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TITLE

PRODUCTION TEST IP-490-A-FP, EVALUATION OF
DIFFUSION BONDED FUEL ELEMENTS

AUTHOR

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May 2, 1962

PRODUCTION TEST IP-490-A-FP
EVALUATION OF DIFFUSION BONDED FUEL ELEMENTS

INTRODUCTION

Possible limitations to the Al-Si bonding process are being examined under an FPD-IPD testing program. The results from this testing program should provide valuable

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information as to the capabilities of the Al-Si bonded fuel elements at programmed operating conditions. If the Al-Si test⁽¹⁾ should demonstrate that the Al-Si bonding process may become limiting, then an alternate bonding process technology will be needed in a relatively short period of time.

At this time there are four potential alternate bonding processes being studied. These include: (1) Sylcor hot press, (2) Hanford hot press, (3) Hanford gas pressure, and (4) Hanford hot die-sizing. The first two are ready for reactor testing, whereas the gas pressure bonding and hot die-sizing processes are still under development. This report outlines the irradiation program for the preliminary evaluation of these processes as potential replacements for the Al-Si process.

OBJECTIVE

The objectives of this test are to determine the gross dimensional stability of hot pressed fuel and to evaluate bond quality differences between Al-Si bonds and solid state diffusion bonds.

TEST SUMMARY

Irradiation testing will be conducted at C reactor and will be carried out in two parts:

Part I - Sylcor and Hanford hot press diffusion bonding processes will be compared to the Hanford Al-Si bonding process. Eighteen (18) measured monitor columns of CVNS fuel elements will be irradiated to an 800 MWD/T goal exposure.

Part II - Hanford gas pressure and Hanford hot die sizing solid state diffusion bonding processes will be compared to the Hanford Al-Si bonding process. Again, eighteen (18) measured monitor columns of CVNS fuel elements will be irradiated to an 800 MWD/T goal exposure.

BASIS AND JUSTIFICATION

Examination of available pre-irradiation data on Hanford fuel element external bond strengths indicates the strength of the Al-Si bond is relatively low. The average and maximum strengths of Al-Si bonds are 13,500 psi and 20,000 psi, respectively, whereas, for nickel diffusion bonds, the average strength is 21,000 psi and the maximum strength is 30,000 psi. In addition to being stronger, the nickel diffusion bond is reported to be tougher.⁽²⁾ The process will permit close control of can wall thickness and will increase the uranium to aluminum weight ratio as a result of replacing the equivalent of the Al-Si bonding annulus with uranium.

The ultimate limit of the Al-Si bonding process has never been determined, and,

(1) HW-65870-C, "Production Test IP-344-A-FP, Evaluation of Al-Si Bond Characteristics," M. A. Clinton, July 10, 1961.

(2) HW-65759, "Proposed Solid State Diffusion Bonding (SSDB) Process-Gas Pressure Bonding", E. A. Weakley, June 22, 1961.

if the Al-Si bonds undergoing evaluation at high specific powers and exposures⁽³⁾ indicate any deficiencies it may be necessary to develop a replacement process. The nickel diffusion bond is being developed and evaluated as a replacement for the Al-Si process should one be required.

TEST DETAILS

1. Reactor - C Reactor will conduct both parts of this production test.

2. Material

A. Fuel Elements

1. Geometry - The CVNS fuel geometry will be utilized in both parts of this test.

2. Fabrication - Specific details concerning the fabrication and ex-reactor testing may be found in the test design document.⁽⁴⁾ Aluminum components will be fabricated from X-8001 aluminum alloy. Fuel cores for Part I will be rolled dingot. Either ingot or dingot fuel cores may be utilized for Part II.

