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for

PRODUCTION TEST IP-447-C
ROD DROP TRANSIENT COMPARISON - D AND DR REACTORS

OBJECTIVE

The purpose of this test is to set an upper limit on shadowing of the DR Reactor vertical safety system control strength by residual boron-steel balls in the graphite stack. Such an experimental determination should permit less stringent total control requirements than those based presently on necessarily conservative assumptions.

BASIS AND JUSTIFICATION

If the boron-steel balls lodged in the graphite were some distance away from the safety channels, they would not affect the system strength as much as if immediately adjacent to the channels. Any poison immediately adjacent to the safety control would shadow the safety system's incremental effect and thus reduce its control effectiveness.

Until there is definite proof of the location of the residual balls, it is necessary to take no credit in nuclear safety administration for their presence even though they are

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known to poison the reactor by approximately 1-1/2 per cent δk and to require compensating additional enrichment. In other words, supplementary poison must be presently charged during outages in order to compensate for the additional enrichment even though the residual boron balls plus the vertical safety system probably represent much more control capacity than the vertical system alone. Confirmation of near-normal vertical safety system strength would eliminate part of the supplementary poison presently required for total control, and would reduce outage lengths by allowing a higher multiplication factor in the portion of the wet reactor most affected by residual balls.

Because of uncertainties in residual ball uniformity, a system strength test is to be combined with individual channel measurements. Cold, dry measurements as are carried out during initial reactor startups cannot be considered with irradiated fuel loadings. Therefore, the rod-drop technique of measuring the flux decay after several individual vertical safety rod scrams plus a full system scram will be used.

Previous testing with the rod drop method has shown that results have a strong dependence on system and detector geometry in a large reactor.^{/1/} Therefore this test is directed toward making a comparison between two systems with equivalent channel spacings and detector locations, namely D and DR. It is hoped and expected that the DR system, though shadowed by residual balls, will show greater effectiveness in a rod drop test than D's by virtue of the greater diameter of the DR rods (3" vs. 2-1/4"); a similar ratio exists between DR square channel and D rounded channel Ball 3X column effective diameters. A demonstration that the ball shadowed DR system were as effective or at least nearly as effective as the normal D system would alleviate considerably the present need for supplementary shutdown poison to meet DR total control requirements.

DESCRIPTION OF THE TEST

As implied above, rod drop transient measurements will be carried out in both D and DR reactors. Specifically the complete test will consist of two separate tests at each reactor. It has been assumed that the local control strength of the safety system located near the near and far side enrichment patterns has been effectively reduced by approximately 75 per cent to 80 per cent of its original strength before the ball drop. The first test will be an attempt to determine whether or not specific VSR's in the pattern of the residual balls, have actually been affected as much as was necessary to meet total control criteria. At least five selected safety rods or pairs of rods will be scrambled into the pile while the power is increasing on about a 30 second rising period.

The tests will be scheduled immediately following a minimum outage at D and DR reactors. It is possible to make a minimum outage at D Reactor without supplementary poison for total control. However, at DR Reactor, because of the residual balls in the pile, the safety system must be supplemented by poison splines before the xenon has decayed sufficiently for the wet reactor to go critical. Therefore the VSR's will be shadowed by total control poison during the initial test at DR Pile.

If the data from the initial test provides evidence that the vertical safety rods at DR Reactor, although possibly shadowed by residual balls and total control poison, are at least as effective or nearly as effective as the safety rods at D Reactor, local and effective strength of the DR rods will then be conservatively increased to a value comparable to the D Pile rods. If the DR rods can be assumed to be at least 80 per cent as strong as the D Reactor rods (i.e. 60 per cent of their normal strength), this increase will permit the second part of the test to be performed, during a following outage, without the shadowing effect of supplementary poison necessary to satisfy total control.

/1/HW-43893, Measurement of the Control Strength of the Vertical Safety Systems (Final Report, PT-105-554-A) by C.L. Miller, September 1, 1956

During the second test, the piles will again be started after a minimum outage and the same rods as tested previously will be scrammed while the power level is increasing close to a 30 second rising period. Finally, the complete vertical safety system will be scrammed into the reactor while it is operating at a 500 MW power level. This test will determine, by comparison of the reactivity transients, the effectiveness of the DR Reactor safety system in relation to the D Reactor safety system.

Any further recommendations to assume a stronger DR safety system strength will be based on the results of the two tests. Merely proving that the safety system strength at DR is adequate to guarantee reactor safety during a minimum outage without supplementary poison will increase the pile's efficiency by approximately five hours per minimum outage.

The same detection and recording instrumentation will be used in each case, and detector geometry will be duplicated as exactly as possible. Reactor operating limitations prior to the rod drop are specified in the procedure section to provide equivalent base conditions prior to the time of scram.

