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February 17, 1972

RECEIVED FEB 18 1972 U.S. ATOMIC ENERGY COMMISSION Regulatory Mail Section

Dr. Peter A. Morris, Director
Division of Reactor Licensing
U.S. Atomic Energy Commission
Washington, D.C. 20545

Subject: Supplementary Information to Special Report No. 6 "Reactor Asymmetrical Neutron Flux Distribution" - Dresden Unit 2

Dear Dr. Morris:

On March 17, 1971 we submitted to you Special Report No. 6 concerning the asymmetry which we found in the neutron flux distribution in Dresden Unit 2. As a result of this asymmetry and analytical studies, the feedwater sparger on Dresden Unit 3 was modified to correct this situation. Additional testing has been done on Dresden Unit 3 to determine if the modification made to the feedwater sparger has corrected the asymmetry. To date, the results of this testing have been inconclusive.

The attached report discusses the background of this problem and what has been done to date in addition to the information which we submitted to you on March 17. This supplementary information indicates that further testing will be done on Dresden Unit 3. When this testing has been completed, a final report will be submitted to you.

If you have any questions on the above information, please let me know. In addition to three signed originals, 19 copies of this supplementary information are also enclosed.

Very truly yours,

Wayne L. Stiede

Wayne L. Stiede
Nuclear Licensing Administrator

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841

841

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SUPPLEMENTARY INFORMATION TO SPECIAL REPORT NO. 6 "REACTOR ASYMMETRICAL NEUTRON FLUX DISTRIBUTION"

February 17, 1972

Received w/Ltr Dated 2-17-72

Comment

A summary of the progress toward identification of the causes and definition of the corrective action to be taken to eliminate reactor power asymmetry is presented.

References

1 - Dresden Nuclear Power Station Unit 2 Special Report No. 6 "Reactor Asymmetrical Neutron Flux Distribution", March 17, 1971.

2 - NEDO-10299 Core Flow Distribution in a Modern Boiling Water Reactor as Measured in Monticello, January 1971.

Background

During plant startup testing of Dresden Unit 2, indications of a power asymmetry problem were identified by the incore nuclear instrumentation system. The reference report contains:

a. a summary of those findings;

b. the tentative conclusions about the cause(s) of the asymmetries;

c. the conclusion that the power asymmetries do not introduce a safety problem; and

d. the statement that "further investigation of this phenomenon is continuing."

The following is a summary of the progress since that report.

General

As of the date of this report a <u>final</u> conclusion as to the cause of, and corrective action for, the power asymmetries does not exist. However, all of the reactor test data analysis, analytical study, and feedwater sparger flow distribution testing done in 1971 support the theory that the power asymmetries are caused by non-uniform temperature of the core flow at the core inlet and that this can be corrected by properly distributing the feedwater flow around the downcomer annulus. The conclusion reached in the reference reports that temperature forced asymmetries do not present a safety problem is still applicable.

The primary reason for the lack of conclusive results at this time is that small errors and/or uncertainties in the incore instrumentation data tend to mask any thermal-hydraulically forced power peaking. These errors/uncertainties are generally insignificant to the designed function of this instrumentation, but they are very significant when attempting to accurately identify the small variations of present concern.

A test is presently planned for Dresden Unit 3 which is specifically designed to eliminate as many of the "masking effects" as possible. This test includes both use of the incore instrumentation, with a set of procedures designed to emphasize any temperature forced asymmetry, and application of some radio chemistry techniques which have previously been used to measure reactor carryover, to independently measure the amount of mixed feedwater delivered to the core through each jet pump diffuser. Ideal test results would be quantitative agreement between all three (incores, radio chemistry, analytic prediction) methods of determining the feedwater distribution. Equal success would result if the two experimental techniques agree and provide the information required to correct the analytic model.

Specific Areas of Progress during 1971

A. Dresden Unit 3 Sparger Modification

Modifications were made on the feedwater spargers in several plants (Dresden Unit 3, Quad-Cities Units 1 and 2, and others) based on performance knowledge available in the spring of 1971. These modifications were an attempt to take timely action to eliminate any core inlet temperature nonuniformity.

Nuclear data from the normal plant startup test program at Dresden Unit 3 has been collected and analyzed. However, the results are inconclusive. The uncertainties/errors in this data make it impossible to reach final conclusions regarding the extent of improvement affected by the sparger modification. Both General Electric tests (see B below) and analytic work (see D below) have indicated that the modification is not "perfect" but in the final analysis the plant performance is the ultimate measure of modification adequacy. For this reason the more precise tests described above are critical to the final evaluation. Accurate knowledge of the modification effect should identify and allow corrections of any shortcoming which are left in the modification technique.

B. Full Scale Feedwater Sparger Tests

During 1971 General Electric conducted an extensive test program on a full scale production feedwater sparger. The program, initiated in parallel with the Dresden Unit 3 modification, was designed to obtain data for use as the basis for refinement of the calculational model used to predict the flow distribution from each orifice on the sparger. Tests were performed using a production sparger varying flow rates to cover the full range of reactor operation. Accurate measurements were made of the pressure distribution along the sparger and the flow through each orifice.

