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PRODUCTION TEST IP-696

EVALUATION OF ARCH-RAIL SUPPORTS

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PRODUCTION TEST IP-696

EVALUATION OF ARCH-RAIL SUPPORTS

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PRODUCTION TEST IP-696
EVALUATION OF ARCH-RAIL SUPPORTS

INTRODUCTION

Large scale self-support fuel usage at the K Reactors began in mid-1963. With the advent of the new fuel element concept, self-support development work in different areas was required. One such area was that of the supports, or rails, used on the elements. The initial self-support rail design on the elements, in order to meet production commitments, was only slightly modified from previous test models. These rails were identified as "bridge rails." Development of the self-supports has continued and the first major modification, the "arch-rails," of the original design is now ready for reactor testing.

OBJECTIVE

The objective of this test is to evaluate the heat transfer and coolant flow characteristics of fuel elements fabricated with the arch-rail self-support.

TEST SUMMARY

Up to 110 columns of fuel elements containing arch-rail self-supports will be irradiated in the KW Reactor in a two-step test. The first step will consist of ten fuel columns, seven arch-rail, and three conventional bridge-rail, equipped with downstream thermocouple probes. An additional ten columns of arch-rail elements will be charged as a part of the first step. The second step, to commence after assurance that the initially-charged fuel columns meet established operating limit criteria, will consist of approximately 90 columns of lot-charged elements containing the arch-rail supports. The ten thermocouple probes used in Step 1 will permit measurement of the annular coolant temperature distribution from which R values will be calculated. The ten fuel columns used with the thermocouple probes will be monitor columns and will be given post-irradiation examination and measurement.

BASIS AND JUSTIFICATION

The bridge-rail currently in use on K self-support fuel elements was developed to meet the initial demands of the large scale program. While its use has proved quite satisfactory, the rail design was never considered to be optimum. Development work of supports has continued with the goal of providing a support which would minimize fabrication problems as well as show economic gain.

The present bridge-rail presents some degree of difficulty in fuel element fabrication as the support height, a critical design parameter, is not constant during attachment to the fuel element, requiring an extra fabrication step of "sizing" the supports to meet the established specifications for height. The bridge-rail also proves difficult to align on the fuel element surface during attachment to the fuel element.

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The bridge-rail is easily deformed, although the ultimate strength of the support is consistent with requirements. Very small deformation, in the order of 0.005 inch, in the support height occurs in handling the elements. As the reactor-established specifications dictate a support height tolerance of ± 0.003 inch, numerous fuel elements are rejected during fabrication because of the "fragile" qualities of the supports.

The support-rail proposed as a replacement for the current bridge-rail, identified as the arch-rail, see Figure 1, lessens the fabrication difficulties. The load-deflection characteristics, as shown in Figure 2, of the new support are much more desirable in the low-deflection region, indicating added stability over that of the bridge-rail during handling. Alignment of the supports during attachment to the element is more easily accomplished with the arch-rail, as a "split-weld" technique is used for the ultrasonic attachment. The welding tip actually determines the alignment of this support since a single fixed tip applies the welds to the two sides of the support. The fact that a single welding step is required for each support reduces the number of welds per fuel element from the 16 now needed with the bridge-rail to eight. As only one weld per support is needed with the arch-rail, failure of the weld will result in loss of the support in that location; similar weld failure with the bridge-rail would not result in loss of the support. Inspection techniques during fabrication will assure that each weld on the arch-rail will be shear tested for attachment strength.

Savings of up to \$100,000 per year may be realized, through increased yields and decreased fabrication costs, with the use of the arch-rail.

The arch-rail has been given many ex-reactor tests, and although the data have not been completely analyzed, preliminary information indicates that this support is completely compatible with the present system. The load-deflection characteristics, Figure 2, appear to be more favorable than those of the current model. Friction coefficients of the two support types are comparable. Tests were conducted in various combinations of element orientation and lubricants, with performance of the support types not differing significantly.

Tests were conducted to assess fuel element support damage to the Zircaloy-2 process tube. Both arch-rail and bridge-rail supports were tested on a mechanically expanded section of fuel cladding in a short section of Zircaloy process tubing. The cladding was expanded to give a pre-determined load on the fuel supports and process tube deformation was measured and recorded. The arch-rail and the bridge-rail caused about the same amount of deformation to the tube but the arch-rail required less force to remove from the tube than the bridge-rail, indicating that fuel discharge forces in some cases may be decreased with the new support type.

