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July 27, 1959

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Process and Reactor Development Sub-Section
Research and Engineering Section
IRRADIATION PROCESSING DEPARTMENT

PROPOSED PROJECTION FUEL TESTING PROGRAM II

INTRODUCTION

Sufficient changes in the original projection fuel testing⁽¹⁾ schedule have occurred to make the original schedules confusing. It is the intent of this document to revise and up-date those schedules so as to be a more realistic guide for associated development programs.

OBJECTIVE

The program objective is to develop the technical feasibility and justification for the use of projection fuel elements on as rapid a schedule as possible. The concepts considered for testing include: a) ribbed fuel elements for use in current ribbed process tubes specifically to eliminate the purported cause of hot-spot ruptures, i.e., misalignment, (bumper concept), and b) projection fuel elements for use in ribless process tubes to not only eliminate misalignment but also to permit flexibility in fuel design after installation of zirconium process tubes (self-supported concept). Even if the hot-spot rupture problem is not solved by the projection fuel elements, the program must still develop the self-supported concept in time to meet potential ribless zirconium tube installation schedules.

SUMMARY

The attached program outlines the steps to be pursued in development of the projection fuel concept. It specifically outlines development of an acceptable bumper fuel element and associated equipment by July 1960 as an interim measure that may be used to reduce the hot-spot rupture incidence without replacing all process tubes; and the development of self-supported fuel elements on a schedule to support the zirconium tube testing program. The program is summarized in the attached chart indicating previous testing and forecasting testing and development schedules currently deemed feasible.

GENERAL

Two concepts are to be considered for testing initially in this program; 1) the self-supported projection element for use in ribless or vestigial ribbed process tubes, and 2) the bumper projection element for use in ribbed process tubes in which the element is tube-rib supported and the projections act only as bumpers to guarantee the annular flow area. It is understood that the optimum fuel concept from the zirconium tube concept is a self-supported element in which fuel-tube flexibility is attained. The bumper concept may provide an economic means of reducing the incidence of hot-spot ruptures pending the change-over to the zirconium

Reference

1) HW-59149, "Proposed Projection Fuel Testing Program," E. C. Wood, 2/6/59.

tubes and eliminating the need for an immediate crash tube replacement program.

The bumper and self-supported fuel elements to be tested are similar in appearance and manufacturing techniques, differing only in dimensions. To both classes, collapsible bridge rail supports are either spot welded or ultrasonically welded, four near each end on ninety degree centers. The fuel element is a normal AlSi dip canned I and E fuel element, meeting all quality control standards prior to rib attachment. The self-supported projection element is designed for use in ribless process tubes and as the name implies, the projections maintain centering of the element. This concept is also adaptable to use with a "guide-rib" tube for poison spline useage. The bumper fuel element on the other hand was designed to provide the benefits of projection fuel elements during the period before process tube replacement. It is envisioned as being a projection element supported with the ribs of the process tube; the projections acting merely to guarantee a minimum annulus clearance. This clearance is of the order of 15 to 25 mils in the various tube geometries.

Many unanswered problems are involved in the bumper concept, however, the chief one being the technical feasibility of the program. Fuel element instability and rupture could cause sticking problems too severe to be practical. It does, however, offer a potential solution to the hot-spot rupture problem which makes it attractive economically.

Preliminary test loadings which have been accomplished to date are:

- a) Nine columns of solid fuel elements self-supported in ribless aluminum process tubes at B Reactor were irradiated to goal exposures up to 500 MWD/T without evidence of a hot-spot flow pattern. Even though patterns were observed on the control fuel elements, the test was of insufficient size to be statistically significant.
- b) Thirteen columns of I and E natural fuel have been irradiated to exposures up to 870 MWD/T, also in B Reactor, and visual examination has revealed no hot-spots. These data are significant statistically and indicate a reduction in hot-spot incidence of at least a factor of 4 at greater than 99% confidence levels and a factor of 10 at the 95% level as compared with a sample of normal production elements chosen at random from material in the discharge area.
- c) Ten columns of bumper I and E fuel elements were charged into KW Reactor during March 1959 to investigate difficulties expected with this concept. One column was discharged inadvertently during the next outage, and one column was discharged without evidence of hot-spots at approximately 600 MWD/T. The other eight columns and the ten control columns are scheduled for irradiation to 800 MWD/T. They should be ready for discharge about August 1, 1959.

The future program is outlined on the attached plot and includes:

- a) An irradiation test of 4 columns of 1.4% enriched I and E self-supported elements and controls in B Reactor until one rupture is sustained to evaluate the capability of this concept to withstand irradiation at specific powers up to 100 KW/ft, and to attempt to establish rupture resistance.

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- b) A demonstration scale loading of up to 100 columns of self-supported I and E elements in C Reactor utilizing ribless zirconium process tubes to pilot operation with this concept.
- c) A 100 tube demonstration test, split 20 tubes per old reactor, of I and E natural bumper fuel elements and controls to pilot operation with this concept.
- d) A 4 tube run-to-failure test in F Reactor of 0.94% enriched I and E bumper elements and controls to attempt to evaluate rupture resistance of this concept.
- e) Preliminary test loadings in the K and remaining old reactors to test fuel calculations prior to a large scale loading.

It is assumed that equipment development problems can be solved to meet this schedule; however this may not be the case. Listed in the appendix are the various phases of associated program which would require attention and it is the intention of this report to outline the schedules which should be met to accomplish this. These are arranged in tabular form for easy reference. The overall program is summarized in the attached sketch.

