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REVISION 1 TO PRODUCTION TEST AUTHORIZATION - 026
EVALUATION OF AUTOCLAVE FILMS CORROSION RESISTANCE

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REVISION 1 TO PRODUCTION TEST AUTHORIZATION - 026
EVALUATION OF AUTOCLAVE FILMS CORROSION RESISTANCE

INTRODUCTION

The parent test document¹ authorized a test "to determine the comparative corrosion behavior of standard fuel given special autoclave treatments with fuel given standard autoclave treatment." The test consisted of 20 columns, 46 pieces per column, of K5AE hot-die-sized (HDS) fuel. Four special autoclave treatments, as listed below, were to be tested against the standard autoclave treatment by alternating fuel with a special treatment and fuel having the standard treatment in the downstream half of five columns per each special treatment. Actual investigations and tests^{2,3,4} indicated a marked improvement in the corrosion behavior of 1245 and 8001 cladding alloys when subjected to certain various dichromate autoclave cycles and resulted in developing a dual cycle chromic acid autoclave treatment⁵ which could be adapted to production quantities of fuel. Further investigation^{6,7} resulted in the development of a dual cycle autoclave treatment utilizing a deionized autoclave followed by a neutralized potassium dichromate autoclave treatment that eliminated an undesirable "worm tracking" phenomenon associated with earlier attempts to produce the dichromate autoclave film. As a result, the treatments in Table I were proposed for in-reactor testing.

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TABLE I

SPECIAL AND STANDARD AUTOCLAVE TREATMENTS

Water Cycle: Deionized water
Dichromate Cycle: Potassium dichromate, 8-10 weight percent, pH 6.6-6.8
Time: 25-30 hours each cycle

<u>Treatment</u>	<u>Cycle Temperature (C)</u>	
	<u>Water Cycle</u>	<u>Dichromate Cycle</u>
A	170	170
B	290	170
C	290	230
D	340	230

Standard Autoclave Cycle: Deionized Water, 40 hours, 170 C

In preparing the specially autoclaved fuel for PTA-026, it was noted that some of the fuel had minute inclusions and pits in the dichromate autoclave film, possibly a result of an inadequate solution to the "worm tracking" problem. While it was uncertain as to whether these film defects would actually affect

the fuel performance, a decision was reached to eliminate all such fuel from the test material in an effort to exclude an additional test variable. In addition, general consensus indicated the necessity of eliminating any such film defects to realize the full potential of specially autoclaved fuel from a performance standpoint. Fuel displaying pits and inclusions also posed serious inspection problems. As a result, a decrease in the number of dichromate filmed fuel elements available for this test has been realized.

The test authorized by the parent document was originally scheduled for charging in June, 1966, and was primarily designed to investigate the effects of the special autoclave films on uniform corrosion, with their effect on nonuniform corrosion being secondary. Since this date, primary interest in the test has shifted to investigating the possibility of their providing a barrier to nonuniform ledge and groove corrosion.

OBJECTIVE

The objective of this test is to investigate the possibility of specially autoclaved fuel providing a barrier to nonuniform ledge and groove corrosion and to determine the practicality and benefits of further pursuit of such preventive measures.

TEST SUMMARY

The test will be conducted in KE Reactor instead of KW Reactor as originally authorized in an attempt to distribute more evenly the heavy testing load being experienced at both reactors. The susceptibility to nonuniform ledge and groove corrosion of fuel with four different dual cycle dichromate autoclave films will be compared to the performance of normally autoclaved control fuel fabricated from the same lots.

The test will be comprised of 18 51-piece K5AE fuel columns. The specially autoclaved fuel will be located in positions 1-8 of 15 columns to be irradiated to approximately 800 Mwd/t, and in the downstream 10 positions of three columns to be irradiated to approximately 400 Mwd/t, where it will be striped according to the test design.⁸ The remainder of the fuel columns will be composed of standard production K5AE fuel.

As the preservation of the autoclave films is very important in obtaining valid test results, hand charging of the fuel is authorized. If, upon the concurrence of the Manager, KE Processing, and the test author, it is felt that adequate control can be maintained, the downstream 10 pieces of each column only need be hand charged. The remaining 41 pieces of each column could then be machine charged in an effort to reduce the amount of outage time required by this test.

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BASIS AND JUSTIFICATION

Table II lists the quantity of variously treated fuel included in the original test design* and those currently available for testing after screening out all fuel elements displaying pits or inclusions in the autoclave film.

