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(54FR 30905)

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COMMENTS OF OHIO CITIZENS FOR RESPONSIBLE ENERGY, INC. ("OCRE") ON PRM-50-53 (54 FED. REG. 30905, JULY 25, 1989)

The petitioner OCRE herein submits comments and reports to be made part of the record in this petition to reopen the ATWS rulemaking proceeding in light of the power oscillations occurring at the LaSalle-2 BWR following a dual recirculation pump trip on March 9, 1988.

The following enclosed reports should be made part of the record:

Exhibit 1: AEOD Special Report on the LaSalle-2 event, AEOD Special Report No. AEOD/S803, dated June 8, 1988.

Exhibit 2: excerpt from the NRC Augmented Inspection Team report on the LaSalle-2 event.

Exhibit 3: letter report by the Advisory Committee on Reactor Safeguards, dated June 14, 1989, re Boiling Water Reactor Core Power Stability.

Exhibit 4: "A Report on Reactor Study Issue Number 25" prepared for the Ohio State University Expert Panel by Dr. William P. Stephany of Nuclear Education & Training Services, Inc. ("NETS"). (This report is part of the comprehensive review of the 1975 General Electric Nuclear Reactor Study (commonly known as the Reed Report) commissioned by the Public Utilities Commission of Ohio. The attachments to the report are not included herein.)

These reports support OCRE's position regarding the ATWS rulemaking in light of the LaSalle-2 power oscillation event. The AEOD report, which was largely the basis for OCRE's 1988 petition in this matter filed under 10 CFR 2.206, states that the LaSalle event "<u>necessitates</u> that ATWS mitigation be reviewed in light of this event." Exhibit 1, p. 7, emphasis added. The NRC's Augmented Inspection Team also expressed concern that, "in view of the large magnitude of the APRM oscillations in LaSalle, the AIT believes that the ultimate power level without scram is unknown, and that the 500% bounding level assumed in the ATWS investigation may not be bounding. LPRM oscillation magnitudes more than seven times those of the APRMs have been observed in the case of regional oscillations." Exhibit 2, p. 24. These reports illustrate the

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NRC Staff's concerns and advice on this matter, which OCRE is endorsing.

Significantly, the reason ATWS is still a safety issue today, despite the ATWS rule, 10 CFR 50.62, is that the Commission failed to follow the advice of its own Staff in the ATWS rulemaking process. In NUREG-0460, Volume 4, the Staff made the following comments regarding ATWS in BWRs:

> Several events are shown to have significant, periodic oscillations in neutron flux following an initial, large neutron flux spike. The staff has never before encountered this type of accident behavior prediction, and so it has never been specifically considered in previous PCI evaluations. . . . The combined effects of high neutron flux spikes, resulting in high cladding and boil temperatures, followed by oscillation in flux, fluid flow, etc., raise questions not only about fuel future, but also about the potential for loss of coolable (rod-like) geometry. The 2200 F, 17 percent oxidation LOCA limits that GE proposes as evidence of coolable geometry are not applicable here because those limits address cladding oxidation and embrittlement effects only. They do not address the potential effects of oscillating mechanical loads on wasted and collapsed cladding that might be "locked onto" the fuel pellets as a result of a BWR ATWS involving a high flux spike, nor do they consider center-melted oxide. NUREG-0460, Volume 4, pp. A-87 to A-89.

The recommended mitigative measure, an automatic, high-capacity standby liquid control system (300-400 gpm), would eliminate or greatly reduce the oscillations. NUREG-0460, Volume 4, pp. A-64, A-48 to -52, A-43, and 29. Unfortunately, this measure was not incorporated into the final ATWS rule. OCRE believes that incorporation of the automatic, high-capacity SLCS, along with the other provisions of the ATWS rule, 10 CFR 50.62, pertaining to BWRs, would allay any concerns about power oscillations resulting from the recirculation pump trip, which is a necessary feature to quickly reduce power and reactor pressure to avoid failure of the reactor coolant pressure boundary.

