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~~PRODUCTION TEST~~ IP-85-A

WATER SHUT-OFF DURING SHUTDOWN AT
C REACTOR.

AUTHOR

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DATE _____

Apr 11 24, 1958

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IRRADIATION PROCESSING DEPARTMENT
April 24, 1958

PRODUCTION TEST IP-85-A
WATER SHUT-OFF DURING SHUTDOWN
AT C REACTOR

OBJECTIVE

1. To measure reactor shutdown uranium fuel core temperatures after water shut-off to process tubes or crossheader, at C Reactor.
2. To measure heat generation in reactor tubes after shutdown.
3. To obtain basic lattice conductance data for reactor safety and other considerations.

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BASIS AND JUSTIFICATION

At the present time the standards relating to the allowable water shutoff times for reactor tubes and crossheaders are based on theoretical calculations. The resulting limits are believed to be quite conservative and to restrict operations unduly in many instances. They are restrictive because of the low accuracy of the conductivity and resistance data on which they are based. It is the purpose of the test to obtain the experimental data necessary to determine new water shut-off curves for the reactors. When reliable information is obtained for elevated temperature lattice conductance then theoretical calculations applying to those values will be far more accurate. The information will be related to water shut-off times, reactor safety considerations such as rod strength and drop time versus uranium fuel melting, etc. It can be roughly estimated that this information will reduce the time delay before tube and/or cross-header water shut-off by as much as 25%. This will save approximately one to two days production per year or about \$60,000.

The value of this information with respect to reactor safety is more intangible but it is possible that even greater savings could develop if the results of these tests were to eliminate the need for an expensive reactor modification.

PROCEDURE

A detailed procedure is presented as an unclassified appendix to this report. In summary, each test will be conducted following reactor shutdown by charging special probes into tubes containing natural and enriched uranium I & E charges. The probe will be loaded into the bore of the central I & E slugs and a thermocouple element forced against the bore surface.

At definite times after shutdown the water flow to the tube will be stopped and the temperature of the central fuel element followed on a calibrated temperature recorder. The times required to reach the set limits of 100, 150, 200, 250, 350 and 450 C will be recorded. The bore temperature should not be allowed to exceed 300 C until just prior to the discharge of the tube. After each successive limit is reached, water flow will be returned to the tubes and the charges allowed to cool down until the outlet temperatures of the tubes are similar to surrounding tubes.

In addition the heat generation rates of the tubes will be determined at various times after shutdown. This will be done by measuring the tube flows, inlet water temperatures and outlet water temperatures of the test tubes.

PROCESS STANDARDS

Process Standard A-C30 specifies the time that water may be removed from a tube or crossheader. One purpose of this test is to obtain more accurate values of water shutoff times.

For the purpose of this test Process Standard A-010, Section 10.03 shall not apply.

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SCHEDULE

The first series of tests under this production test are to be conducted at C-reactor at the first opportunity following the approval of this test.

COSTS

Cost Code: XXXX-5320-72

Outage Time: This test authorizes the use of three hours of shutdown time on four separate shutdowns.

Manpower Requirements: The special nozzle and pigtail will be installed by maintenance personnel. The special thermocouple probe as well as temperature and flow instrumentation will be installed by Irradiation Testing Operation. Measurements will be made and recorded by Irradiation Testing Operation personnel under the supervision of the author of this test or his delegated representative.

Equipment: Special temperature probe equipment has been built and will be used in these tests. This equipment will all be tested in the flow laboratory before being used in the reactor. Special front nozzles will be installed and tubes will be used that have the special outlet temperature probes being used for a number of I & E charges.

REACTOR SAFEGUARDS

The following precautions will be observed in the operation of these tests:

1. The probe temperature or tube outlet temperature of the test tube will be continuously monitored whenever its water flow is reduced below the normal shutdown flow. The test tube will be continuously monitored by both whenever the flow is stopped. Maximum probe and tube outlet temperatures are to be specified and shall not be exceeded.
2. The probe temperature monitor system will be set to give an audible alarm whenever the temperature reaches a pre-determined value and water flow will immediately be returned to the test tube.
3. For each test, maximum theoretical water shut-off times will be established that shall not be exceeded.

SPECIAL HAZARDS

Steam formation will undoubtedly occur in the test tubes. Personnel should be protected from the hazards of steam burns or radioactivity by having the rear of any test tube open to the drain riser, and by having no openings at the front of the tube for steam emission. Sufficient riser pressure will be maintained at all times to sweep steam from test tubes when header is unthrottled. Riser pressure will be specified by Process and Reactor Development Operation.

As a guide for expected charge temperatures the values presented in EW-55335 should be used.

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RESPONSIBILITY

Processing Operations:

1. Operational safety
2. Production continuity
3. Scheduling of the test
4. Installation and removal of the special front face nozzles and pig-tails.
5. Cross-header valving performed in conjunction with the test.