TABLE II
ORIGINAL AND PRESENT SPECIALLY AUTOCLAVED FUEL INVENTORY

<u>Treatment</u>	<u>Original Inventory</u>	<u>Present Inventory</u>
A	60	12
B	60	24
C	60	26
D	60	23

The severe reduction in the number of available test elements would at first glance appear to have an adverse effect on any test design. Ledge and groove corrosion, however, is seldom observed beyond position 9 or 10 in enriched fuel columns, and the greatest severity is concentrated in positions 2 through 5 in the column. This fact has permitted the design to include only the downstream eight positions instead of the downstream 24 positions used in the original test. The control, standard autoclaved K5AE fuel, will be from the same lot as the test fuel and one control element for each test element will be provided. This design will enable the various autoclave treatments to be compared to the controls as a whole or individually.

The proposed test design will be incapable of detecting a small difference between the performance of the controls and any or all of the various special autoclave treatments. And, of course, the possibility of detecting a variation between the performance of the control and test elements as a whole is greater than detecting a difference between the controls and any one special treatment. A disadvantage of the test resulting from the limited number of test fuel elements available will be that as the observed difference in performance between the control and test fuel decreases, the level of significance that may be associated with the results decreases quite rapidly.

* The original test design included the fuel in the downstream one half of each test column.

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Small differences in performance, however, are relatively unimportant as far as this test is concerned. In order to economically justify special dual cycle autoclaving for production quantities of HDS fuel, the improvement in performance realized by such treatment would appear to require a difference of at least the order of magnitude which can be detected by this test. Thus, the test design will permit one of the following conclusions to be drawn, based on test results:

1. Special dual cycle autoclave treatments for improving HDS fuel performance do not appear to be economically justified.
2. Special dual cycle autoclave treatments for improving HDS fuel performance are worthy of further development and testing.

Additional justification exists for performing this test. It is the first in a series to determine the effect of special surface treatments on localized (ledge and groove) and uniform fuel cladding corrosion. Two similarly directed tests will be conducted in the future, one to test unautoclaved HDS fuel and the other to test nickel-plated HDS fuel. HDS fuel was chosen for these tests in that the bond is better suited to withstanding the severe thermal conditions required to apply some surface treatments and because localized corrosion is presently a limiting factor in HDS fuel performance. These three tests are expected to provide valuable information which will be applicable to the High Power Density Program and to the Basic Plutonium Production Program.

TEST DETAILS

A. Reactor

This test will be conducted at KE Reactor.

B. Fuel Elements

1. Fuel Model

All elements in this test will be of the K5AE model.

2. Fabrication

The elements used in this test will be fabricated according to the Engineering Specifications, Hot Die Sizing Fuel Fabrication Process,⁹ using impact components, with the exception that a number of the test elements, as specified in Table II, will receive the special autoclave cycles listed in Table I.

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3. Supports

All elements will be fitted with arch rails meeting all attachment quality and dimensional requirements for K5AE fuel in the Engineering Specifications.⁹

4. Quantity

A total of 918 K5AE fuel elements will be required for this test. The fuel will be delivered in pallets and will be arranged in the specified charging order. A representative of Research and Engineering will monitor charge make-up. Spare elements will be provided with the test material.

5. Pre-Irradiation Testing Measurements

In addition to all normal quality tests and measurements, the downstream 10 elements will have warp-ellipticity, OD and ID measurements at the three standard locations taken and recorded. The downstream 10 pieces shall be weighed. Individual columns will be identified by a series number and a position number for identifying each position within any column.

6. Fuel Columns

The fuel columns will be 51-piece K5AE columns and will require a standard (K5N equivalent) downstream dummy pattern.

C. Process Tubes

It is intended that these columns be irradiated as support in the current E-D loadings at KE Reactor. The columns shall be exposed in central zone zirconium process tubes. The tubes will be chosen by the assigned Process Physicist in conjunction with the test author, and subject to the approval of the Manager, KE Processing. In choosing the process tubes, it should be remembered that goal exposure for the test material is 800 Mwd/t.

In view of the current E-D loading schedule at KE Reactor, it should not be necessary to discharge sub-goal columns to provide space for this test. If circumstances indicate that a delay in charging the test material may be avoided by discharging sub-goal material, such action is authorized.

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D. Irradiation

1. Charging

The test fuel columns will be hand charged in the specified numerical order, or if agreed upon, only the downstream 10 elements of each column will require hand charging. The appropriate column series number will be recorded with respect to the particular tube into which each series is charged. A representative of Research and Engineering will monitor the charging.

2. Data

Daily flow and outlet temperature data will be recorded by KE Processing personnel and forwarded to the test author. Forms for recording the data will be provided by the test author.