It is significant that independent reviews of ATWS and the LaSalle event also point out the need to reconsider the ATWS rulemaking in light of the LaSalle oscillations. Exhibit 4, prepared by NETS, a firm which provides consultants and services to the nuclear industry, concludes that "there is a large gap between the ATWS prevention and mitigation recommendations stated in NUREG-0460 and the ATWS Rule stated in 10 CFR 50.62. In light of the recent LaSalle event, the consequences of the recirculation pump trip ATWS mitigation feature do need to be reviewed, and the concerns expressed by the NRC Staff in Vol. 4 of NUREG-0460 also need to be looked at again." Exhibit 4, p. 16. The ACRS also recommends that "considerable attention be given in the longer term to the development of an improved understanding of the conditions that can lead to an ATWS compounded by core power oscillations." Exhibit 3.

OCRE would urge the Commission to follow the advice of its Staff as given in NUREG-0460, the AEOD report, and the LaSalle Augmented Inspection Report, as well as that of independent reviewers such as the ACRS and NETS.

Respectfully submitted,

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EXHIBIT 1

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JUN 08 1988

MEMORANDUM FOR: Thomas E. Murley, Director
Office of Nuclear Reactor Regulation

Eric S. Beckjord, Director
Office of Nuclear Regulatory Research

FROM: Edward L. Jordan, Director
Office for Analysis and Evaluation
of Operational Data

SUBJECT: AEOD CONCERNS REGARDING THE MARCH 9, 1988 POWER OSCILLATION EVENT AT LASALLE 2

Enclosed is an AEOD Special Report detailing our concerns about the LaSalle 2 power oscillation event of March 9, 1988. We have reviewed calculations performed by Brookhaven on the BWR Nuclear Plant Analyzer, as well as the licensee's LER and other foreign and U.S. information. Although this is the first event of this type at a domestic reactor, similar events have occurred in foreign reactors. Based on this review, we classify this event as an important precursor event with significant safety concerns. Our most significant concerns and associated recommendations are described below.

1. The LaSalle event raises questions about the adequacy of the analysis used to meet the core stability requirements of GDC-12 when both recirculation pumps are tripped. The event also points out the difficulties the operators face in rapid diagnosis of and response to an event which readily promotes significant complicating factors such as subsequent loss of feedwater heating and reactor water level fluctuations. Simple and unambiguous procedures are needed to assure prompt proper operator response which ensures compliance with GDC-12. GE SIL 380 does not provide adequate guidance.

2. During startup and shutdown, BWRs routinely enter regions of potential thermal-hydraulic-neutron kinetics instability. This operation can be avoided without large impact on plant operations by modifying plant operating procedures to increase recirculation flow slightly early in the startup and by inserting control rods sooner during shutdown. Several foreign reactors operate with power/flow operating restrictions that avoid the unstable region. Additionally, reduction or loss of forced recirculation flow during plant transients can result in the plant entering regions of potential instability. Prudent operator action is needed to restore stable plant operation and to avoid actions which could initiate events with more significant consequences. For example, restart of recirculation pumps following loss of feedwater heating or MSIV closure could result in additional reactivity insertion while the reactor was exhibiting power oscillations.

3. This event has implications regarding the reactor transient response to a recirculation pump trip during an ATWS. In particular, the power oscillations may substantially exceed previously predicted values and thus raise questions regarding previous fuel integrity evaluations.

~~8806170060~~ 3pp.

Conclusion

The March 9 LaSalle event indicates serious deficiencies in the core stability analysis for LaSalle and perhaps other BWPs. Further, such undamped power oscillations call for prompt operator recognition and action, yet at LaSalle, operators were not trained to recognize or respond to such oscillations. Adequate plant procedures did not exist at LaSalle, and few, if any, plant simulators in the U.S. are capable of modeling these types of oscillations.

It is not at all clear at this time that we understand the nature and potential consequence of such power oscillations considering such factors as improper or no operator action, alternative core configurations and equipment failures, or divergent localized power oscillations. Since it will take time to thoroughly analyze and understand the LaSalle event and its implications on other BWRs, we conclude that, at least in this interim period, action is warranted to minimize the potential for core instability. Our recommendations in this regard are presented below.

We anticipate a written response to these recommendations within 45 days as discussed in NRC Manual Chapter 0515.

