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.

HW-57735

**Cover Sheet for a Hanford
Historical Document
Released for Public Availability**

Released 1994

**Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830**

**Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute**

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This is a **historical document** that is being released for public availability. This was made from the best available copy. Neither the United States Government nor any agency thereof, nor Battelle Memorial Institute, nor any of their employees, makes **any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.** The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

HANFORD TECHNICAL RECORD

(CLASSIFICATION)

GENERAL ELECTRIC

DECLASSIFIED

HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

DOCUMENT NO.

HW-57735

SERIES AND COPY NO.

DATE

October 9, 1958

RESTRICTED

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

TITLE

REVISION TO TECHNICAL CRITERIA & BASED PRESSURIZED, WATER COOLED, GRAPHITE MODERATED PRODUCTION REACTOR

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. L. Dickeman

ISSUING FILE

THIS DOCUMENT MUST BE LEFT UNATTENDED OR WHERE AN UNAUTHORIZED PERSON MAY HAVE ACCESS TO IT. WHEN NOT IN USE, IT MUST BE STORED IN A LOCKED REPOSITORY. APPROVED GUARDED AREAS WHILE IT IS YOUR POSSESSION AND UNTIL YOU HAVE OBTAINED A SIGNED RECEIPT FOR 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 IN ANY PLACE OR RESIDENCE IS PROHIBITED. IT IS NOT TO BE DUPLICATED. ADDITIONAL COPIES ARE REQUIRED, OBTAIN THEM FROM THE ISSUING FILE. ALL PERSONS HANDLING THIS DOCUMENT ARE REQUESTED TO SIGN IN THE SPACE PROVIDED BELOW.

ROUTE TO:	PAYROLL NO.	LOCATION	FILES ROUTE DATE	SIGNATURE AND DATE
<i>W.R. MacLean</i>	<i>11</i>	<i>20-10</i>	<i>10-15-58</i>	<i>(M) 10-28-58</i>
<i>G.H. Hurd</i>	<i>660</i>	<i>1704/D</i>	<i>Nov 1958</i>	<i>CH</i>
<i>M.R. Noon</i>	<i>9322</i>	<i>048</i>	<i>1-27-59</i>	<i>Notting 3/20/59</i>
<i>ST Long</i>	<i>2578</i>	<i>048</i>		

RECORD
COPY

Indefinite Retention

Disposal Date

54-3000-340 (3-57)

Authority RICHLAND, WASH

Authority

(CLASSIFICATION)

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DECLASSIFIED

DECLASSIFIED

HW-57735

Page 1

DISTRIBUTION

1. ER Astley	10. AB Greninger
2. JR Carrell	11. GL Locke
3. AB Carson	12. WK MacCready
4. DL Condotta	13. D Marinos
5. RF Corlett	14. JS McMahon
6. DH Curtiss	15. GJ Rogers
7. RL Dickeman	16. RE Trumble
8. WD Gilbert	17. FW Woodfield'
9. OH Greager	18. 300 Files
	19. File Copy

RESTRICTED DATA

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
9 pages. No. 12 of
19 copies. Series

October 9, 1958

REVISION TO TECHNICAL CRITERIA AND BASES
PRESSURIZED, WATER-COOLED, GRAPHITE MODERATED PRODUCTION REACTOR

Attached is a draft of revisions being made to subject document, HW-53612. These revisions pertain to the moderator only, and will be incorporated in an overall revision of the Technical Criteria, which will be issued soon.

RL Dickeman
Manager, Process and Reactor Development Operation

RL Dickeman:bs

Attach.

Classification Cancelled and Changed To

DECLASSIFIED

By Authority of DS Lewis

CG-PR-2 12-14-93

By J E Sneyly 1-4-94

Verified By DK-Hansen 1-14-94

MASTER

DECLASSIFIED

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DECLASSIFIED

HW-57735

Page 2

TECHNICAL CRITERIA AND BASES
PRESSURIZED, WATER-COOLED, GRAPHITE MODERATED PRODUCTION REACTOR

Approved:

Group: 1 - Reactor Process Area

Subject: 1.1 - Moderator

Topic: 1.1.1 - Material

D. H. Curtiss

D. H. Curtiss

W. D. Gilbert

W. D. Gilbert

R. E. Trumble

R. E. Trumble

R. L. Dickeman

R. L. Dickeman

Date: 10-9-58

REQUIREMENT

The moderator shall be high quality graphite. The state of technology in the production of graphite moderator is such that material with known desirable characteristics in use is identified primarily by defining the process and materials with which it is made. This criterion is issued to state the minimum identifying features of acceptable reactor graphite.

CRITERION

- a. High quality graphite is fabricated from petroleum coke and coal tar pitch, graphitized at not less than 2400°C, has a machinability index (see reference below) of not less than 0.45, and a purity such that its absorption cross section is not more than 4.83 millibarns for 2200 m/second neutrons. Density shall be not less than 1.4 g/cc nor more than 1.7 g/cc.
- b. The selection of raw materials will be limited to Texas Rockport coke and Standard pitch except that other petroleum cokes and/or pitch may be considered, providing sufficient data exist on the irradiation stability to warrant their selection.