PROCEDURE

1. Preparation

- a. The second test will determine the effectiveness of the complete safety system by comparison of the reactivity transients after scramming from 500 MW. Detector geometry must be duplicated as closely as possible to obtain trustworthy data from this test. Therefore a compensated ion chamber will be inserted under number 5 riser at D and DR Reactors respectively, sometime prior to the second test. Before the chamber can be installed the current due to the neutron flux must be calibrated under the number 5 riser at D Reactor. This calibration has already been obtained at DR Reactor. This calibration can be performed quickly during any shutdown period without interrupting outage work. Instrument and Electrical Development will provide all the necessary equipment, and be responsible for conducting the test and obtaining necessary data on the electronic equipment.
- b. The subcritical monitors will be sufficient instrumentation for recording test data during the initial tests.
- c. The reactivity conditions of the pile must meet prescribed standards for each test. These are as follows:
 - 1) No water leaks nor saturated moderator shall exist at the time of testing.
 - 2) The test must be performed with an undistorted flux pattern. Stable equilibrium conditions must have existed prior to the shut down preceding the test.
 - 3) The complete ball 3X system should be in operation during the tests so that only a minimum amount of supplementary poison will shadow the control system. Only specific VSR's are required for the first test and these are listed in the test procedure. The complete VSR system will be required during the second test.
 - 4) The result of outage work performed prior to the test must not cause a flux distortion during the test. Any localized discharge could have considerable influence on test data. The responsible Operational Physics representative will determine if conditions are satisfactory for the test.

- d. Preparations at DR Reactor will include the charging of supplementary control poison prior to the test in order to meet total control requirements. This poison will reduce the strength of the rods at DR Reactor and add a conservative factor to the test results.

If the second part of the test is performed all of the above will be applicable (except para. d).

- e. Additional preparations for the second test at D and DR Reactors.

- 1) Prior to the test a compensated ion chamber, provided by Operational Physics Operation will be installed under the number 5 riser at D and DR Reactors respectively.
- 2) The exterior circuitry and recording equipment will be provided on a loan basis by Instrument and Electrical Development Operation whose responsible representative will direct installation and perform the necessary testing.

2. Procedure for First Test

- a. Each reactor will schedule outage work so that the testing can begin at the time normally required for startup after a minimum outage. This is usually between 30 to 35 hours, depending on the fuel discharged.

Outage work can be resumed after the testing if it is desirable to do so, otherwise the reactor will be ready to continue normal operation following the test.

- b. All test instrumentation will be checked and operating. Only the subcritical monitors will be used to obtain test data during the initial test.
- c. Normal cold startup procedure (at full water pressure) will be employed until the pile power shows approximately a 30 second rising period.
- d. The 30 second rising period will be maintained for at least one minute or until the 1 MW power level is reached. The control rod positions during the 30 second period will be noted.
- e. After the power level reaches 1 MW and held constant with horizontal control rods, the Beckman readings will be noted. The level will be reduced to 0.5 MW, and the Beckman trips will be set at the observed 1 MW point.
- f. The SN relay will be bypassed.
- g. Sufficient HCR will be withdrawn to allow the power level to cause the Beckmans to trip the safety system. The entire vertical rod system must trip as intended before the next step is taken.
- h. The Panellit scram circuit will be bypassed.
- i. The horizontal rods will be inserted manually following the scram and before the next startup. Then the vertical safety rods, followed by the horizontal control rods, will be withdrawn according to secondary cold startup procedures.

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- j. After criticality the horizontal rods will be adjusted to about a 30 second period.
- k. The 30 second period must be maintained for at least one minute or until 1 MW power level is attained.
- l. Vertical safety rod number 24 will be scrammed into the pile.
- m. The scram reactivity transient will be recorded for two minutes following the scram.
- n. To prevent any delayed neutron effects and to facilitate rod withdrawals, vertical rods numbers 34, 10, 38, 14, and horizontal rods numbers 4 and 6 will be inserted into the pile and then withdrawn as instructed by the responsible Operational Physics representative to obtain the next rising period.
- o. VSR's 34, 10, 38 and 14 and HCR's 4 and 6 will be withdrawn, the HCR's adjusted as necessary to about a 30 second period, but in no case faster than a 15 second period, and the previous procedure will be repeated at least twelve times for the following rod or rod patterns.

Period #2	Vertical Rod #23
" #3	" #25
" #4	" #28
" #5	" #20
" #6	" #15
" #7	" #33
" #8	" #22
" #9	" #26
" #10	" #23 & #25
" #11	" #28 & #20
" #12	" #15 & #33
" #13	" #22 & #26

The results from these initial scram tests may indicate that additional rod configurations should be checked. The responsible Operational Physics representative will specify if additional tests are necessary and the specific rods to be tested. In any event no more than three hours from the time first critical is attained until the final rod scram is authorized for this test.

- p. The SN relay will be unbypassed as soon as the last test has been completed.
- q. If the outage schedule has been completed prior to the test the second startup can take place immediately. Normal secondary cold startup procedure as authorized by Process Standards will be followed.

