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PROCESS IMPROVEMENT TRANSITION AUTHORIZATION
IP-14-I

D REACTOR FULL PILE LOADING OF BUMPER FUEL
ELEMENTS

AUTHOR

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PROCESS IMPROVEMENT TRANSITION AUTHORIZATION IP-14-I
D REACTOR FULL PILE LOADING OF BUMPER FUEL ELEMENTS

OBJECTIVE

The purpose of this PITA is to authorize full pile loading of natural and enriched bumper fuel elements in D Reactor. Incentives for loading bumper fuel elements in the fringe zone will be reviewed and, if desirable, recommendations to curtail fringe loading may be made based on economic considerations.

BASIS AND JUSTIFICATION

Prior to 1957 all Hanford reactors operated with a standard solid fuel element which had been in use since Hanford operation began. However, as power levels and reactor operating conditions increased in severity, these solid fuel elements caused more and more production losses because of ruptures. These ruptures could be broadly classed in two categories as "splits" and "hot spots." Split type ruptures were related to elevated temperatures in the core of the fuel element so the I&E fuel element was devised to cool the core. Loading of the I&E elements began in C Reactor in 1957 and proceeded through the other reactors in 1958 and 1959. The I&E fuel element has successfully eliminated split type ruptures; however, as power levels and reactor operating conditions increased further in severity, hot spot type ruptures became more significant.

Several improvements in the original I&E fuel element have been made which have increased hot spot rupture resistance. However, one of the many postulated causes of hot spot ruptures, misalignment of fuel elements in the tube, has not been eliminated. Misalignment of a fuel element in the tube means that a slug is close to or touching the inside surface of the tube. Consequently, there is less water going by the slug, less heat transferred to the water, and an increase in the surface temperature of the slug at that point causing a "hot spot." The increased temperature at this hot spot causes accelerated corrosion and if the slug remains in the pile long enough, corrosion may proceed down to the uranium core causing a rupture.

A new I&E fuel element design has been proposed which would reduce fuel misalignment. This slug has rails attached to its sides which physically prevent the slug from coming closer than a predetermined distance to the inside surface of the tube. Run-to-rupture and other tests of these slugs (termed bumper slugs) have shown that they reduce hot spot incidence⁽¹⁾⁽⁴⁾, and that, under the test conditions, bumper slug rupture performance was a factor of 38 better than normal I&E slugs irradiated under similar conditions (at the 95 per cent confidence level)⁽²⁾. In order to obtain conclusive results from these run-to-rupture tests in a short length of time and to compare bumper and regular fuel element performance on the basis of only hot spot induced ruptures, 1.47 per cent enriched slugs with high tube powers were used. However, under normal operating conditions, tube powers will be less and tube exposures will be longer. This means that greater amounts of uniform corrosion⁽⁵⁾ will occur under normal operating conditions, and if hot spot corrosion and subsequently hot spot

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ruptures are essentially eliminated, uniform corrosion may proceed to the point where ruptures occur. An estimate of a uniform corrosion rupture model has been made, and under similar normal operating conditions it has been estimated that bumper fuel element performance will be better than regular I&E performance by roughly a factor of $10^{(3)}$.

The purpose of this authorization is to implement full scale loading of bumper slugs into D Reactor so that their performance may be piloted for the rest of the Hanford reactors. A factor of 10 improvement in fuel element performance will result in an increase in production in MWD's and/or an increase in net return. Early application of this potential advantage to the other Hanford reactors is obviously desirable so complete central zone loading of bumper slugs has been specified in essentially one metal cycle and the highest reasonable exposure has been specified. This will help to indicate any large differences in fuel element rupture performance from those anticipated, will speed eventual evaluation of the true rupture performance, and will indicate the magnitude of any serious practical problems associated with full scale pile loading all of which is necessary before all Hanford reactors are committed to bumper slugs.

TEST DETAILS

A. Slug Design

The following specifications are applied to fuel elements authorized for loading under this PITA.

1. All fuel elements will be the three-bumper design so that they can be oriented to allow the use of poison splines⁽⁷⁾.
2. All fuel elements will be the O-III-NB and O-III-EB type⁽⁶⁾ except for a few O-II's that have already been canned or that might be canned before complete conversion to O-III's.
3. Current model mixer slugs will be used to make mixer bumper fuel elements.
4. Rails will be the current design as specified in drawing H-3-17003, Rev. 2. In addition, all finished slugs will conform to drawing H-3-7950, Rev. 3.