ADVICE

Selection of the graphitization process to achieve higher purity than indicated above is an economic balance between fabrication costs and initial enrichment.

DATA AND REFERENCES

Machinability - HW-31578, "Machinability of Graphite for Future Reactors," E. M. Woodruff, July 21, 1954.

Process - GEH-15043, "Equipment and Operating Procedures Used in Manufacture of GBF Graphite Bars," D.C. Hamster, June 24, 1959.
GEH-21466, "Manufacturing Instructions Covering the F Process," D. C. Hamster.

Patent No. 12694 June 1, 1909, "Acheson Process" (AGOT Process)

DECLASSIFIED

HW-57735
Page 3

Topic: 1.1.1 - Material (Cont'd)

Purity - HW-43547, "Hanford Test Pile," M. V. Davis and H. A. Fowler,
June 7, 1956.

HW-49757, "Discussion of Testing in the Hanford Test Pile,"
M. V. Davis, April 19, 1957.

Cross-section criterion is equivalent to a dih of zero as
measured in the 305 reactor against primary standards.

AGOT process graphite will range in purity from - 0.5 to + 0.5
dih. F process graphite will range from + 0.8 to + 1.1 dih.
Maximum attainable purity is 1.16 dih.

DECLASSIFIED

HW-57735

Page 4

TECHNICAL CRITERIA AND BASES
PRESSURIZED WATER-COOLED, GRAPHITE PRODUCTION REACTOR

Approved:

Group: 1 - Reactor Process Area
Subject: 1.1 - Moderator
Topic: 1.1.2 - Gas Atmosphere Composition

D.H. Curtiss D.H. Curtiss

W.D. Gilbert W.D. Gilbert

R.E. Trumble R.E. Trumble

L. Dickeman L. Dickeman

Date: 10-9-58

REQUIREMENT

The pile gas atmosphere composition shall be controlled so that chemical reaction of the moderator and the pile gas atmosphere under normal operating conditions will not impair the structural function of the moderator over the life period of the facility.

CRITERION

The maximum amount of uniform oxidation of any portion of the graphite which is used as a structural component may not be more than 10% during the life of the facility. If maximum graphite temperature exceeds 650°C, a totally inert atmosphere is required, e.g., helium, nitrogen. For maximum graphite temperatures below 650°, mixtures of carbon dioxide and helium may be used, as indicated below.

DATA

For maximum graphite temperatures in excess of 300°C, it may be assumed that oxygen will react quantitatively with the graphite. Similarly for temperatures in excess of 500°C and 700°C water vapor and carbon dioxide respectively react quantitatively. Helium and nitrogen are chemically inert to graphite. For mixtures of carbon dioxide and helium between temperature ranges of 540°C and 630°C, the attached graph defines gasification rate of 2%/1000 operating days. For each increase of 10°C above this line, the rate doubles. For a decrease of 10°C below this line, the rate of reaction is 1%/1000 operating days.

The purity of the inert helium or nitrogen shall be as specified in the Essential Materials Manual, HW-19156.

FIGURE 1.1.2
GASIFICATION OF GRAPHITE IN
CARBON DIOXIDE - HELIUM MIXTURES

DECLASSIFIED

TECHNICAL CRITERIA AND BASES
PRESSURIZED, WATER-COOLED, GRAPHITE MODERATED PRODUCTION REACTOR

Group: 1 - Reactor Process Area

Subject: 1.1 - Moderator

Topic: 1.1.3 - Graphite Temperature

Approved:

D.H. Curtiss D.H. Curtiss

W.D. Gilbert W.D. Gilbert

R.E. Trumble R.E. Trumble

R.L. Dickeman R.L. Dickeman

DECLASSIFIED

Date: 10-13-57

REQUIREMENT

The maximum graphite temperature, the temperature distribution within a lattice unit, and front to rear distribution shall be so controlled that the stack deformation as a result of normal pile operation will not impair the operability during the useful reactor lifetime, (which is 25 yrs. from startup).

CRITERION

- a. Because of reactor safety considerations associated with stored energy in the graphite, the minimum graphite temperature at any point shall not be less than 200°C.
- b. Graphite contraction data now available indicate that temperature-dependent contraction rates are experienced at temperatures in the range of 1000°C, and may be experienced at temperatures as low as 800-850°C. The basic maximum graphite point temperature limit is thus established at 850°C. Under certain conditions, a volume average temperature limit may be used as an alternative to the 850°C point temperature limit, and if so used shall be in conformance with the following:
 1. The volume average temperature of any load bearing portion of a graphite component for which dimensional stability is required shall not exceed 800°C.
 2. For those graphite components that are non-load bearing, and whose dimensional stability does not affect other reactor components, the maximum point graphite temperature may be greater than 850°C, but shall not exceed 1200°C.
 3. The exercise of the above alternatives shall receive the concurrence of Research and Engineering Operation.

