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12 pages.

PRODUCTION TEST IF-431-A
EXPANSION OF OVERCORE TEST FACILITIES
C REACTOR

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August 11, 1961

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PRODUCTION TEST IP-431-A
EXPANSION OF OVERBORE TEST FACILITIES
C REACTOR

The continued interest in overboring, as a substantial portion of a Reactor Plant Improvement Program, has indicated a need for more experience and information to adequately demonstrate the benefits of the case. To provide for this experience, the present overbored test channels in the C Reactor are to be expanded in number. This production test provides the authorization for accomplishing this work.

OBJECTIVE

The objective of this production test is to authorize the installation of at least 40 additional large size Zircaloy process tubes in graphite channels that have been enlarged to 2.275 inches at C Reactor and to charge these tubes with large diameter (CVIN) fuel elements to obtain preliminary conversion ratio data and further qualitative data regarding the irradiation behavior of large diameter fuel element designs.

SUMMARY

This test authorizes the installation of at least 40, and not more than 50, large size Zircaloy-2 process tubes in the C Reactor and the continued charging of these tubes with CVIN oversized fuel elements until authorized by Process Standards or until it is deemed impractical to convert C Reactor for the use of this type fuel element, or until August 21, 1963; whichever is the sooner.

The process channels converted under the authority of this test will be located in one block in the flattened central zone of the reactor so that irradiations may be made for the collection of conversion ratio data. These data will contribute to the evaluation of conversion ratios for the fully overbored reactor.

Secondary to the objective, but nonetheless important to the development of a capability to successfully modify the reactor, is the opportunity afforded for the development of improved hardware design. The channels to be outfitted under this test will be equipped with hardware of two different designs in approximately equal numbers. Experience obtained with these designs, as well as that already existing under the provisions of an earlier test, will provide a good basis for the design of hardware to be installed under a full reactor conversion project.

All channels modified under this test will be tubed with smooth-bore Zircaloy-2 process tubes and fueled with self-supported, internally-and-externally cooled fuel elements (CVINS). The fuel will be irradiated to a maximum of 1500 MWD/T under this authorization.

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BASIS AND JUSTIFICATION

With the confirmation of the large incentives that exist for the enlarging of the reactor process channels and fuel elements,⁽¹⁾ plans have been prepared to so convert the older reactors and the C Reactor as a portion of a Reactor Plant Improvement Program. The Program calls for a project outage of C Reactor, as lead reactor, on August 1, 1963. To meet this date, Title I Design should begin March 15, 1962. Prior to that date, about February 1, 1962, an interim analysis of fuel performance and detailed technical criteria for the modified reactor conditions must be in hand. In order to satisfy this requirement, fuel performance information and product yield data must be obtained on a maximum schedule. Twenty overbored channels have been equipped with large process tubes and are currently being used for fuel evaluation tests,⁽²⁾ but the location and number of these tubes is not adequate to provide firm information on the necessary schedule.

To provide for the collection of this information on schedule, it was decided that the overbore tubes at C Reactor should be expanded in number by at least 40 tubes, and that these should be installed in an arrangement that would provide pertinent physics information. To accomplish this installation in an orderly and timely fashion, a Task Group was established, with representation from IFD Facilities Engineering, Manufacturing, and Research and Engineering Sections, and the group was charged with the responsibility for accomplishing the installation during August, 1961. At the time of the formation of the Task Group, they were given two ground rules under which the expansion of the facilities was to be accomplished:⁽³⁾

1. The test facility expansion will be constructed in a manner that is consistent with and, as nearly as possible, identical to the final conversion and will become part of the final conversion.
2. The process tubes to be installed for the expanded facility will be of Zircaloy-2 and of the same size as the Zr-2 smooth-bore process tubes currently installed, namely:

O. D.	= 2.250 inch, maximum
I. D.	= 2.147 ± 0.003 inch
Wall Thickness	= 0.040 inch, minimum
Length	= 43 feet, + 3, - 0 inches

Other bases and criteria for the installation of the additional overbored process tubes have been separately recorded.⁽³⁾

TEST DETAILS

1. Material

a. Fuel Elements

The fuel elements to be irradiated in the process tubes to be installed under this authorization shall be large size natural uranium self-supported

fuel elements (CVINS) identical to those now being evaluated in the existing overbore process tubes under Production Test IF-381-A-FP. The performance of this fuel design has, to date, proved quite satisfactory and no reason exists for any alteration in the design at this point.

