 13-E; 1-N; 11-E
3	SDSDP; 7-E; 1-N; 5-E; 1-Mixer; 7-E; 1-N; 13-E; 1-N; 8-E
4	SDSDP; 9-E; 1-N; 3-E; 1-Mixer; 9-E 1-N; 13-E; 1-N; 6-E
5	SDSDP; 11-E; 1-N; 2-E; 1-Mixer; 11-E; 1-N; 13-E; 1-N; 3-E

c. Control Charges

Conversion ratio data for the E-N load has been obtained from a previous small scale experiment in the H Reactor^{/5/}. The full-scale E-N load will allow a refinement of this data on a large scale without perturbations caused by operation with the normal reactor loading.

Tritium yield measurements will normally be accomplished by extraction of large portions of the reactor loading to preserve the operating efficiency of the extraction plants. However, in order to assure early availability of data representative of the full-scale loading it appears prudent to provide also for small-scale yield analyses.

On this basis four fringe Li-Al charges (tubes 0164, 0180, 2151 and 3296) will be charged with numbered N pieces identified as to both tube and piece, lowest numbered piece downstream. The location of other special pickup tubes will be selected at the discretion of Process and Reactor Development to meet the requirements of the table below.

/5/ HW-60340, Production Test IP-255-A-9-FP, E-N Demonstration Test, R.E. Hall and W.S. Nechodom, 5-8-59.

Table I. Special Pickup Charges Required for Isotope Measurements

A. With Natural Center and Fringe Load

<u>Type Metal</u>	<u>Location</u>	<u>No. Batches</u>	<u>Tubes/Batch</u>	<u>No. of Exposures</u>	<u>Total Tubes</u>
Solid Natural U	1st L.U.	3	6	1	18
I&E Natural U	2nd L.U.	3	6	1	18
I&E Natural U	3rd L.U.	3	6	1	18
I&E Enriched U	4 & 5 L.U.	3	8	1	24

B. During E-N Irradiation

and 1962 Boll	1st L.U.	4	1	1	4
3 mar 3 and 4 1962 I&E Enriched U	2nd L.U.	6	8	2	48
" " "	3rd L.U.	3	8	1	24
" " "	4 & 5 L.U.	3	8	1	24
" " "	6th L.U.	3	8	1	24
3 and 4 1962 E-N	Flat Zone	6	8	2	48

C. After Discharge of E-N Core

and 1962 I&E Enriched U	6th L.U.	3	8	1	24
and 1962 I&E Natural U	6 or 7 L.U.	3	6	1	18

3. Charging

Charging of the fringe blanket loading should be effectively completed about one month prior to the E-N loading. Charging details for the fringe blanket load have been specified in HW-66300 Part I. 16/

Charging of the striped (E-N) loading will begin two operating weeks prior to the scheduled shutdown for a block discharge. A block of tubes 18 tubes high by 15 tubes wide (270 tubes total) will be charged in order to provide hot-reactivity data. The remaining tubes will be charged during the scheduled block outage. Information obtained from operation with the 270 tube block may result in modification of the charge makeups of the remaining E-N charges. Each tube within the 270 tube zone (outlined in Fig. 1) will be charged with a specified E-N charge except PCCF and other inactive tubes and several tubes which will be left charged natural uranium until the rest of the E-N loading is charged. These latter tubes will be used for final reactivity adjustment of the 270 tube zone and are tubes 1771, 1778, 2077, 2479, 2568, 2572, 2971, and 3078.

Reactivity changes due to loading the 270 tube block should be equal to about one milli-k loss after samarium saturation and after adjustment for the poison previously necessary in the natural uranium load in that region prior to discharge. If the region contained one mk of poison prior to the natural uranium discharge, the reactivity change should be negligible; if two milli-k, a one milli-k gain should result, etc.

This first complete group of E-N tubes will be discharged together and the second block of E-N charges will then be charged together. The charge makeups of the second E-N block may be further modified if operation with the first block indicates the need.