DATA AND BASES

Potentially, a new reactor will require high graphite temperatures in operation. Extensive data are currently available only to an exposure temperature of 500-550°C. and an exposure of 5000 Md/CT at Hanford. Some data exist at exposure temperatures of 750°C, 975°C, and 1050°C. These data are from MTR exposures in

Topic: 1.1.3 - Graphite Temperature (Cont'd)

the high flux facility in the L-42 position. The few data in this temperature range indicate an increase in the contraction rate of the graphite for exposure temperatures in excess of 750°C. Because of the nature of the structural function and irreplaceability of the moderator, it is deemed necessary to limit the maximum graphite temperature to a modest extrapolation of experimental data and reactor experience.

For any given exposure temperatures up to 200°C, graphite expands and accumulates stored energy linearly with neutron dose and at a rate which is an inverse function of the exposure temperature. For exposure temperatures in excess of 200°C and up to 750°C, graphite contracts linearly with neutron dose and at a rate of 0.02%/1000 MD/CT. For purposes of design scope, a contraction rate of 0.02%/1000 MD/CT over the life of the pile can be assumed for graphite temperatures between 200°C - 800°C.

To calculate maximum graphite temperatures for symmetric geometry, standard heat transfer methods are satisfactory. For complex lattice geometries, resistance analog computations are recommended. For these calculations, the following data may be used.

1. The heat generation in the graphite moderator for the proposed 7-rod cluster fuel element (0.7" Dia. rods in a 2.7" I.D. tube) should be 5% of the total heat generated in the lattice unit.(1)
2. The graphite thermal conductivity values may be taken from Figure 1.1.3.
3. For a lattice geometry wherein the tube lies in contact with the channel assume a line contact resistance equivalent to two mils helium gas gap.
4. For "centered tube in tube block" geometry use standard methods.
5. For filler block lattice geometries use the following surface conductance values:
 - a) Vertical contact surfaces use a contract resistance of 500 Btu/hr, ft², °F.
 - b) Horizontal contact surfaces use the following values:

Approximate Contact Pressure -				
psi	0	9	27	36
Thermal Conductance				
Btu/hr., ft ² , °F	500	1000	2000	2800

6. Thermal conductivity of helium, carbon dioxide, and mixtures of these gases at elevated temperatures are referenced in 3. For thermal conductivity of nitrogen see reference 4.

Unlimited

DECLASSIFIED

HW-57735
Page 8

Topic: 1.1.3 - Graphite Temperature (Cont'd)

Thermal expansion coefficients for graphite of density 1.4 - 1.7 g/cc are tabulated below:

<u>Type Graphite</u>	<u>Density</u>	<u>Thermal Expansion Coeff.</u> <u>(1/°C) x 10⁶</u>	
		<u>parallel</u>	<u>transverse</u>
KC	1.70 - 1.72	1.6	5.5
CSF	1.65 - 1.67	1.6	4.8
TS-GBF	1.62 - 1.64	2.2	4.2
TS-GBF	1.50 - 1.55	2.1	3.9
TSF	1.4	2.4	3.0

The above coefficients are average values for temperatures in the range of 25°C to 650°C.

REFERENCES

1. For general information on radiation damage to graphite at exposure temperature up to 200°C.

"Irradiation Damage to Artificial Graphite" by W. K. Woods, L. P. Bupp, J. F. Fletcher. Paper presented before International Conference on Peaceful Use of Atomic Energy, Geneva, Switzerland, August 8-20, 1955.
2. J. H. McCrary, "Estimate of the Fraction of Fission Energy Dissipated in the Graphite Moderator for Cluster Type Fuel Elements," HW-53286.
3. H. L. Hollister, "Heat Transfer Coefficients Graphite to Graphite" Test Project #33, March 1, 1951.
4. HW-28766, "Calculated Thermal Conductivities for He-CO₂, He-Ne, and He-N₂ Mixtures," J. M. Davidson.
5. HW-21741, "Calculated Thermal Conductivities of Pure Gases and Gas Mixtures at Elevated Temperatures," J. M. Wright.
6. Design Data, G. E. Standards G-515, pg. 16.
7. NAA-SR-1520 Effect of Reactor Irradiation at Temperatures between 400 & 700°C on k of graphite. R. E. Durand and D. J. Klein - July 15, 1956.
8. HW-36095, P.T.-105-521-E - "Interim Report The Effects of Pile Exposure on Full Size Graphite Bars," C. N. Spalaris.
9. HW-24174, "Pile Graphite Thermal Conductivity," D. H. Curtiss, 4-18-52.
10. AECD-3647 Reactor Handbook Vol. III, Section 1, pg. 139, March, 1955.

DECLASSIFIED

HW-57753

46-57735

Topic: 1.1.3

FIGURE 1.1.3
THERMAL CONDUCTIVITY
OF TS-CBF GRAPHITE

**DATE
FILMED**

6 / 28 / 94

END