3. Nominal Dimensions - The following table shows various dimensions for the bare cores and the finished fuel elements:

	Hanford Al-Si	Hanford HP	Hanford GPB	Hanford HDS	Sylcor HP
a) Nominal Core OD	1.406"	1.432"	1.432"	1.432"	1.434"
Nominal Core ID	0.488"	0.427"	.437"	.437"	0.436"
Nominal Core Length	8.378"	8.400"	8.365"	8.600"	8.455"
b) Nominal Finished Element OD	1.499"	1.494"	1.494"	1.494"	1.494"
Nominal Finished Element ID	0.375"	0.375"	0.375"	0.375"	0.375"
Nominal Finished Element Length	8.965"	9.000"	9.000"	9.000"	9.080"
Nominal Rib Height	0.082"	0.082"	0.082"	0.082"	0.082"
Maximum Circumscribed Circle	1.660"	1.660"	1.660"	1.660"	1.660"

4. Self-Supports - The self-support rails will be ultrasonically welded to the fuel element and will be similar in appearance to those on the presently used CIVNS element.⁽⁵⁾

(3) Op cit, HW-65870-C

(4) HW-73093-A, "Design of Production Test IP-490-A-FP, Evaluation of Diffusion Bonded Fuel Elements", W. H. Hodgson and M. A. Clinton, March 26, 1962.

(5) HW-61669-C, "PT-IP-272-A-FP, Pilot Test of Self-Supported Fuel Elements in Ribless Zirconium Process Tubes, R. E. Hall and D.H. Curtiss, July 27, 1959.

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5. Pre-Irradiation Testing, Measurements, and Marking

The following tests and measurements are to be made on cores and fuel elements prior to irradiation:

<u>Test</u>	<u>Purpose</u>	<u>Core Status</u>	<u>Data</u>
1. UT-2	Measure Grain Size	Bare	Record Data
2. Surface Test	Core Surface Quality-Visual After Ni Plate	Bare Ni Plated	
3. Length	Core Dimensions	Bare & Canned	" "
4. Outer Diameter(3)	" "	" " "	" "
5. Inner Diameter(2)	" "	" " "	" "
6. Warp Ellipticity	" "	Canned	" "
7. Weight (1-23)	Corrosion	"	" "
8. Bond Test	Braze Porosity	"	" "
9. Stud Pulling	Bond Strength	"	" "
10. Metallography	Bond Quality	"	Photomicro- graphs
11. Identity -	Identity and position of measured fuel elements will be recorded by a series and position number stamped on the base of each fuel element.		

6. Column Make-Up - Columns will be made by alternating fuel elements from two of the three groups in each part. To simplify the description, the following code will be used:

A - Sylcor Hot Press
B - Hanford Hot Press
C - Hanford Al-Si (1st Part)
D - Hanford Al-Si (2nd Part)
E - Hanford Gas Pressure
F - Hanford Hot Die Size

The elements will be made into columns as listed below:

	<u>Number of Charges</u>	<u>Groups Represented</u>	<u>Number of Pieces Through 32 pieces</u>
(Part I)	6	AB, AB, AB	" " "
	6	AC, AC, AC	" " "
	6	BC, BC, BC	" " "
(Part II)	6	DE, DE, DE	" " "
	6	DF, DF, DF	" " "
	6	EF, EF, EF	" " "

Thus, in the event one type should prove dimensionally unstable or rupture prone, the test of the other types will not be in jeopardy and the comparison of the remaining processes will still be on a statistical basis. Columns will be placed in specially identified shipping pallets in charging order.

B. Process Tubes

Smooth-bore Zr-2 process tubes installed into C reactor under authorization

of IP-272-A⁽⁶⁾ will be utilized in this test.

C. Dummies and Seating

The downstream dummy pattern and seating method in use for CIVNS elements at the time this test is charged shall be used.

D. Thermocouple Probes - Not required for this test.

E. Probolog - Not required for this test.

3. Irradiation

A. Charging

All test columns will be charged in numerical order with piece number one downstream. Each column will have the fuel identification number (series and/or lot number) recorded opposite the tube number on the front face sequence sheet. Charging of material for both parts of this test will be followed by a representative of Research and Engineering. Test columns will be charged into locations which will provide similar irradiation conditions for all tubes. Locations will be selected by the assigned Process Engineer and Physicist with the concurrence of the test author and will be selected from those tubes nearest goal exposure.