3. Goal Exposure

Three columns, to be specified by the test author, will be discharged at approximately 400 Mwd/t to provide a check on fuel performance at intermediate exposures. The remaining columns shall be irradiated to ~800 Mwd/t. As in the parent document, it is not intended that failures be sustained in this test. No previous in-reactor experience is available for K5AE fuel at normal power levels, and this in itself might be expected to increase the possibility of a failure. PTA-011 has provided data on operation with K5AN fuel to goal exposures under normal conditions. While the frequency of nonuniform corrosion has generally been greater on HDS fuel than on AlSi fuel, the capability for irradiation to goal exposure has not been seriously affected.¹ In addition, in- and out-of-reactor tests involving similar and identical autoclaved elements, respectively, have shown increased resistance to corrosion. The majority of the fuel involved in this test, however, is normally autoclaved K5AE.

In the event of a fuel failure, the disposition of the remaining unruptured test columns shall be determined following evaluation of circumstances surrounding the event. Discharge of all or part of the test prior to goal exposure is subject to mutual concurrence of the Manager, KE Processing and the Manager, Fuels Engineering Subsection.

4. Discharge

All fuel columns of this test will require special pickup. The early

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discharge columns should be stored in a separate bucket. The remaining fuel can be stored with a maximum of five columns to a single bucket.

5. Post-Irradiation Examination

The test fuel will require shipment to the 105-C Fuel Examination Facility for post-irradiation examination. The elements will receive warp-ellipticity and OD and ID measurements at the three standard locations. The downstream eight pieces shall be weighed. Test fuel shall remain at the 105-C Fuel Examination Facility until released by the test author. Single elements may be selected for examination in the Radiometallurgy Laboratory of BNW.

E. Process Standards¹⁰

The charging of K5AE fuel as specified by this document is hereby authorized. Process Standards are not affected in any other respect and shall remain applicable to this test irradiation.

F. Hazards

No new or unusual hazards are associated with this test. Past experience has revealed no detrimental effects to reactor operation resulting from the use of similar special autoclave films.

G. General

1. Schedule

Charging of the test material is requested for the first available outage at KE following approval of this test. This authorization shall expire December 31, 1968.

2. Costs

The maximum primary outage costs incurred as a result of this test will be associated with charge-discharge and special pickup of the test material. The maximum estimated time for these operations is:

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Charging	4-1/2 hours
Discharging and special pickup	<u>2-1/2 hours</u>
Total	7 hours

Costs resulting from outage time requirements for this test may be assigned to cost code XXX-5R41-XXX.71.

J. P. Schmidt, Engineer
Product Engineering Unit
Fuels Engineering Subsection
Research and Engineering Section

JPS:cmd

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RESPONSIBILITIES

Production Fuels Section shall be responsible for fabricating, identifying, and measuring all test fuel as per applicable specifications and details specified herein.

For
W. M. Mathis, Manager
Production Fuels Section

Research and Engineering Section

Fuels Engineering Subsection shall be responsible for over-all test coordination, for reporting of in-reactor operating data and analyzing test results, for monitoring charge make-up and charging of the production test fuel, and for concurring in the selection of process tubes by the assigned Process Physicist.

J. T. Stringer, Manager
Fuels Engineering Subsection

Reactor Engineering Subsection shall be responsible for providing assistance to the KE Processing Unit in pre-shutdown scheduling and fuel charging as requested, and for forwarding test data to the test author.

Re
R. W. Reid, Manager
Reactor Engineering Subsection

Physics Subsection shall be responsible for selection of process tubes to be used for this test, with the concurrence of the test author and the Manager, KE Processing.

G. F. Owsley, Acting Manager
Physics Subsection

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Testing and Irradiation Services Subsection shall be responsible for the post-irradiation examination of the test fuel in the Irradiated Fuel Examination Facility as specified herein.

L. V. Barker, Acting Manager
Testing and Irradiation Services

Manufacturing Section

Production Subsection shall be responsible for maintaining records of exposure for the test columns, and for scheduling charge-discharge of the test fuel columns as specified herein.

A. P. Vinther, Manager
Production Subsection

KE Processing Unit shall be responsible for charge-discharge and special pickup of test fuel, for recording operating data as required, and for concurrence of the process tubes selected for this test.

R. G. Clough, Manager
KE Processing Unit

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APPROVALS

R. W. Reid

R. W. Reid, Manager
Reactor Engineering Subsection
Research and Engineering Section

G. F. Owsley

G. F. Owsley, Acting Manager
Physics Subsection
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R. S. Bell

R. S. Bell, Manager
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W. M. Mathis

For W. M. Mathis, Manager
Production Fuels Section

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