The data from the initial tests at each reactor will be compared and a preliminary report issued. If the vertical rods at IR Reactor do not prove to be of sufficient strength to justify the elimination of supplementary control poison during the length of a minimum outage, the second test will be canceled or modified.

If the vertical safety rods at IR Reactor prove to be more effective or at least nearly as effective as the rods at D Reactor, the second test will be performed at both reactors using the following procedure.

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3. Procedure for Second Test

- a. Each reactor will schedule outage work so that the testing can begin at the time normally required for startup after a minimum outage.

Outage work can be resumed after the test if it is desirable to do so, otherwise the reactor should be ready to continue operation following the test.

- b. All test instrumentation will be checked and operating. This includes the subcritical monitors plus the amplifier and recorder associated with the compensated ion chamber under number 5 riser.
- c. The initial test program will be repeated exactly as listed previousl.
- d. After the initial test has been repeated the Panellit will be unbypassed.
- e. The VSR's will be withdrawn simultaneously and then normal cold startup procedures will be followed until the pile power level is 500 MW.
- f. The power level will be held at 500 MW and a temperature map will be recorded.
- g. The responsible area physics representative will determine if the flux shape is satisfactory by comparison of the Beckman traces and tube temperature data. If there is evidence of an unbalanced flux in the pile, the control rod will be manipulated until a satisfactory condition exists.
- h. The complete vertical rod system will be scrambled into the pile and the reactivity transient recorded for up to 20 minutes following the scram.
- i. The SN relay will be unbypassed and all horizontal control rods will be inserted.
- j. If the outage schedule has been completed prior to the test the second startup can take place immediately. Process Standard C-060 permits all the VSR's to be withdrawn under specified conditions. The HCR withdrawal rate will depend on the reactivity of the pile at the time of startup and is also prescribed in Process Standards C-060 page 15-1.2 (HW-46000 D).

COST

1. Code _____-5R42-_____.78

2. Production

Approximately six hours effective production time at each of the D and IR Reactors. Unless the test requires interruption of outage work, up to seven hours is authorized at each reactor.

3. Manpower

No additional operating personnel are required for the test. Approximately fifteen hours of instrument craft time will be necessary for instrument installation at each reactor.

4. Equipment

One compensated ion chamber must be installed under number 5 riser for the second test at each reactor. The chamber will have to be wired to a BL Log N period amplifier and high speed recorder.

The recorder and amplifier will be provided by Instrument and Electrical Development Operation, who will also be responsible for proper installation and testing of that apparatus.

SCHEDULING

Each test should be scheduled first at IR Reactor and then at D Reactor since it will be necessary to compare the data received from both piles but specific application and recommendations will only affect IR Reactor.

Each test should be performed during the first outage mutually agreeable to the respective D and IR Processing Management and the Operational Physics representative.

Minimum acceptable conditions are:

1. Satisfactory equilibrium conditions prior to the test.
2. Dry moderator during the outage.
3. Reasonably balanced fuel discharge during the outage.
4. VSR safety system operable.

REACTOR HAZARDS

1. Standard C-060 requires all serviceable HCR's be fully inserted before pulling the vertical safety rods. Normal cold startup procedures will be followed for the initial startup of both the first and second tests. But for any startup periods following the initial period, only vertical rods numbers 34, 10, 38, 14 and horizontal rods numbers 4 and 6 will be used. The reactivity transient will have been exactly measured during the initial startup period so that these rods will provide adequate control. The elimination of the other VSR's and HCR's during the test will reduce the time for rod withdrawal and considerably speed up test procedure. All the vertical safety rods will be scrammed by any No. 1 safety circuit trip except the Panellit, or if the pile power exceeds one MW.
2. The SN relay will be bypassed to prevent an HCR scram. The purpose of the test is to measure the effectiveness of the vertical safety rods without the interference of other control poisons.

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3. The Panellit trip system will be bypassed during the test. Pile power level will never exceed 1 MW. The maximum tube power expected under distorted conditions would be ~1 KW; ample cooling is provided at top of riser of 75 psi to cool tubes at 50 KW power per tube.
4. Process Standard C-030 relating to cold startup procedure will apply for the first startup period and rise to power level. After this initial period the Beckman trip points must be set so that power level will never exceed 1 MW. The following test periods will be obtained while the Beckmans are set at the 1 MW power level limit.
5. All the Beckman trip settings will be normal and the Panellit system will be unbypassed when the power level is increased to 500 MW during the final stages of the second test.

RESPONSIBILITIES

1. D and IR Reactor Operation

For scheduling of the test and for the operational safety of the reactor: D and IR Processing Operations

2. Facilities Engineering Operation

For providing, installing and operating necessary instrumentation: Instrument and Electrical Development Operation

3. Research and Engineering Operation

For detailed test planning, coordination and consultation during the test, for collection and analysis of data, and for final test reporting: Operational Physics Operation - A. D. Vaughn

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