B. Restricted Reactor Locations

1. Bumpers normally may be loaded anywhere below 38 row in the central zone. However, there have been indications that some new process tubes do not meet specifications; new process tubes which do not meet required specifications or which are deformed in some way when installed may not pass bumpers below 38 row. Because of these possibilities it is recommended that new tubes being installed in the pile be checked in such a way that correct internal dimensions are guaranteed through the entire length of the tube. In addition, extreme care in installing tubes must be exercised in order to prevent any deformation of the tube.

2. Loading of bumpers on 38 row or above will be recommended by the Process Engineer based on probing data, traversing data, and tube data.

C. Loading Schedule

Full scale full pile loading of bumper fuel elements is targeted for January, 1961, and will be essentially completed in one metal cycle. Front nozzle and charging machine modifications will have to be made concurrently with loading; therefore, any serious problems with the new charging machines or with execution of nozzle modifications may cause a large drop in charging rates and may delay or stretch out this schedule.

D. Power Levels and Goal Exposures

Currently planned power levels will be followed, and an average goal exposure of 900 MWD/T is specified for all tubes. However, changes in power level and/or goal exposure to take advantage of bumper slug experience will be recommended by Process Technology Sub-Section. Other changes in power level and/or goal exposure which are appropriate because of changes in the process not connected with bumper slugs may be made as they are normally made at present.

E. Flow and Panellit Changes

There will be no significant difference in tube flows or Panellit pressures between O-III bumper slugs and the current O-II fuel elements. Those few O-II bumper slugs loaded will cause a flow decrease of about five per cent and corresponding slight Panellit pressure increases.

F. Charge Column Makeup

No change in column length or makeup will be made as a result of the bumper slug load except that a revised mixer slug location will be recommended by Process Technology Sub-Section by February 1, 1961. The new mixer location will be picked on the basis of minimizing tube and slug corrosion in order to obtain the best overall tube and slug performance.

HAZARDS, PROBLEMS, AND PROCESS STANDARDS

- A. Bumper slugs are not specified by Process Standards for use in any reactor. This PITA authorizes full pile loading of bumper slugs into D Reactor. Applicable process standards will be reviewed for revision upon successful demonstration of bumper slugs as normal production fuel elements.
- B. A suitable procedure for modifying the front-face nozzles to meet bumper slug specifications and for insuring that they meet minimum safety requirements has not been completed. Several IPD components are currently working on this problem, and a final modification will be authorized by a design change. However, the present loading schedule depends on the speedy solution of this problem, and a delay will mean the current goal to begin loading in D Reactor during January, 1961, may not be met.

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- C. The use of bumper slugs may increase the number of stuck slugs (including those obtained when charging into distorted or bad process tubes and those obtained from slugs warped during irradiation) and damaged tubes. The magnitude of this problem is difficult to predict, but it will be determined from the experience gained in loading and operating with bumper slugs as authorized by this PITA. This problem will be minimized in sections of the reactor where severe graphite distortion exists by the probing and traversing program that is planned at D Reactor. Also, new tubes that do not meet required specifications should not be inserted into any section of the reactor; this could cause an increase in the potential for stuck slugs and a large increase in the rupture potential. Tubes which can be charged but which are being scratched when they are charged may need to be examined based on some suitable schedule in order to determine the extent of damage caused by scratching. Such a schedule would be determined based on tube examination and experience gained from operation with bumper slugs.
- D. The program of nozzle modification and replacement that is finally developed must be done as speedily as possible in order to reduce outage time losses. However, nozzle alignment on the pile will be more important because the broached nozzles will expose more of the entrance lip of the tube thereby increasing the potential for tube damage during the charge-discharge operation. Consequently, correct and accurate nozzle alignment must be assured as the nozzles are replaced. In addition, a program of front Van Stone flange examination may be required in the future to determine the extent of any damage caused by charge-discharge.
- E. Ruptured bumper slugs may be harder to remove than ruptured normal slugs. They may require higher pushing forces and may cause more tube and graphite damage. The extent of this problem is difficult to predict, but will be developed from the experience gained in loading and operating with the bumper slugs. Appropriate changes in stuck rupture pushing procedures and/or methods of detecting and shutting down for bumper slug ruptures will be made, if necessary, as a result of bumper slug operating experience.
- F. Bumper slugs irradiated to an average goal exposure of 900 MWD/T are not expected to cause any significant extra physics problems as long as poison splines can be used. However, there may be some minor power level restrictions during startup which are imposed by speed-of-control considerations. Special procedures, if necessary, will be specified by the Operational Physics Sub-Section prior to full-pile loading of bumper fuel elements.
- G. No additional difficulties in administration of TAI limits will result from the bumper slug load.
- H. Several metal handling problems will need consideration when bumper slug loading commences. These include possible re-establishment of rear face tip-offs during charge-discharge, difficulties in getting slugs down the discharge chutes, revised storage bucket loading procedures, etc.