The results of these tests were used to improve the analytic model in such a way that it would be applicable for predictions of flow distribution from all of the standard spargers presently designed, and for the most probable modifications to these spargers; e.g., varying hole sizes, holes in the center tees, etc. (see D below for more model discussion).

The model was then used to predict flow distributions from a sparger which had been substantially modified and tests were run to confirm the model accuracy. These later tests proved that the analytic model can accurately predict the flow distribution from a sparger which has been modified in any of the ways which are presently being considered as viable techniques for improving the feedwater distribution.

C. Plant Startup Data Analysis

Data has been collected from the incore nuclear instrumentation (both TIP and/or LPRM) during the normal startup test programs from Dresden Unit 2, Millstone, Monticello, Dresden Unit 3, Fuku-I, AKM and Nuclenor (all plants). Significant effort has been applied to derive an accurate definition of the thermal-hydraulically forced power asymmetries from this data. However, as mentioned above there have been significant problems encountered in isolating this single effect from all of the other variables which influence local instrument measurements.

289.4

For this reason there are apparent contradictions in some of the data when it is taken at face value without recognition of the "masking effects." Hence the following conclusions must be qualified as <u>tentative</u> and subject to further test verification. With this provision the tests indicate:

1. That all jet pump plants which have been through their startup program have power asymmetry.

2. That the magnitude of this asymmetry varies from plant to plant, is always small, and results in no safety problems.

3. That the peaking is sensitive to feedwater temperature.

4. That there is qualitative correlation between location and magnitude of the power variation and the areas of the core that receive coolant flow whose temperature varies from average.

This last point is of course the critical conclusion. As Yet, the data analysis has failed to provide consistent quantitative correlation of the magnitude and location of all power perturbations with the predictions of core inlet enthalpy perturbations. Efforts are continuing to improve our data analysis techniques to the point where all of the significant measurement perturbations can be eliminated except the thermal-hydraulic effects.

The difficulties in this area have also been the impetus behind the development of tests which would reduce the number of influencing variables. The result is a two phase program which was mentioned earlier. It is currently proposed for application on Dresden Unit 3.

This program can be outlined as follows:

1. Establish operation of 65% power and 100% core flow with an octant symmetric control rod pattern for 12-24 hours.

2. Obtain two sets of TIP data with center hole readings for each machine before, in the middle, and after each set (about 8-12 hours).

289.5

3. Reduce feedwater temperature about 100°F by valving out extraction steam for the B, C and D feedwater heaters. This step will increase power to about 85% (about 22 hours).

4. Take two more complete sets of TIP data (about 8-12 hours).

In addition to the TIP data other significant information must be collected; e.g.:

1. Thermal hydraulic data from plant process instrumentation.

2. LPRM readouts from the process computer at about 15 minute intervals.

3. Water samples are to be collected from jet pump diffuser instrumentation lines for radionuclide analysis.

D. Analytic Model Development

The analytic models used to define the sparger modifications in the spring of 1971 have been substantially modified. Much of this refinement was made possible by the feedwater sparger tests (see B above). In addition, analytic work has been done to improve the modeling of feedwater mixing after it leaves the spargers.

The current model has six major parts:

1. A feedwater system analysis model to define the boundary conditions to each sparger.

2. A sparger flow model to define flow distribution from each sparger.

3. An upper plenum mixing model.

4. A downcomer mixing model.

5. An analysis of the effect of the jet pump drive flow attenuation of any temperature non-uniformity.

6. A lower plenum mixing model.

The most critical part of this model is based on experimental data. However, at present the combined package is still unverified. The Dresden Unit 3 test mentioned above holds the most promise for overall model verification. Once this is accomplished the model will be the primary tool for defining the required modification to eliminate power asymmetries in all plants.

E. Elimination of Flow Maldistribution as an Asymmetry Cause

The original Dresden Unit 2 report indicated that maldistribution of flow to various fuel bundles could also be a contributor to the power asymmetries. It also indicated that General Electric did not believe this to be significant. This contention has since been confirmed by direct measurement of channel flow in Quad-Cities Unit 1 under the most asymmetric power plenum flow boundary conditions - one pump operation with the equalizer line between the two ring headers closed. This condition allows backflow through ten of the twenty jet pumps while the lower plenum is supplied flow from the other ten active jet pumps. The Quad-Cities Unit 1 tests proved that even under these extreme conditions the flow to each fuel bundle is uniform; i.e., bundle flow is independent of location in the core. A topical report similar to reference 2 on this subject will be released in the spring of 1972.

Conclusions

A. Small BWR power asymmetries do exist.

B. They are still believed to be forced by non-uniform core inlet temperature.

C. These asymmetries do not present a safety problem.

D. A significant effort has been and still is underway to fully understand the forcing mechanism and the corrective action required.

E. The most important next step in this effort is performance of the proposed Dresden Unit 3 test.

F. Ideal test results will confirm the presently available analysis model and hence lead directly to corrective action on many BWR's.

2897