POLICY ISSUE
(Information)

November 16, 1992 SECY-92-386

For: The Commissioners

From: James M. Taylor
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Subject: REGULATORY ACTIONS RESULTING FROM THE STAFF'S REVIEW OF THE POWER OSCILLATIONS EVENT AT LASALLE 2

Purpose: To inform the Commissioners of the conclusions and planned actions resulting from the staff's review of boiling water reactor (BWR) safety issues from the power and flow oscillations that occur during certain reactor core design and operating conditions. This is the las of several information papers to the Commission describing the progress of the staff review.

The staff review has considered (1) the causes and characteristics of oscillations, (2) the replacement of current corrective actions by long term solutions, (3) the possible effects of large oscillations on anticipated transients without scram (ATWS) and (4) a recent power oscillation event at Washington Public Power Supply System Nuclear Plant No. 2 (WNP-2).

Background: The staff began the review to address generic concerns about the large power oscillations observed during the instability event at the LaSalle County Nuclear Station, Unit 2, on March 9, 1988. General Design Criteria 10 and 12

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in Appendix A to Part 50 of Title 10 of the Code of Federal Regulations (10 CFR Part 50) require assurance that power oscillations which can result in conditions exceeding specified acceptable fuel design limits (SAFDL) are not possible or can be reliably and readily detected and suppressed. When studies for the BWR Owners Group (BWROG) indicated that detection and suppression without violation of the SAFDL could not be assured, the staff issued Bulletin 88-07 and its Supplement 1, "Power Oscillations in Boiling Water Reactors," December 30, 1988, requesting that all BWR licensees take specified interim actions to prevent the occurrence of uncontrolled power oscillations until a long-term more positive resolution could be developed. The interim actions, which have increased awareness among the operators, have been generally effective in the intervening period while BWROG and NRC conducted studies to find the long-term solution. In studying and reviewing oscillations, BWROG and the staff have focused on the effect of large power oscillations on the consequences of anticipated transients without scram (ATWS) events. By Director's Decision enclosed in the April 27, 1989, letter from Dr. Murley to Ms. Susan L. Hiatt, Representative of Ohio Citizens for Responsible Energy (OCRE), Dr. Murley agreed to consider an OCRE request to reopen rulemaking proceedings for ATWS as a Petition for Rulemaking under 10 CFR 2.802 of the Commission's regulations. The basis for the request was the possibility that the ATWS analyses were invalid because they did not appropriately account for the effect of large power oscillations. These analyses were the underlying basis for the prescriptive design requirements established in 10 CFR 50.62 to reduce the risk from ATWS events. To address this concern in their programs for evaluating power oscillations during ATWS events, the NRC and BWROG also evaluated the effectiveness of manual and automatic actions to mitigate the consequences of power oscillations.

Both the ATWS studies and the long-term solution studies have required analyses to evaluate the effect of reactor design characteristics and operating conditions on the oscillations and the effect of the oscillations on the thermal hydraulic behavior of the core. Substantial

effort was necessary to develop computer codes to simulate the oscillation behavior of the modeled reactors and to validate and verify these codes to ensure they will give accurate predictions. This paper in conjuction with the following list of previous Commission papers complete the staff commitment to keep the Commission informed of its progress on this work:

SECY-91-323, October 11, 1991
SECY-91-90, April 3, 1991
SECY-90-152, April 27, 1990
SECY-89-074, February 27, 1989

Discussion: Staff Evaluation of Stability Issues

After the LaSalle event, AEOD, NRR, and RES began a coordinated effort with their contractors at ORNL, BNL, and INEL and with BWROG and its contractor, General Electric (GE), to improve their understanding of BWR stability phenomena. The staff has reviewed analytical studies of ATWS scenarios, and sensitivity studies, and has evaluated reactor instability events, primarily those at foreign reactors. In reviewing these studies, the staff has improved its understanding of the principal fuel and core design parameters and the power distribution control and other core operating conditions that contribute to instability.

Based on this improved understanding, analyses have been performed by the BWROG and the staff to develop and evaluate long term solutions to detect and suppress oscillations and to evaluate ATWS events.

In September 1992, the staff issued NUREG/CR-6003 (ORNL/TM-12130), "Density-Wave Instabilities in Boiling Water Reactors," to document its knowledge of BWR stability and design and operating sensitivities.

The staff's understanding of the potential problems of adverse operating parameters was enhanced by the investigation of the August 15, 1992 instability event at WNP-2. The operators manually scrammed the reactor after observing power oscillations of 25 percent peak-to-peak at operating conditions well below the stability exclusion region boundary. The instability has

been determined to arise, in part, from thermal hydraulic characteristics of the fuel and the core loading pattern, and primarily from the power distribution which involved large radial and axial peaking. Subsequent operation with more appropriate restrictions on power distribution resulted in stable operation.