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COSTS

Funds required for modification of front-face nozzles and for modification of the charging machines will be borne by the Manufacturing Section. A future, improved charging machine is being developed and will be funded on an Appropriations Request.

Because of the potentially serious problems discussed in items C and E above, up to ten tubes are authorized by this PITA for borescopic examination, if necessary, with the concurrence of D Processing Operation.

Other special work required for assessing tube and slug performance from operation with bumper fuel elements will be (or have been) authorized with other production tests.

All other costs incidental to charging bumper fuel elements into D Reactor will be borne by D-DR Reactors Operation.

RESPONSIBILITIES

A. D-DR Reactors Operation will be responsible for:

1. Making all necessary modifications to plant equipment such as charging machines, front-face nozzles, nozzle alignment equipment, loading pallets, etc., and for issuing a design change on the nozzle modifications.
2. Scheduling and loading bumper fuel elements, and overall coordination of the bumper fuel element program at D Reactor.
3. Operating the reactor with bumper fuel elements in a safe manner and in accordance with process standards.
4. Obtaining any data requested to evaluate reactor operation with bumper fuel elements.

B. Process Technology Sub-Section will be responsible for:

1. Reviewing reactor operation with bumper fuel elements and recommending any appropriate changes in reactor operating conditions such as power level and goal exposure.
2. Reviewing process standards for appropriate changes based on experience gained with reactor operation with bumper fuel elements.
3. Assessing bumper slug rupture performance and establishing a revised rupture model if required.
4. Recommending a new mixer slug location which will balance both tube and slug corrosion for best overall reactor performance.
5. Recommending tubes in the pile where bumper slugs should not be loaded because of distortion severe enough to cause stuck slugs.

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C. Operational Physics Sub-Section will be responsible for:

1. Insuring that the reactor conforms to established total control and speed-of-control criteria at all times.
2. Making all necessary enrichment and control changes to support the bumper fuel element load at the goal exposures specified.

D. Process and Reactor Development Sub-Section will be responsible for:

1. Revision of O-III-NB and O-III-EB slug design as required. Any deviation from the design specified on Page 3 "Slug Design" shall be authorized by a supplement to this PITA.
2. Providing technical bases to Process Technology Sub-Section to use in assessing tube corrosion performance. These bases will be used in conjunction with fuel element quality calculations to obtain an optimum mixer slug location.
3. Providing necessary bases for speed-of-control standards prior to full-pile loading of bumper fuel elements.

E. Applied Reactor Engineering Operation will be responsible for:

1. Specifying an acceptable front-face nozzle design.

F. Facilities Engineering Section will be responsible for:

1. Developing acceptable modified charging machines.

JL Benson:md

Process Engineering Unit
Research and Engineering

- (1) HW-60444 D, Clinton, MA, "Supplement A to PT IP-262-A-11-FP, Evaluation of Projection Fuel Elements for Use in Ribbed Process Tubes," 10/7/59, (Secret).
- (2) HW-60444 E, Clinton, MA, "Supplement B to PT IP-262-A-11-FP, Evaluation of Projection Fuel Elements for Use in Ribbed Process Tubes," 6/20/60, (Secret); and Personal Communication, Clinton, MA, 11/1/60.
- (3) Personal Communication, Bloomstrand, RR, 11/8/60.
- (4) Many hot spots appear on slugs which are not ruptured. Generally, it can be said that a greater number of hot spots on a particular group of slugs indicates that the chances for a hot spot rupture in that group are greater.

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- (5) Metal is always being corroded away from the slugs while they are in the reactor. If the slugs are aligned normally, corrosion proceeds more or less "uniformly" over the outside surface of the slug. If a slug is misaligned, a hot spot occurs as explained above and greatly accelerated corrosion occurs.
- (6) This includes dingot material as authorized by HW-65395, Sup. C, "Supplement C to PITA IP-10-I, Irradiation of Alloyed Dingot Uranium Fuel Elements," Shimer, RD, 10/12/60, (Secret).
- (7) Any fuel elements of the four-rail design will be charged under authorization of a separate production test.

APPROVALS

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