AIM

Association for Information and Image Management

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

Centimeter

Inches

MANUFACTURED TO AIM STANDARDS
BY APPLIED IMAGE, INC.

1 of 1

(CLASSIFICATION)

DECLASSIFIED

DOCUMENT NO.

HW-77946

SERIES AND COPY NO.

GENERAL ELECTRIC

HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

DATE

6-19-63

☒ XX

THIS DOCUMENT CONTAINS UNCLASSIFIED DATA DEFINED IN ITS TRANSMISSION OF THE DEVELOPMENT OF ITS CONTENTS IN ANY MANNER BY AN UNAUTHORIZED PERSON IS PROHIBITED.

TITLE

STUDY OF HANFORD PRODUCTION CAPABILITY THROUGH FISCAL YEAR 1973

☐

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

A. B. Greninger

CIRCULATING COPY
RECEIVED 700 AREA
JUN 20 1963
RETURN TO
TECHNICAL INFORMATION DIVISION

THIS DOCUMENT MUST NOT BE LOANED OUT OR WHERE AN UNAUTHORIZED PERSON MAY HAVE ACCESS TO IT. IT MUST NOT BE STORED IN AN APPROVED LOCKED POSITION WITHIN AN APPROVED GUARD AREA. IT IS YOUR RESPONSIBILITY TO KEEP IT AND ITS CONTENTS WITHIN THE COMPLETION OF THE PROJECT FROM UNAUTHORIZED PERSONS. ITS TRANSMISSION AND STORAGE AT YOUR PLACE OF BUSINESS IS PROHIBITED. IT IS NOT TO BE REPRODUCED OR REPRODUCED IN ANY MANNER. IT IS YOUR RESPONSIBILITY TO RETURN IT TO THE ISSUING OFFICE. ALL INFORMATION RELATING TO THIS DOCUMENT IS REQUESTED TO BE KEPT IN THE SPACE PROVIDED BELOW.

ROUTE TO:

PAYROLL NO.

LOCATION

FILE ROUTE
DATE

SIGNATURE AND DATE

SEP 5 63

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

(CLASSIFICATION)

DECLASSIFIED

DECLASSIFIED

HW-77946

Page 1

This document contains restricted data as defined in the Atomic Energy Act of 1954. Its transmission or the disclosure of its contents in any manner to an unauthorized person is prohibited.

This document consists of 10 pages.

STUDY OF HANFORD PRODUCTION CAPABILITY
THROUGH FISCAL YEAR 1973

June 19, 1963

HANFORD ATOMIC PRODUCT OPERATION
RICHLAND, WASHINGTON

Classification Cancelled and Changed To

DECLASSIFIED

By Authority of SE Gydese,
CG-PR-2, PR-24, 3-30-94
By DK Hanson, 4-15-94
Verified By Jenni Maley,
4-18-94

APPROVED:

AS. Geringer

General Manager

IRRADIATION PROCESSING DEPARTMENT

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

NOTICE

This report was prepared for use within General Electric Company in the course of work under Atomic Energy Commission Contract AT(45-1) - 1350, and any views or opinions expressed in the report are those of the author only. This report is subject to revision upon collection of additional data.

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission or his assignment with such contractor.

DECLASSIFIED

D I S T R I B U T I O N

- 1 - 8. AEC-HLOO: Attn: J. E. Travis
- 9. R. L. Dickeman
- 10. O. H. Greager
- 11. A. B. Greninger
- 12. W. E. Johnson
- 13. H. M. Parker
- 14. P. H. Reinker
- 15. O. C. Schroeder
- 16. S. H. Small
- 17. 300 Files
- 18. Records Center
- 19 - 27. Extra

DECLASSIFIED

T A B L E O F C O N T E N T S

	<u>Page</u>
I. INTRODUCTION	4
II. PRODUCTION FORECAST	4
III. POSSIBLE INCREMENTAL PRODUCTION WITH PLANT IMPROVEMENTS	5
IV. ESTIMATE OF OUR ASSURANCE OF PRODUCTION CAPABILITY	6
A. Fuel Element Performance	6
B. Bulk Outlet Temperature Limits	7
C. Graphite	7
D. Aluminum Process Tube Corrosion	8
E. Reactor Shields	9
F. E-N Loading	9
G. Accidents	9
H. Conclusions	10

DECLASSIFIED

I. INTRODUCTION

A letter dated June 3, 1963 to W. E. Johnson, General Manager, Hanford Atomic Products Operation, from J. E. Travis, Manager, Richland Operations Office requested an updated study on the expected life of existing production reactors similar to Sections II, III and IV of document HW-59000(1). This study covers the ten year period to FY 1973 as the previous study document covered the ten year period FY 1958 to FY 1968.