Research and Engineering Operation:

Process Technology Operation:

1. Selection of tubes for the production test.
2. Coordination of this test with other production tests.

Process and Reactor Development Operation

1. Evaluation of the process implications of the test.
2. Issue a final report of the test and recommendations of process interest.

Irradiation Testing Operation:

1. Design and test the special equipment used in this test.
2. Installation and control of equipment during the test and the removal of the test equipment when the test is completed.
3. Conducting the test and collection of pertinent data.
4. Installation of the special outlet temperature probes for the desired test tubes.

Reactor Engineering Operation
Research and Engineering Operation

Process Engineering Operation
Research and Engineering Operation

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APPENDIX I

DESCRIPTION OF EQUIPMENT

1. Outlet Temperature Probe: This will be the standard I & E temperature probe that is now in use in many of the I & E tubes at the reactors now charging I & E metal.
2. Front Face Fittings: These consist of a special nozzle and pigtail as shown in Figure 1.

The nozzle is a standard front face nozzle shortened to allow elevator clearance for the test assembly; and with a special end-cap that has a sealing gland for the introduction of the temperature probe. This should reduce water leakage down to a negligible value. The pigtail contains both a flow meter and a special valve for shutting off water flow. This is a plug valve with a clearly marked valve position and a positive means of locking this valve in the open position. This will be installed on the desired test tube at the start of the testing period and removed prior to startup of the reactor.

3. Bore Temperature Probe: The first model of this assembly is shown in Figure 2. It consists of a push-pull flexible cable modified to have an expanding mechanism at the inner end, a control lever outside the tube, and a thermocouple element to measure fuel bore temperature.
4. Auxiliary Equipment: This will consist of a high temperature recorder and a sensitive flow indicator. At all times this test tube or tubes are to be connected into the usual Panellit and outlet temperature monitor systems.

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APPENDIX II

Out-of-Pile Testing

The test probe previously described will be placed in a full-scale flow laboratory tube containing a standard I & E charge and equipped with a test nozzle and pigtail. The entire assembly will be checked at 100 psi pressure to determine that the equipment will hold water. The nozzle with a standard pigtail will also be pressure tested at full header pressure. The probe will be tested for ease of charging and discharging and the ability to make thermocouple contact in the bore.

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APPENDIX III

GENERAL TEST PROCEDURE

1. Water Shut-Off Test to Single Tubes

- a. A regular metal and an "E" metal I & E tube will be selected which are relatively free from control rod flux distortion or poison tube effects, and have an exposure of 1.5 to 2.5 months.
- b. A special front face nozzle will be installed on these tubes during the first shutdown after the approval of this test.
- c. During the following shutdowns the desired water flow shut-off tests will be performed in the following manner:
 - (1) Establish the length of time the tube can be without water flow.
 - (2) Valve the rear crossheader of the test tube to the drain riser.
 - (3) Replace the standard pigtail with the special pigtail. During replacement water is to be supplied to the tube with a stinger.
 - (4) Open pigtail valve before removing stinger.
 - (5) Install the I & E fuel element bore surface temperature monitor, modified nozzle insert, and modified nozzle cap. This installation requires stopping the water flow to the tube, therefore, the installation must be completed in the time interval specified by step (1).
 - (6) Insert thermocouple to desired location in fuel element column.
 - (7) Stop water flow to tube by closing pigtail valve.
 - (8) Watch the temperature as recorded from the probe thermocouple and tube outlet thermocouple and return water flow to the tube:
 - (a) When the bore surface temperature reaches 170, 250, 300, 350, or 450, or the tube outlet temperature reaches a specified value as agreed upon by the Area Analyst, Process Engineer, and Test Authors.
 - (b) If the temperature rise of the probe thermocouple exceeds 100 C during the first five seconds.
 - (c) The time established by step (1) is not to be exceeded.
- d. This test should be repeated for several tubes at various times after shutdown. Whenever possible, it should be fitted into shift change or lunch periods so that there is minimum interference with normal shutdown work.
- e. This test should be run before and after a CO₂ gas purge which reduces the helium concentration at least 20 per cent.

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- f. Following the completion of these tests the temperature probe will be removed, a solid end cap placed on the nozzle, and the special valved pigtail removed. Water should be supplied to the tube with a stinger during the replacement.

2. Heat Generation Test

At various times after shutdown the water flow and inlet and outlet temperatures of the test tubes will be recorded.

Note:

- a. Whenever the ΔT across the tube is less than 10°C the tube flow should be reduced by throttling the pigtail valve.
- b. Heat generation data should not be obtained until equilibrium conditions have been established in the lattice units around the test tubes. Therefore, there should be a delay of one to two hours after every water shut-off test before taking heat generation data.

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FIGURE - 2
BORE TEMPERATURE PROBE

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FIGURE -- 1
MODIFIED NOZZLE AND PIGTAIL

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