It is emphasized that this schedule is based primarily on fuel element availability schedules, and that other factors such as tube availability, reactor equipment development and reactor outage scheduling could alter the timing. Current zirconium tube delivery schedules are considered in this report. In addition, as with any program, negative or inconclusive results could likewise cause delays. Comments from other groups regarding the scheduling would be appreciated in order that future schedules may reflect insofar as possible these problems.

Acting Supervisor
Reactor Fuels Unit
Process and Reactor Development Sub-Section
Research and Engineering Section
IRRADIATION PROCESSING DEPARTMENT

AC Callen:RE Hall:gb

A. GENERAL PROGRAM

OLD REACTORS

Past Nine columns of solid natural self-supported elements irradiated to exposures up to 550 MWD/T and 60 KW/ft of U at B Reactor. No hot-spots observed. Six columns of I and E natural self-supported elements were exposed to 400-600 MWD/T at B Reactor. No hot-spots evidenced. Rib condition excellent. Conditions were less even than with the solid elements due to geometry.

Present Thirteen columns of I and E natural elements are now operating to 800 MWD/T exposures at powers in the range of 800-100 KW/Tube at B Reactor. (Self-supported elements).

Future Charge 4 columns with 1.47% E-metal to approximate powers in range of 1600 KW/Tube. (Self-supported elements).

Charge a 100 tube bumper test at D, DR, F, H, and B Reactors about 8-59 (20 tube/reactor), to evaluate on demonstration scale the results of K test.

Charge 4 columns of 0.947% enriched bumper fuel elements and controls for irradiation until two ruptures are sustained in each type.

K REACTORS

Nine columns of bumper type I and E elements are under irradiation at KW Reactor as a preliminary test. Goals are 400-800 MWD/T in power range 1150-1300 KW/Tube.

C REACTORS

Replace 100-200 tubes with ribless tubes for concurrent development of self-supported and zirconium tube concepts.

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B. SLUG REQUIREMENTS

<u>Date Required</u>	<u>Number and Description</u>
Now and continuous	4 columns per month of OIIN self-supported fuel elements for the current test in B Reactor.
7-59	4 columns of 1.47% enriched OIIN geometry (7" length) for a run-to-failure test at B Reactor. (24 pieces per charge).
7-59	30 columns of OIIN bumper fuel elements and 30 columns of OIIN controls for the first portion of the bumper demonstration loading.
8-59	30 columns of OIIN bumper fuel elements and 30 columns of OIIN controls for the second portion of the bumper demonstration test.
8-59	4 columns of 38 pieces each, 0.947% enriched OIIE geometry plus 4 control columns of OIIE elements for a run to failure test at F Reactor.
8-59	2 columns of CIVN (1.500 x 0.380 natural) self-supported fuel elements for preliminary in-reactor verification of flow and heat split calculations. (One column also required for laboratory testing).
9-59	40 columns of OIIN bumper fuel elements and 40 columns of OIIN controls for the last portion of the bumper demonstration test.
10-59 to 12-60	30 columns per month continuously of CIVN self-supported fuel elements for support of the C Reactor self-supported demonstration facility.
4-60	10 columns of KIVN and KIVE (sizes unknown) self-supported I and E fuel elements for preliminary K reactor determination of operating characteristics.
6-60	10 columns of OIVN and OIVE (sizes unknown) self-supported I and E fuel elements for preliminary verification of calculated operating characteristics in the old reactors.

C. CHARGE MACHINE DEVELOPMENT

<u>Date Required</u>	<u>Description</u>
10-59	A prototype C reactor charge machine capable of charging CIVN (1.500 x 0.3800) elements to support the 100 tube demonstration facility.
6-60	A "final" design C reactor charge machine capable of normal charge machine performance for eventual use at C reactor. It should be capable of handling smooth and projection fuel elements.
6-60	A modified charge machine prototype capable of initial charging of bumper fuel elements at K and the older reactor areas.
8-60	A modified charge machine prototype capable of charging self-supported fuel into the K reactors.

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CHARGE MACHINE DEVELOPMENT (continued)

<u>Date Required</u>	<u>Description</u>
10-60	A prototype charge machine capable of charging self-supported fuel into each of the old reactors.
1-61	"Final" design charge machines for all reactors capable of charging smooth and both types of projection elements (where required) at normal charging rates.

D. NOZZLE DEVELOPMENT REQUIREMENTS

<u>Date Required</u>	<u>Requirement</u>
10-59	Front and rear nozzles for use at C reactor for the 100 tube demonstration test. Rear nozzles can probably be reamed but new front nozzles will probably be required since the diameter must be increased from 1.500 to 1.680.
4-60	Front and rear nozzles for use at K reactor. Should be capable of both bumper and self-supported use.
6-60	Front and rear nozzles for use at the old reactors. Should be capable of use with both bumper and self-supported elements.

E. TUBE REQUIREMENTS

<u>Date Required</u>	<u>Requirement</u>
10-59	100 ribless C reactor zirconium tubes.
4-60	10 ribless K reactor zirconium tubes.
6-60	10 ribless old reactor zirconium tubes.

F. DUMMY SPACER ELEMENTS

Sufficient dummies should be procured of the self-supported type (an example of which is depicted in SK-1-3688) to support each self-support loading after the preliminary loading at C reactor since FPD capability will not be sufficient to handle the added load. Procurement should be handled by the individual reactor areas.

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BUMPER CONCEPT PROGRAM

SELF SUPPORTING CONCEPT PROGRAM

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