In Section II, production has been forecast for the existing plant with no improvements beyond the current program for installation of zirconium process tubes in the K Reactors. Section III contains estimates of additional production from the six smaller reactors made possible through overboring the process channels and retubing with zirconium plus the associated water plant expansions. Section IV presents our analysis of the assurance which can reasonably be assigned to the predictions of Sections II and III. The production forecasts have been prepared from the same base as the current production studies and have been developed within the technical limits listed later in the report.

II. PRODUCTION FORECAST

Actual production for FY 1962 and forecasted production for the ten year period beginning with FY 1963 are shown in Table I.

TABLE I

Forecasted Production for Existing Plants
Input Production - Kgs of Plutonium

FY 1962 -	4,238	FY 1968 -	4,780
FY 1963 -	4,226	FY 1969 -	4,780
FY 1964 -	4,220	FY 1970 -	4,780
FY 1965 -	4,780	FY 1971 -	4,780
FY 1966 -	4,780	FY 1972 -	4,780
FY 1967 -	4,780		

The following assumptions have been used here and in the case covered in Section III.

Assumed:

1. Existing power level restrictions (imposed following ACRS letter of January, 1958 and amended in January, 1959 and January, 1961) will be removed at an early date.

(1) Greninger, A. B., Study of Hanford Production Capability Through Fiscal Year 1968, HW-59000, Dated 11-24-58, (Secret).

DECLASSIFIED

2. Plant maintenance and operation expense, and development expense, will be funded as necessary.
3. Fuel exposure levels will be determined by product specification.
4. Except for minor irradiation services and tests, all production capacity will be devoted to the production of plutonium.

General scheduling and planning bases which enter into the forecasted values in Table I are as follows: Mass replacement of aluminum tubes during FY 1962 and FY 1963, and installation of zirconium tubes at the K Reactors in FY 1963 and FY 1964 result in uniformly depressed production for these three years. Therefore, in FY 1965 production will rise to the steady-state yearly basis primarily through restoring the K Reactors to full capability. This steady-state yearly production is expected to continue throughout the remainder of the ten year period.

No major plant improvements to provide increased production are considered here, beyond completion of zirconium tube replacement at the K Reactors. Minor production improvements which may be realized are considered to be compensated by changing maintenance requirements associated with the increasing age of the reactors. The primary limiting factors on power levels over the ten year period are assumed to be the bulk outlet water temperature limits, 95 C at the K and C Reactors, and 93.5 C at the five smaller reactors, and graphite temperature limits at the K Reactors in the winter season. Fuel element planning is on the basis of an aluminum-clad metallic element exposed to an average of about 650 MWD/T. Continued availability and use of uranium enriched to 0.95 per cent U-235 to supplement pile reactivity is reflected in the production figures.

III. POSSIBLE INCREMENTAL PRODUCTION WITH PLANT IMPROVEMENTS

A 47 per cent increment of production capacity as compared with FY 1962 is possible by a combination of the following plant improvements.

- A. Overboring of tube channels in the six smaller reactors.
- B. Installation of zirconium tubes in the overbored channels.
- C. Expansion of the six smaller water plants.

Assuming 20-week outages at each reactor to accomplish the improvements, with the first outage beginning in the last half of FY 1965, steady-state production would be achieved in FY 1969. Based on FY 1962 actual production, the production in the intervening years would be: FY 1965 - 108%, FY 1966 - 116%, FY 1967 - 126%, and FY 1968 - 145%. Production for each fiscal year, 1969 through 1972, would be about 147 per cent of FY 1962 actual production.

DECLASSIFIED

IV. ESTIMATE OF OUR ASSURANCE OF PRODUCTION CAPABILITY

In assessing our production capability including our estimate of assurance, the technological problems facing the reactors, their severity and their potential for timely solutions are pointed out. A review of the reliability and patterns of HAPO forecasting does not appear appropriate other than to note, 1) during the first five years of the ten year forecast in the reference document(1), HAPO production forecasts were exceeded by 5-1/2 per cent, and 2) it is interesting to mention that the case of the overbored smaller reactors would put HAPO production back on the growth curve of the reference document(1) for FY 1968.

A. Fuel Element Performance

Fuel performance is no longer a limit to power levels and production at the Hanford reactors. The superior fuel element failure characteristics of the internally and externally cooled (I&E) fuel element and improved fabrication techniques and quality control have reduced production losses from ruptures to a relatively low level. Irradiation experience with smooth elements in ribbed aluminum tubes and more recently with self-supported elements in smooth-bore zirconium tubes at the K Reactors supports this conclusion. Fuel quality, as determined from rupture rate - operational severity correlations, has improved by a factor of about 75 since 1958; increases in operational severity during this period were substantially less. Extrapolating to anticipate operational severity levels it is determined that present fuel quality with the current product specification will not limit operation.