Recommendation to NRR

Pending a full understanding of the LaSalle event and its implications, we believe that all BWRs should be required to:

(a) Immediately insert control rods to below the 80% rod line following reduction or loss of recirculation flow or other transients which result in entry into potentially unstable regions of the power/flow map.

(b) Increase recirculation flow during routine reactor startups and insert some control rods prior to reducing recirculation flow below 50% during shutdowns to avoid operation in potentially unstable areas of the power/flow map.

(c) Immediately scram the reactor if (a) or (b) above are not successful.

Recommendation to RES

Review resolution of GIs B-19 and B-59 and ATWS mitigation in light of the LaSalle operating experience.

Please let me know if we can provide any clarification or additional assistance. If you have questions regarding the enclosed Special Report, please call Jack Rosenthal on x24440.

Original Signed By:
E. L. Jordan

Edward L. Jordan, Director
Office for Analysis and Evaluation
of Operational Data

Enclosure: As stated
Distribution: See next page

*SEE PREVIOUS CONCURRENCE

*DSP:AEOD	*DSP:AEOD	*DSP:AEOD	*DSP:AEOD	*D:DSP:AEOD	DD:AEOD	*D:AEOD
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AEOD SPECIAL REPORT

UNIT: LaSalle 2
DOCKET NO.: 50-374
LICENSEE: Commonwealth Edison

SPECIAL REPORT NO.: AEOD/S803
DATE: June 7, 1988
EVALUATOR/CONTACT: J.Kauffman/G.Lanik

SUBJECT: AEOD CONCERNS REGARDING THE POWER OSCILLATION EVENT AT LASALLE 2 (BWR-5)

EVENT DATE: March 9, 1988

SUMMARY

The LaSalle event involved power oscillations caused by neutron flux/thermal hydraulic instabilities of a magnitude that were not predicted by design analysis, unanticipated by the operators, and potentially in conflict with General Design Criterion (GDC) 12. Based on vendor analyses, two NRC Generic Issues (GIs) had previously been resolved concerning stability of BWRs; and this event raises questions regarding the adequacy of those resolutions.

Since analyses predicted that these oscillations would not occur, little guidance and training were provided for operator detection and response. Further, operation in unstable areas of the BWR power/flow map has potential adverse safety consequences. Because LaSalle 2's core was calculated to be more stable than the typical BWR core, other BWRs may be more susceptible to this problem.

In light of the present uncertainties, we recommend that BWR licensees should be required to implement procedures to:

a) Immediately insert control rods to below the 80% rod line following reduction or loss of recirculation flow or other transients which result in entry into potentially unstable regions of the power/flow map.

b) Increase recirculation flow during routine reactor startups and insert some control rods prior to reducing recirculation flow below 50% during shutdowns to avoid operation in potentially unstable areas of the power/flow map.

c) Immediately scram the reactor if a) or b) above are not successful in preventing and suppressing oscillations.

We also recommend that NRR revisit GIs B-19 and B-59 and ATWS mitigation in light of the LaSalle operating experience.

Description of the Event (Compiled from licensee's 50.72 report, March 9, 1988, and references 1 through 5).

While performing the functional test on a differential pressure switch, an instrument maintenance technician inadvertently valved in the variable and reference legs with the equalizing valve open, thereby connecting the variable and reference legs. This initiated a "pressure equalization" between the variable and reference legs, and resulted in a high "indicated" level to the feedwater level control system, causing the feedwater pumps to begin reducing flow. Realizing a valving error was made, the reference leg was immediately isolated from the variable leg. This resulted in a low "indicated" level spike. The level spike caused other level switches, utilizing the same reference leg, to also actuate, including the trip of the reactor recirculation pumps from an Anticipated Transient Without Scram (ATWS) signal.

Due to the rapid power reduction from 84% to approximately 40% caused by the trip of both recirculation pumps, feedwater heater high level alarms were received and heaters began automatically isolating. This resulted in reduced feedwater temperature and the insertion of positive reactivity due to the negative moderator temperature coefficient. With feedwater level control adequately handling the level transient, the licensee tried to re-establish feedwater heating and to restart the recirculation pumps. Attempts to restart the recirculation pumps were unsuccessful.