Long Term Solution Pursuant to GDC 10 and 12

The BWROG proposed to resolve the stability issue by ensuring an automatic protection action (i.e., reactor scram or selective control rod insertion) to prevent power oscillations that could violate the SAFDL. The BWROG proposed three options and the associated licensing methodologies for implementing this resolution. Licensing methodology would include, for example, those assumptions and analytical methods used to calculate exclusion region boundaries for each cycle. BWROG described these options and methodologies in NEDO-31960 and its Supplement 1, "BWROG Owners' Group Long-Term Stability Solutions Licensing Methodology," NEDO-31960, May 1991 and March 1992. A summary description of the proposed solutions and the staff's review findings follows:

I-A. Exclusion Region. The BWROG used well-defined procedures to calculate an exclusion region in the high power/low flow portion of the power/flow map for each generic reactor type. Plant operation outside of the exclusion region are very unlikely to result in instabilities. If the reactor is operated within this exclusion region, control rods will be inserted automatically to reduce power and exit the region or to trip the reactor.

Other versions of Option I have been proposed, including I-D for three plants which are potentially more stable. These are simpler, less costly designs using the current APRM system or use on line stability monitoring to enter otherwise excluded regions. For these systems, the BWROG submitted material is incomplete, and will be supplemented in April 1993. The staff will complete its review of this solution approximately 2 months after receipt.

II. Quadrant-Based APRM Scram. In BWR/2 reactors, the existing APRM for each quadrant can

detect both in-phase and out-of-phase oscillations with sufficient sensitivity to initiate automatic protective action to suppress the oscillations before safety limits are violated.

III. Local Power Range Monitor (LPRM) Based Detect and Suppress. The signals from a core-wide distribution of combinations of a small number of LPRMs are analyzed on-line by using three diverse characteristics of oscillation signals. If any of the three analyses detects an instability, automatic protective action is initiated to suppress the oscillations before safety margins are compromised.

The staff reviewed the proposed solution techniques and the licensing methodology proposed to calculate the exclusion region boundaries and APRM or LPRM reactor trip set points. The staff's principal concluding review findings are as follows:

1. The licensing methodology proposed by BWROG for calculating the exclusion boundary is conditionally acceptable. This methodology includes the treatment of uncertainties and the selection of initial conditions and calculation parameters. The staff approval is conditional on the licensee implementing plant-specific operating procedures that ensure consistency with the axial and radial peaking factors assumed for the power distribution. The condition is intended to preclude intermediate power operation control rod configurations that result in skewed power distributions as occurred at WNP-2 during low flow power maneuvering.

2. The oscillation detection algorithms and set point methods proposed by the BWROG are acceptable. A minimum of three diverse software detection algorithms are used.

3. A select rod insert, which is being considered for some plants, is an acceptable protection action for any of the solution techniques provided that backup full trip is initiated when either the oscillations are not effectively suppressed or the reactor does not exit the exclusion region within a

short trip delay time.

4. If solution option I-A is used at a plant equipped with flow control valves, it may be necessary for the plant to include an online stability monitor to strengthen administrative controls that ensure stability outside of the exclusion region during low flow power maneuvers. A stability monitor may also be required to strengthen administrative controls to ensure the exclusion boundary is conservative for other plants using solution I-A.

The staff will seek to have the Committee to Review Generic Requirements (CRGR) review the SER documenting the staff's review findings together with a generic letter in which the staff proposes regulatory requirements to ensure compliance with GDC 10 and 12. In the proposed generic letter, the NRC will also indicate that licensees should select a solution option and propose an implementation schedule for each BWR plant. The staff will review the proposed solutions and implementation schedules for individual plants and will negotiate these solutions and schedules with due regard for competing priorities. The licensee will likely need several years to complete the hardware modifications. Therefore, the generic letter should also address actions for the licensee to strengthen the interim administrative controls to ensure compliance. The staff will propose the following changes: a manual trip requirement for each plant entering the exclusion region (plants with non-filtered flow biased scram circuits are now exempt) and procedural controls on the control rod position pattern to limit power peaking during low power maneuvering.

Closure of ATWS Rule Stability Issues

In February 1992, the BWROG submitted a report, NEDO-32047, "ATWS Rule Issues Relative to BWR Core Thermal-Hydraulic Stability," which documents the results of studies using the TRACG computer code to evaluate the effect of large power oscillations on the consequences of ATWS. The BWROG presented to the staff its supplemental studies in progress and will document these studies in a supplement to NEDO-32047 that is now due for submittal. Also scheduled for November submittal is a seperate

report on studies of the most appropriate mitigation actions and recommended changes to the Emergency Procedure Guidelines (EPGs). The staff has nearly completed its review of the studies discussed at the progress meetings. The staff concluded that low probability (failure of all rods to scram) ATWS events with cold feedwater available are likely to produce large amplitude oscillations that may lead to the melting of a small fraction of the fuel and cladding. However, containment integrity will be maintained if procedures consistent with existing EPGs are followed and the mitigating systems such as the boron injection system work as designed. Radiological consequences have been examined and will remain within 10 CFR Part 100 limits as they have in previous ATWS reviews. The BWROG will revise the EPGs to take mitigating actions earlier to limit core damage which may result from an ATWS event.

The staff discussed these issues with the Advisory Committee on Reactor Safeguards (ACRS). The ACRS is awaiting additional documentation and further study of selected issues. Upon receiving this information, the Committee plans to continue its review which will probably be completed in the December-January timeframe. The staff expects to complete the documentation of its review within one month of receiving the BWROG documentation. RES intends to review the documentation from the NRR review, the results of the ACRS review, and other documents and public comments received on the OCRE Petition on the ATWS Rulemaking (PRM 50-53). RES intends to recommend a response to the OCRE petition in early 1993.

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