The I&E fuel element has essentially eliminated the cleavage failures associated with solid fuels, and corrosion failures have been minimized by fuel element and process tube geometry refinements designed to minimize misalignment and assure optimum coolant distribution around the periphery of the fuel elements. The reduction of process cooling water pH to 6.6 will further reduce fuel jacket corrosion failures. Specific tests and irradiations under the more severe reactor conditions representative of those postulated in this report support the expectation that fuel element failures will remain at a relatively low frequency. Substantial improvements currently being developed and effected in fabrication and quality control will result in further fuel quality improvements.

The 40 tube small-scale overbore test facility at the C Reactor has been in operation about two and one-half years. The favorable fuel element performance confirms that ruptures would not be a serious problem in an overbored reactor. The operational severity in the test facility is considerably higher than that expected under full reactor operating conditions; both specific power and discharge exposures are 20 to 30 per cent greater in the test facility which substantiates the favorable fuel performance prediction for the full reactor overbore.

DECLASSIFIED

B. Bulk Outlet Temperature Limits

The bulk outlet temperature limits are not expected to change from the present 93 - 95 C range. A bulk outlet temperature limit is required because the Hanford reactor effluent piping systems are not designed for pressures of more than a few pounds, and damage could result to the system if saturation temperatures were more than slightly exceeded. Operation is carried out at a point established as conservatively below saturation temperature because of the potential small temperature surges which would result from loss of BPA power, pump failure, or possible inadvertent reactivity insertion. The bulk effluent temperature limit will be the principal technological limit to reactor power levels for the six smaller reactors throughout the forecast period. In the K Reactors, however, the forecast is based on graphite temperature limits in the winter season and bulk temperature limits the remainder of the year.

C. Graphite

Increasing distortion of the graphite stack, due primarily to contraction, has been a problem during the past five years as indicated in the reference document(1), and is expected to continue to reflect in control rod and tube channel maintenance problems during the next ten years. Contraction of the graphite stacks is progressing at a rate which is nearly proportional to the reactor power levels and is resulting in distortion of the channels through the stack as well as breakage and slipping of blocks into channels. Process channel distortions eventually result in tube bending sufficiently severe that regular sized fuel cannot be charged into the tubes. Shorter fuel elements are now used in a limited number of upper tube rows at some of the smaller reactors. However, a graphite channel broaching operation in conjunction with required tube replacement from corrosion considerations partially restores the channel alignment such that fuel charging is no longer a major problem. Channel drilling with the zirconium tube program at the K Reactors assures that the zirconium tubes will have at least a ten year life before curvature interferes with fuel charging.

A thorough laboratory program coupled with extensive monitoring of distortion has characterized the mechanism of graphite dimensional changes sufficiently well that prediction of maximum gross stack distortion can be made with a reasonable level of confidence. Although all planning is based on a continuation of this linear rate, recent data from small graphite test samples irradiated to high exposures in the GETR indicate that a slower rate might become evident about 1966 to 1968.

During the past two years distortion coupled with breaking and slipping of the graphite blocks has restricted movement of some of the safety and control rods in their channels. Several permanent solutions are being examined for application to this problem. Meanwhile safety rod operability is being maintained satisfactorily through replacement of solid rods with flexible "knuckle" rods and treatment of the channels to restore sufficient clearance and alignment. Various combinations of techniques currently

DECLASSIFIED

under investigation for a more efficient long term solution to safety channel damage include the following: sleeving part or all of the channels to restrict graphite movement, improving drilling techniques to correct distortion on a routine maintenance basis, and using smaller rods as might be permitted by making other changes which would reduce the strength requirements necessary to meet the safety criteria.

Control rod problems are less serious than the safety rod problems because the strength and operability requirements are less stringent. Thus, channel drilling and procurement of smaller and more flexible control rods is believed to provide a satisfactory long term solution. To conclude, it appears that maintenance and engineering development work will be required to maintain the process channels and the safety and control systems with the continuing graphite contraction; however, experience with drilling techniques and the progress of the current development work assures that the distortion problem can be controlled without undue effect on costs and operating efficiency.