Hand charging is authorized in order to minimize damage to the self-supports if a satisfactory charging machine is not available.

B. Data - No special operating data recordings are planned.

C. Goal Exposure

Goal exposure for all test columns will be 800 MWD/T. Goal exposure changes may be made by request from the test author with the concurrence of the reactor processing manager.

D. Discharge

All columns will be monitor columns and will require special pickup and shipment to the 105-C MEF for post-irradiation examination and measurement. All test columns containing one type may be discharged prior to reaching goal exposure after two failures have occurred in that type provided all columns can be specially picked up.

E. Operating Limits

The operating conditions and limits which apply to the CIVN-S geometry will be applicable to this material. Existing Process Standards will be used as the basis for all operating conditions and limits not specifically covered within this test authorization.

(6) Op cit HW-61669-C (69 tubes of I.D. $1.681 \pm .005$).

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4. General

A. Schedule

Fuel elements for Part I have been fabricated and are ready for reactor charging. Reactor charging is requested for the first outage following approval of this test.

Further development work on Part II fabrication processes will require 3 to 4 months. Fuel elements for evaluation under Part II are expected to be ready for charging about August, 1962.

B. Duration

Irradiation of each Part of this test will require about 4 months. This test authorization will expire on December 1, 1963.

C. Post-Irradiation Examination

All pre-measured fuel elements will:

- 1) Be weaseled and visually inspected for surface conditions,
- 2) be measured for length, warp, and diameter changes (OD₁, OD₂, OD₃, ID₅ and ID₇),
- 3) have weight recorded (pieces 1 - 23),
- 4) be bond tested if equipment is available.

Selected pieces may be set aside for stripping and bare core measurements depending on either the preliminary visual examination results or a later analysis of the measurement data. Also, selected elements may be sent to Radiometallurgy for destructive examination.

D. Costs

The primary outage time losses resulting from this test will be associated with charge-discharge and special pickup. All incremental costs associated with the performance of this test may be charged to XXXX-5R24-XXX.73. Outage time requirements are listed below for scheduling purposes:

<u>Job</u>	<u>Processing Time</u>	<u>Elevator Time</u>
Charge	1/2 mh/tube	1/4 hr/tube
Special Pickup	1/2 mh/tube	----

E. Hazards

No new or unusual hazards are associated with this test.

RESPONSIBILITIES

Fuels Preparation Department

Responsibilities assigned to the Fuels Preparation Department are authorized by HW-73093-B, which in brief, authorizes fabrication of the test material and assigns responsibilities within Fuels Preparation Department necessary to carrying out this production test.

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Irradiation Processing Department

Research and Engineering Section

Process and Reactor Development Sub-Section - shall be responsible for coordination of the test, analysis of operating data, reporting of in-reactor performance, and for provision of bases for operating limits.

Process Technology Sub-Section - shall be responsible for providing assistance to both the Processing Operation and the Process and Reactor Development Sub-Section in pre-shutdown scheduling, in charging the test materials, in selection of test channel locations, for forwarding operating data to the author, and for specification of operating limits.

Operational Physics Sub-Section - shall be responsible for providing assistance in selecting test channel locations, and for reactivity adjustments as required by this test.

Component Testing Unit - shall be responsible for post-irradiation fuel element examination and measurements.

Manufacturing Section

Production Scheduling - shall be responsible for scheduling discharge of the test material.

C Reactor Operation - shall be responsible for scheduling, for operational safety and production continuity of the reactor, and for charging the test material.

M. A. Clinton

M. A. Clinton
Reactor Fuels Unit
Process & Reactor Development
Research and Engineering Section
IRRADIATION PROCESSING DEPARTMENT

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