All CVINS fuel specifications and pre-irradiation measurements listed in the authorizing document⁽²⁾ for Production Test IF-381-A-FP will apply to fuel irradiated under the provisions of this test.

b. Process Tubes

Zircaloy-2 process tubes installed under this test shall meet the "Specification for Zircaloy-2 Smooth-Bore Process Tube for Overbore Test at 105-C" dated October 11, 1960, in all respects, unless specific waiver of a portion of the specification has been granted by Research and Engineering Section.

c. Dummies

Downstream dummies will be 8-inch expendable perforated aluminum spacers with support as follows:

- 1) Four rails each end on 90° centers in line.
- 2) Support height about 0.300 inch. The nominal rib diameter is 2.000 inches.
- 3) Supports at least 1 inch from the ends of the spacer.

d. Hardware

The use of the larger process tube dictates the use of new tube end hardware to accommodate the larger fuel element and tube geometry. Should the reactor be fully converted to the larger process channels, the required replacement of hardware presents the opportunity to eliminate certain weaknesses of existing standard hardware components, such as: the marginal strength of the inlet nozzles and end caps, protection against heat transfer burnout in the event of failure of inlet face components, maintenance problems associated with gas and water leaks, and the time required for maintenance or replacements because of awkward configuration of hardware.

In order to evaluate design innovations that have the prospect of eliminating or strengthening the weaknesses listed above, two sets of hardware have been designed for installation with the larger process tubes. Equal numbers of each design will be installed, and the relative merits of these will be compared with those of other overbore hardware concepts presently being tested on-reactor.⁽⁴⁾ From this experience will come the basis for a final hardware design for the full reactor change out.

Each of the two hardware designs, herein authorized for installation, will undergo a single-tube on-reactor evaluation prior to the 10-tube installation. The authorization document⁽⁵⁾ for the advance on-reactor evaluation cites the salient features of each design, and they will not be repeated here.

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It should be recognized that following the installation of these tubes, there will be a total of 48 oversize zirconium tubes bearing hardware of three different designs on the reactor. This does not categorically deny the compatibility of these three designs with each other or with the final full-reactor design. Presumably, an adapter can be made to utilize the ultimate hardware design on these tubes.

e. Charging Machine

A suitable machine for charging the large fuel elements through the hardware of both designs, or a suitable adapter for existing machines, will be provided by Reactor Modification Design, Facilities Engineering Section.

2. Installation

a. Location

The process channels to be overbored and outfitted with large Zircaloy-2 process tubes and new hardware will be located in a 6-by-8 lattice block of C Reactor, rows 28 through 33, vertical columns 62 through 69 minus one lattice in each corner (2862, 2869, 3362, and 3369) and minus the four channels in this block already outfitted with overbore equipment (2863, 2866, 3363, and 3366). Hardware installed on rows 31 through 33 shall be of the so-called Clamp-Nozzle Design (Drawing Nos. SK-1-4774 and SK-1-4781); hardware installed on rows 28 through 30 shall be of the so-called Flapper Valve Design (Drawing Nos. SK-1-4806 and SK-1-4767).

b. Channel Dimensions

The graphite process channel will be overbored to a diameter 25 mils greater than the process tube maximum diameter (process tube maximum O. D. is 2.250 inch, so channel diameter will be 2.275 inch).

Inasmuch as the fully converted reactor will require that channel coring or enlarging portions of the channel more than the bore diameter, the channels affected by this test will be so cored, if possible. The coring diameter will be 250 mils greater than the graphite bore diameter (2.525 inch) and the coring will extend into the graphite stack a distance of 3 feet from the end of both the inlet and outlet gunbarrel.

c. Schedule

The installation will proceed in two steps: the first, to take place about August 21, 1961, will accomplish the installation, outfitting and fuel loading of the large Zircaloy-2 process tubes in the authorized channels on rows 31 through 33; the second step, that of installing, outfitting and fueling the remaining authorized channels will be accomplished at a subsequent outage.

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3. Irradiation

a. Charging

All tubes to be loaded under this test shall contain the same number of active fuel elements - 18 to 20 - the number will be specified by the test author, with the concurrence of the Manager, C Processing, prior to the charging.