The second graphite life consideration is to assure that the lattice maintains sufficient structural strength over the required reactor life. Principally this requires that graphite oxidation be maintained at a very low rate. The oxidation rate is controlled through minimization of the amount of air and water which enters the reactor, and through regulation of the temperature of the graphite; this latter factor strongly affects the rate at which the oxidation takes place. Although graphite temperature limits with minimum attained rates of oxygen introduction should not limit power levels at the smaller reactors, the K Reactor power levels will be limited to levels slightly above the current administrative limit. An extensive laboratory and monitoring program is in progress to better characterize quantitatively the in-reactor oxidation rates in relation to water vapor, graphite reaction at high temperature, and the effect of burnout on the structural integrity of the lattice. Also improved operating techniques are being developed to obtain an assured lower concentration of air and water vapor in the inlet reactor gas, and thus permit increased graphite temperatures.

D. Aluminum Process Tube Corrosion

The most important problem occurring since the first forecast report has been that of aluminum process tube corrosion. Increased process tube leaks and higher tube replacement frequency requirements at the smaller reactors since early 1961, when power levels reached new highs, markedly reduced operating efficiency and raised costs. However, an aggressive tube replacement program during the past two years, heavily supported by engineering effort to improve equipment and techniques, has reduced tube leaks to a low level. Improvements resulting from a concurrent developmental program for reducing tube corrosion have increased the expected mean aluminum tube life from a low of less than two years to greater than four years for reactors operating on bulk outlet temperature limits. The principal improvements have resulted from careful control of the coolant distribution in the process tube channel (closer specifications on process tube dimensions and use of water mixing elements in the fuel charge) and lowering of the

RECEIVED

coolant pH from 7.0 to 6.6. On this new basis the smaller reactors will undergo central zone tube replacement two times during the ten year period unless retubed with zirconium.

In the K Reactors, the tube corrosion problem is being permanently resolved by replacement of most central zone aluminum tubes with zirconium tubes before leak difficulties appear. This replacement, started in 1963, will be completed early in 1964 at both K Reactors. Channel renovation in conjunction with the zirconium tube installation will assure a ten year tube life before continued channel bowing from graphite contraction would prevent normal size fuel in more than a very few tubes.

E. Reactor Shields

The four-foot thick biological shields of the smaller reactors (C Reactor excepted) are constructed of alternate layers of iron and masonite. On the basis of seven years of experience obtained from careful monitoring of the biological shield temperatures, the shield leakage rates during the ten year period of this forecast are not expected to be a problem. The originally expected deterioration rates have been largely alleviated by the charging of isotope-producing poison elements in selected fringe columns. Economic extension of fringe-poison methods already in use would compensate potential increases in shield deterioration following reactor improvement modifications such as overboring.

The iron-masonite biological side shields at C Reactor, the concrete top shield at C Reactor, and the concrete biological shield surrounding the K Reactors are supplied with coolant tubes which preclude the necessity of special measures to limit heat damage.

F. E-N Loading

This fuel and target loading for the simultaneous production of both tritium and plutonium is continuing at H Reactor. The striped core loading is surrounded by the normal E-metal flattening ring and a fringe poison layer. Incremental effects of this loading on component irradiation severity relative to natural uranium loadings are nominal. These incremental amounts of increased irradiation severity within the core region, partially off-set by decreased severity in the reactor fringe, would not be sufficient to alter the conclusion stated for normal loadings - namely, that the reactor components will provide adequate serviceability throughout the ten year period of this forecast.

G. Accidents

The most serious accident that could occur at a Hanford reactor would involve loss of cooling water, as this would be followed inevitably by a meltdown of the uranium fuel in all uncooled process channels and loss of the reactor if a considerable number of channels were involved. Possible loss of coolant has been the subject of extensive study by ourselves and also by the Advisory Committee on Reactor Safeguards over a period of years. We have concluded that the most severe credible accident for a Hanford

RECEIVED
JAN 10 1964

production reactor would be either the loss of cooling to one process tube without prompt reactor shutdown, as could occur if flow were lost to a tube having an inoperative panellit gage, or the loss of cooling to a few process tubes with prompt reactor shutdown as would occur if a cross-header failed. Such incidents have been estimated as having the finite probability of occurring once in the lifetime of all the Hanford reactors. If the single tube incident should occur, the melted slug column could present quite a difficult contamination/repair problem, and could well require three to six months downtime for the work needed to return the unit to service. The few tube incident, while involving a more extensive area of the reactor should present a less serious repair problem because of the prompt shutdown.

Catastrophic accidents from severe earthquake or falling objects such as meteors or airplanes have a very low order of probability and have been omitted from further consideration. There is no record of earthquakes in the vicinity of Hanford of sufficient intensity to damage the existing reactor structures or cooling systems.

H. Conclusions

In summary, analysis of technological problems which directly affect pile life and efficiency indicates there is reasonable confidence that the forecasted production levels can be maintained through the ten year period.

DECLASSIFIED

DATE

FILMED

8/18/94

END