DECLASSIFIED

HW-66300 PT2

Page -6-

The charge makeups for the first block will be such that an excess reactivity will be "built-in" to the reactor to accommodate long-term reactivity losses which are expected to occur with the E-N loading. This excess reactivity will be compensated initially by 10 N charges containing 13 I&E N pieces of four inch nominal-length centered in the tube and charged in PCCF tubes. If the reactivity decreases as expected, the poison value of these tubes will be reduced as needed until they operate normally as dummy columns.

The E-N loading will be defined by the seventh lattice unit in from the outer edge of the reactor. The sixth lattice unit will be used for final reactivity adjustment of the fringe poison.

Discharge of E-N charges prior to goal and recharging with other charges will be permitted to maintain a proper reactivity balance.

SUPPLEMENTAL CONTROL

The supplemental control requirements will not be affected by the blanket load. The following comments on supplemental control are related to the striped core requirements.

The full 24-tube PCCF system should be retained. Requirements of PCCF tube locations in the striped loading should not vary initially from present planning with the natural load; any adjustments made should be made following operating experience with the full E-N load.

To minimize losses from lack of familiarity with the reactivity transients of the E-N load and the removal of 10 PCCF tubes from service for use as N tubes (except on startups), H Reactor has been recommended for priority in obtaining the spline coiler. It is expected that a fully operating spline system will be in use prior to the charging of the E-N core. In addition, splines will be desirable for taking flux traverses during operation.

GOAL EXPOSURE

Adjustments to the goal exposures of the various charges, to take advantage of the special conditions existing with the full fringe poison loading authorized herein, will be made through normal manufacturing and technical assistance channels.

GRAPHITE TEMPERATURES AND HELIUM USAGE

Tube powers approximately 8 percent above present natural uranium columns and average specific powers up to 13 percent above present natural uranium average specific powers are expected with this loading. However, since the longitudinal flux is expected to be "depeaked" 10 to 12 percent it is not believed that maximum graphite temperatures will vary significantly from those presently experienced (however, the average graphite temperature in the axially-flattened E-N loading should be higher at a given helium concentration). No major change in helium concentration is therefore expected and there should be no appreciable change in helium requirements. Even if attempts to "depeak" the axial flux were to fail completely, there would be an estimated increase in H Reactor helium concentration and therefore in helium usage of only about 12 percent.

SPECIAL INSTRUMENTATION

To aid in determining optimum charge makeups the spline flux traverse equipment should be available for use at H Reactor.

DECLASSIFIED

HW-66300 PT2

Page 7

REACTOR MODIFICATIONS

No reactor modifications specifically required by the charging of the striped loading is necessary. Although special types of fuel elements (bumper slugs) are being timed in preparation for this loading, the necessary reactor nozzle modifications are not specified in this production test. Modifications which may be permitted with the fringe blanket load are covered in HW-66300.

DISCHARGE

Discharge of E-N and fringe blanket tubes and subsequent handling procedures must meet Process Standards H-020 and C-13C.02.

REACTOR

H Reactor has been selected for this loading on the basis of balance among factors of control capacity, incentive for fringe poisoning, and effects of other current and expected reactor development programs.

TUBE POWER RECOMMENDATIONS

Maximum recommended tube powers will be based initially upon present operating experience and special conditions existing with the E-N load. Such recommendations will be made through normal manufacturing and technical channels.

Operation with the 270-tube block will include both E-N tubes and natural uranium charges operating in approximately the same flux. The E-N columns should operate at approximately 10 percent higher power than adjacent natural uranium charges. However, it is expected that the E-N charges will "depeak" the maximum flux by about 10 percent. On this basis, the limiting tube power for the E-N charges in the 270-tube block will be 10 percent higher than that for the natural uranium charges during the estimated two-week interval prior to completion of the first E-N block charge.

HAZARDS

Startup reactivity with the full E-N loading will be much higher than for the present loading. For this reason all poison required for equilibrium (N charges in PCCF columns and other N columns) will be charged prior to the charging of any E and E-N columns. (Except PCCF columns to be charged 13 Li-Al at equilibrium may be required to be charged 37 Pb-Cd for startup.) In addition, PCCF tube Pb-Cd charges required for total control and startup control purposes will be charged prior to charging E-N charges. The timing for the insertion of splines required for total control purposes will be specified by the H Reactor physicist. Total control and speed of control requirements for this loading have previously been evaluated^{7,8} and have been reviewed with the Advisory Committee on Reactor Safeguards.