Laboratory data on the hydraulic characteristics of the two supports indicate a substantial decrease in pressure drop across the active section for the arch-rail when compared to the current support. Coolant flow rates may therefore increase by about 4 per cent per tube with use of the new support, and total single-reactor coolant flow rates are estimated to be about 215,000 gpm with the present system through complete use of the arch-rail.

[1] Wood, S. A. Arch-T Self-Supports at K Plant, HW-83593. August 7, 1964.
(Secret)

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Before acceptance of the arch-rail for production use, in-reactor investigations of the characteristics of the support need to be completed. The coolant temperature distribution in the outer annulus of fuel columns having arch-rail supports may differ from that of the conventional support. The coolant temperature unbalance in the process tube must be known so that an evaluation of adherence to current R-value criteria can be made.

Before charging of the second group of elements of this test, up to 90 columns of elements lot-charged, data from the thermocouple probes must be analyzed by Process and Reactor Development and the results formally transmitted to the Manager, KW Processing, and the Manager, Process Technology. The second group of elements will be irradiated only if maximum R values for the columns will not exceed 1.20.

Fairly large quantities of elements are needed for determining any subtle changes in corrosion as a result of the new support. Use of weight measurements on the monitor columns will permit detection of any gross changes in the corrosion behavior of the elements. Visual examination of 20 to 30 additional fuel columns will allow further evaluation of the corrosion behavior of the fuel.

TEST DETAILS

1. Reactor

This test will be conducted in the KW Reactor.

2. Fuel Elements

a. Model

All fuel elements used in this test will be of the KVNS model.

b. Fabrication

All elements used in this test will be fabricated according to the "F" process,^[2] and shall meet all fabrication and quality specifications in effect at the time of manufacture. Aluminum components will be of 8001-F alloy; all fuel element cores will be of natural uranium formed by the ingot process.

[2] Callen, A. C., "Process Specifications, Fuel Element Manufacturing Processes," HW-47029, March 15, 1957. (Confidential)

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c. Self-Supports

The arch-rail supports used on elements of this test will be fabricated according to the drawing shown in Figure 1. The bridge-rail elements used in this test will be fabricated in accordance with drawing H-3-7948 for KVNS elements. The location of the supports will be as dictated in drawing H-3-7950.

Minimum support heights for all elements of this test will be 0.087 inch. The maximum circumscribed support circle will be 1.700 inches.

d. Quantity

A total of approximately 4200 elements are required for this test. Of the 760 elements to be used in Part I of the test, 114 will use bridge-rail supports and 646 will use the arch-rail. All elements used in Part II, about 3450, are of the arch-rail type. About 400 weighed and measured fuel elements are required.

e. Pre-Irradiation Testing and Measurement

In addition to all the normal quality tests and measurements, ten columns of fuel elements of this test will have OD and ID at the three standard locations, warp-ellipticity, and length measurements taken and recorded. The weight of these elements will be recorded. Of the ten monitor columns, seven will contain arch-rail elements and three will be formed from bridge-rail elements.

f. Fuel Columns

All fuel columns of this test will contain 38 elements each. The ten monitor columns of this test will be identified as to position number within the fuel column and a series number will identify each fuel column. These identifying letters and numbers will be stamped on the base end of the elements. All remaining fuel elements of this test will be shipped as a group to be lot-charged. All of the lot-charged fuel elements will be identified by special lot number.

3. Process Tubes

All fuel elements of this test will be irradiated in smooth-bore Zircaloy-2 process tubes. The ten monitor fuel columns will be charged into tubes selected by the test author and the assigned reactor engineer, with the concurrence of the Manager, KW Processing.

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4. Thermocouple Probes

Ten downstream thermocouple probes will be used in the test. The tubes into which thermocouple probes are to be installed will be as specified by the test author. At least five of the thermocouple probes must be in operating condition for results of the test to be valid.

5. Irradiation

a. Charging

All fuel columns of this test will be machine-charged in numerical order, number 1 piece downstream. Each column series and/or lot number will be recorded as to the tube into which the fuel was charged. A representative of Research and Engineering will follow charging of the ten monitor columns of this test. No subgoal discharge of fuel columns is authorized to permit charging of elements of this test.

b. Data

Daily flow and temperature data for up to 40 tubes of this test will be recorded on data sheets provided by the test author.

c. Goal Exposure

All monitor columns of this test will be irradiated to 1000 Mwd/t; the lot-charged fuel elements will be irradiated under the normal variable goal plan. Changes in this goal exposure plan may be made by the test author with the concurrence of the Manager, KW Processing and the Manager, Production.

d. Discharge

The ten monitor columns of this test will require special pickup. Up to 30 additional columns, as specified by the test author, may also require special pickup.