The downstream dummy pattern will also be specified, contingent upon the active charge. There will be four to six solid aluminum pieces included in the dummy pattern.

There will be no upstream dummy pattern.

b. Operating Conditions

Assuming 95 C bulk outlet temperatures and 102,000 gpm reactor flow, the desired operating conditions for columns loaded under this authorization are:

	<u>5 Inlet</u>	<u>20 C Inlet</u>
Maximum Power	1740 KW	1260 KW
Outlet Temperature	120 C	115 C
Maximum Outlet Temperature		120 C

The fuel charge and dummy pattern will be specified to obtain a nominal tube flow rate of 59 gpm.

c. Conversion Ratio Block

The central eight tubes of the block, tubes 3064 through 3067 and 3164 through 3167, shall be used for the irradiation of fuel elements for special product extraction studies. The loading pattern of these tubes shall be the same as for all others in the test block. For these studies, 20 to 25 charges from five to eight separate irradiations will be required to provide sufficient data for analysis.

d. Goal Exposure

To accomplish the objectives of this test, a range of fuel exposures will be required. Twenty tubes of material shall be irradiated beyond the nominal goal of 800 MWD/T established for this test. The exact exposure will be dependent upon results of post-irradiation measurements currently being obtained. Maximum exposure of these tubes shall not exceed 1500 MWD/T. Also, exposures to values lower than 800 MWD/T will be required for the conversion ratio studies. In cases other than the nominal goal of 800 MWD/T, exposures will be transmitted to, and concurred in by, the Manager, C Processing.

e. Discharging

All columns will be monitor columns and will require special pick-up and shipment to the 105-C Metal Examination Facility for post-irradiation examination and measurement.

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Although no fuel failures are planned under this test, they may occur, and it is extremely desirable to obtain the failed piece for examination along with the remainder of the column. If a charge should stick, regardless of cause, stuck charge and rupture removal procedures will be reviewed by the Managers of Process Technology and of Process and Reactor Development before use. If a tube cannot be recharged, procedures for operation with the empty tube will also be reviewed by the same representatives of R & E before startup.

4. Thermal-Hydraulic Limits

Water shut-off times and Instability Limits will be prepared by Process and Reactor Development and transmitted, through Process Technology, to C Processing prior to startup.

5. Data Required

For the eight central tubes (the Conversion Ratio Block) daily temperature and flow data will be required. Data sheets will be provided.

6. Duration

This test shall continue until full scale reactor use of this material is initiated or until the process tubes and fuel involved are covered by Process Standards, or until August 21, 1963, whichever is the sooner.

7. Post-Irradiation Examination

All fuel elements will be: 1) visually examined and weighed; 2) have warp, ellipticity, diameter and length growth recorded; 3) be bond tested (total count) when possible; and 4) have post-irradiation weight recorded on all downstream pieces 1 through 15.

Elements showing more than 20 mils warp, length increase, diameter increase, ellipticity, or surface bumping shall be set aside for: 1) stripping and bare core measurements of length, diameter, ellipticity, bumping and warp; or 2) shipment to Radiometallurgy Laboratory for further examination. Special attention is to be given to any new or unusual observations.

8. Costs

Funds for the design and procurement of hardware and for the over-all installation will be provided by Facilities Engineering Section. A total of 12 shifts outage time has been estimated for the installation of each ¹⁰/₂₀ tube step.

Incremental costs associated with the fueling of the process tubes will be charged to xxx-5R24-xxx.73. Outage time requirements are listed below:

	<u>Processing Time</u>	<u>Elevator Time</u>
Charge Tubes	3/4 mh/tube	1/4 hr/tube
Discharge and Special Pickup	1-1/2 mh/tube	1/4 hr/tube

Any necessary incremental enrichment required to support this facility will be specified prior to startup.

Strain gages are to be installed on six tubes to monitor the strain loading of the rear shield that results from the use of a fixed rear gunbarrel. Six hours of rear elevator time will be required for their installation.

Six connectors, front and rear, and two crossheaders will be fitted with vibration monitors. One and one-half hours of elevator time will be required for their installation.