Hazards associated with the fringe blanket loading are covered in HW-66300 Part I.

The number of enriched pieces allowed in the basin at one time is defined by Process Standard H-020. Any relaxations in geometry or pickup schemes resulting from equipment and procedure development must be authorized by approved Process Standards revisions.

^{7/7} HW-55704, Full Reactor E-N Load Nuclear Hazards Review, W.E. Niemuth and G.F. Owsley, April 11, 1958.

^{/8/} HW-68250, Total Control Aspects of Fringe Poison Loadings, A.D. Vaughn, January 26, 1961

DECLASSIFIED

HW-66300 PT2
Page -8-

COSTS

Incremental costs and metal throughput estimates for this loading have been itemized in HW-66999/9/. The following items have a direct bearing on operational scheduling:

Downtime

Incremental effect of charging the 270-tube block in advance of the remainder of the block 27 Hours*

Extra pickup time of special charges for isotope yield studies

During and prior to first block load	<u>13</u>	Hours
During remainder of the loading	<u>10</u>	Hours

Special flux traverses .	<u>None</u>	Hours
--------------------------	-------------	-------

Special reactivity measurements .	<u>None</u>	Hours
-----------------------------------	-------------	-------

Operating Efficiency

Estimated effect of 270-tube block on level-operated-efficiency during two-week period.

negligible %

*Including a scheduled outage and startup loss of 7 equivalent hours.

RESPONSIBILITIES

Research and Engineering Section

Process Technology Sub-Section shall be responsible for assistance in charging of the test, determining operating limits, and for interpreting rupture data and providing fuel exposure recommendations.

Process and Reactor Development Sub-Section shall be responsible for assisting in selection of the charge makeup and all modifications of same, and for requesting and obtaining any product formation data from special tubes.

Operational Physics Sub-Section shall be responsible for determining requirements for startup control and equilibrium flattening, determining the amount and location of compensating enrichment, determining the front-to-rear flux distribution, coordinating the test, including special numbered charges, and for analyzing and publishing the final report of production test.

Component Testing Sub-Section shall be responsible for post irradiation examination of selected charges.

DECLASSIFIED

RESPONSIBILITIES (Cont'd.)

Manufacturing Operation

H Reactor Operation will be responsible for the operational safety and production continuity of the reactor, planning and scheduling of the test, and the collection of routine operating data.

Production Operation will be responsible for liaison with Fuel Preparation Department to fulfill material quality and quantity requirements, for normal scheduling of charge-discharge, for proper scheduling of the initial loadings consistent with operating and physics requirements to minimize metal losses.

R. D. Carter

Operational Physics Sub-Section
Research and Engineering Section
IRRADIATION PROCESSING DEPARTMENT

RD Carter:gs

Figure I

DECLASSIFIED

HM-66300 PT2

Page -10-

- ☐ PCCF
- ☐ 270 Tube Block
- ☐ LE-A1
- ☐ Tubes for final reactivity adjustment.

☐ Left natural uranium for original 270-tube block.

E-N loadings are shown by numbers, graphite stringers by G, air channels by A, blank tubes are E metal.

DECLASSIFIED

H.C. Fullmer

Manager, Operational Physics Sub-Section
Research and Engineering Section
Irradiation Processing Department

J. Brown

Manager, Process and Reactor Development
Sub-Section
Research and Engineering Section
Irradiation Processing Department

R. M. Reil

Manager, Process Technology Sub-Section
Research and Engineering Section
Irradiation Processing Department

A. P. Vint

Manager, H Processing Operation
Manufacturing Section
Irradiation Processing Department

R. Rogers

Acting Manager
Applied Reactor Engineering Operation
Manufacturing Section

O. H. Greager

Manager, Research and Engineering Section
Irradiation Processing Department

E. J. Filip

Manager, H Reactor Operation
Manufacturing Section
Irradiation Processing Department

A. B. [Signature]

Manager, Production Operation
Manufacturing Section
Irradiation Processing Department

O. Schmauder

Manager, Manufacturing Section
Irradiation Processing Department

DATE

FILMED

8/9/94

END