No fuel element failures are anticipated in this test. Should a fuel failure occur, however, the fuel columns of this test may be discharged providing that they can be specially picked up.

e. Operating Limits

Operating conditions and limits that apply to the KVNS fuel element model will be applicable to the elements of this test. Existing Process Standards will be used as a basis for these operating conditions and limits. No change in maximum R values is authorized by this test.

The fuel columns of this test may experience a flow rate increase of up to 4 per cent as compared with bridge-coil elements.

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6. Post-Irradiation Examination

The ten monitor columns of this test will receive the normal post-irradiation visual and dimensional measurements in the 105-C Irradiated Fuel Examination Facility. Weight of all of these elements will also be required.

Selected elements may require additional measurement as requested by the test author. Visual examination of up to 30 additional fuel columns may be required. Upon completion of the post-irradiation examination and measurements, all fuel elements are to be retained by the Irradiated Fuel Examination Facility until released by the test author.

HAZARDS

No new or unusual hazards are associated with this test.

PROCESS STANDARDS

No changes or modifications of existing Process Standards are authorized by this test.

COSTS

The outage time lost as a direct result of this test may be assigned to cost code XXX-5R23-XXX.71. An estimate of the outage time required is as follows: for special pickup -- 10 hours; thermocouple probe installation -- 5 hours; total 15 hours.

ISSUE AND EXPIRATION DATES

Elements for Part I of this test will be ready for charging by August 20, 1964. Charging is, therefore, requested for the first outage following approval of this test.

All elements of this test are expected to achieve their goal exposure in less than four months. This test authorization will expire on January 1, 1966.

K. L. Hladek

K. L. Hladek, Engineer
Reactor Engineering
Process and Reactor Development
Research and Engineering Section

KLH:jm

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SPLIT WELD K5 ARCH RAIL

FIGURE 1

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LOAD-DEFLECTION CURVES - K5 SELF SUPPORTS

FIGURE 2

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RESPONSIBILITIES

Production Fuels Section will be responsible for canning, finishing, testing, quality control, and pre-irradiation measurements of fuel elements required in this test.

WMM

Research and Engineering

Process and Reactor Development Subsection will be responsible for over-all coordination of the test, monitoring of fuel element charging as required by this test, selecting specific process tubes as required, reporting in-reactor performance of test material, and analysis of reactor operating data.

h

Process Technology Subsection will be responsible for providing assistance to both Processing Operation and Process and Reactor Development in the pre-shutdown scheduling, for forwarding operating data, for providing assistance in selection of process tubes by the author, and for specification of "Operating Limits."

RLD

Testing Subsection will be responsible for post-irradiation fuel element examination and measuring.

EBL

Manufacturing Section

Production Subsection will be responsible for maintaining accurate records of material charged under this program and for scheduling discharge of the test columns.

RED

KW Processing will be responsible for operational safety and production continuity of the reactor, for charge and special pickup of the test material, for recording operating data as requested, and for installation and maintenance of the downstream thermocouple probes.

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APPROVALS

T. W. Ambrose, Manager
Process and Reactor Development
RESEARCH AND ENGINEERING SECTION

C. G. Lewis, Manager, Testing
RESEARCH AND ENGINEERING SECTION

R. W. Reid, Manager
Process Technology
RESEARCH AND ENGINEERING SECTION

O. H. Greager, Manager
RESEARCH AND ENGINEERING

E. R. Astley, Manager
Applied Reactor Engineering
MANUFACTURING SECTION

R. E. Dunn, Manager, Production
MANUFACTURING SECTION

A. R. Maguire, Manager
KE-KW Reactor
MANUFACTURING SECTION

E. J. Filip, Manager, KW Processing
MANUFACTURING SECTION

R. S. Bell, Manager
MANUFACTURING

J. T. Stringer, Manager
Fuels Engineering
PRODUCTION FUELS SECTION

8/13/64
W. N. Mobley, Manager
PRODUCTION FUELS

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