9. Hazards

- a. Since this fuel geometry has accumulated limited irradiation experience, a higher probability exists of encountering fuel element failures than in normal metal. Every attempt will be made to avoid fuel element failures by making laboratory hydraulic flow checks, and by following a cautious loading schedule. Since this fuel element is larger (ca. 500 mils) than any previously used, it is possible, but not likely, that a threshold has been crossed and failures will be encountered.
- b. Another hazard is the possibility that the entire concept may be deemed infeasible. This could arise from a cancellation of the graphite overbore program due to any number of subsequent decisions, depending on a choice of assumptions.
- c. A slight hazard exists in the use of projection fuel elements, in that it is conceivable that unusual dimensional instabilities could induce stuck fuel elements (ruptures or non-ruptured) due to the fact that fuel element displacement in the process tube is restricted by the projection supports. This in turn could cause troublesome tube removal and replacement difficulties, particularly with zirconium tubes.
- d. A potential hazard exists for damaging portions of the discharge chutes (mattress pads) with the heavier fuel elements. This is being evaluated and is considered a slight problem at this stage of the program.
- e. It appears that no extreme risk is involved in this testing program with regards to safety; and no significant production losses other than those normally involved in any fuel development program are expected, excepting the time required to accomplish the graphite overboring and hardware installation.
- f. Note should also be taken of the industrial hazards arising from the increased amount of zirconium handling, and its potential fire hazard. Furthermore, the removal of irradiated Zircaloy-2 process tubes, if necessary, will constitute a significantly greater radiation hazard than that for existing aluminum process tubes.

Any further hazards are peculiar to the hardware designs and are outlined in the document authorizing the advance test.

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RESPONSIBILITIES

1. Fuels Preparation Department

- a. Manufacturing Section shall be responsible for canning all pieces by the "F" process, finishing and testing the fuel elements, quality control, segregation of test material, maintenance of normal production records, recording data on non-standard operations, providing for attachment of projections, and pre-irradiation measurements and marking of the finished fuel elements.
- b. Engineering Section shall be responsible for procurement and fabrication of material not used in regular production, supplying supplemental operating procedures, providing technical assistance, liaison in the 30C Area, and collection of test data.

2. Irradiation Processing Department

a. Research and Engineering Section

- 1) Process and Reactor Development Subsection shall be responsible for over-all coordination of the test, data analysis, reporting of irradiation experience, recommending column compositions and goal exposures, and providing water shut-off times and instability limits. Specifically, Reactor Engineering shall be responsible for providing the process tubes and for flow lab data and analysis as a basis for operating limits. Reactor Fuels shall be responsible for scheduling fuel elements and for technical assistance regarding fuels matters. Reactor Physics shall be responsible for specifying columns to be utilized in conversion ratio studies and for arranging CPD extraction and analysis. All shall be responsible for reporting their phase of the work as required.
- 2) Process Technology Subsection shall be responsible for assistance in scheduling, in charging the test, for forwarding that data to Reactor Fuels and for specification of operating limits.
- 3) Testing Subsection - Component Testing shall be responsible for obtaining and reporting post-irradiation fuel examination data.
- 4) Operational Physics Subsection shall be responsible for specifying enrichment and supplementary control amounts and locations to minimize flux peaks and depressions, and for ensuring that such compensating measures are consistent with total control standards.

b. Facilities Engineering Section

- 1) Project Engineering Subsection shall have over-all installation responsibility.
- 2) Equipment Development Subsection shall be responsible for providing over-boring and coring equipment, welding equipment, tube cutting and tube collar facing equipment and varstoning tools, and shall provide operating procedures and technical guidance for use of this equipment during the outage.

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- 3) Reactor Modification Design shall be responsible for the design, procurement and off-reactor testing of the hardware, the location and installation of strain gages and vibration monitors, and for evaluation of hardware testing results. Small installation tools, rupture removal tools and charging equipment will also be provided.

c. Manufacturing Section

- 1) C Processing shall be responsible for scheduling the outage, operational safety, production continuity for charging the test fuel elements under direction of Research and Engineering representatives, and for the collection of operating data.
- 2) B-C Maintenance shall remove existing hardware and tubes, bore the channels, and install new hardware, and plan, schedule, and direct the maintenance craft during the outage.

F. W. Van Wormer
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Reactor Engineering Unit
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