With the unit in a high control rod line condition (power was 85% prior to the event) and low flow condition (natural circulation), the unit started experiencing neutron flux oscillations from rapid creation and collapse of voids in the core region. Approximately 5 minutes into the event, multiple high and low alarms were recorded by the local power range monitors (LPRMs). The average power range monitors (APRM) recorders were oscillating between 25% and 50% of full power with an approximate 2 to 3-second period. Because of limitations of the APRM recorders, the actual neutron flux oscillations (approximately 75% power) were larger than the indications of the APRM recorders. The control room operators were in the process of manually scramming the unit, when an automatic scram occurred on upscale neutron trip (118% on APRMs). Immediately prior to the scram, the operators noticed that a majority of the LPRM Hi alarms were lit. The setpoint for the LPRM Hi alarms is 105% of full scale.

Foreign Operating Experience

A number of power oscillation events have been reported by the NEA IRS system. Power oscillations were reported in 1985 and 1986 at a foreign BWR-3 in IRS-677 and 681. The oscillations were 14% peak to peak during natural circulation testing. In June 1982 in IRS-220, a foreign BWR-4 reported oscillations of 75% of the "mean" flux during forced circulation after moving one control rod. The reactor tripped on APRM High Flux after five APRM half scrams had been reset. These power oscillations had a 2.5 second period. In response, operating limits were established at that facility to prevent operation in the area of instabilities. Another event (IRS-220.2) at this reactor in January, 1983, demonstrated that it is possible to start these power oscillations from normal operating conditions. IRS-363 reported that in October, 1983, during testing at the same reactor, divergent, out-of-phase oscillations were experienced. The report describing this event stated that this was "a potential GDC-12 violation." Again, operating restrictions were implemented that require rapidly maneuvering the reactor to a stable region following a single recirculation pump trip. Information received as followup to these events indicates that operating instructions were also developed for loss of feedwater heating events, loss of all recirculation flow, and low recirculation flow conditions. We have also received information that following startup testing at yet another foreign BWR, operating instructions were implemented to prevent routine entry into potentially unstable areas. In particular, guidance was developed to prevent routine entry into these areas during reactor startups and shutdowns, to require increased monitoring of APRMs and LPRMs in potentially unstable areas, and to provide guidance for operator response to certain transients such as loss of feedwater heaters and recirculation pump trips and restarts. In summary, these foreign plants have taken action to restrict or prohibit operation in areas of instability. Figure 1 is an example of operating restrictions during startup and shutdown in place at one foreign BWR.

U.S. Operating Experience

Other than LaSalle, no events involving diverging power oscillations at BWRs were identified in the SCSS operating experience data base. However, startup testing and other testing have included inducing power oscillations, observing the reactor response, and testing the effectiveness of oscillation suppression methods.

Review of the data base since 1980 did capture 167 events involving a trip of one or two recirculation pumps while the reactor was critical. Thus, when combined with routine startups and shutdowns, it is clear that BWRs are frequently operated in potentially unstable regions. The number of reported events is low since there are no reporting requirements for recirculation pump trips, unless it is in conjunction with some other reportable condition. Small power oscillations are similarly not reportable.

Related GDCs and GIs

The LaSalle event relates to two GDCs and two GIs:

"GENERAL DESIGN CRITERION 10 - Reactor Design. The reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to assure that specified acceptable fuel design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences."

"GENERAL DESIGN CRITERION 12 - Suppression of Reactor Power Oscillations. The reactor core and associated coolant, control, and protection systems shall be designed to assure that power oscillations which can result in conditions exceeding specified acceptable fuel design limits are not possible or can be reliably and readily detected and suppressed."

GI B-19: "Thermal - Hydraulic Stability" and GI B-59: "(N-1) Loop Operation in BWRs and PWRs".

These GIs were closed out by the issuance of Generic Letters 86-02 and 86-09. Generic Letter 86-02 stated that the approved GE and Exxon methods for calculation of core stability decay ratio are uncertain by 20% and 25%, respectively, in predicting the onset of limit cycle oscillations (decay ratio = 1.0). The Generic Letter noted, "...BWR 4, 5, and 6s may not be able to show compliance with GDCs 10 and 12 solely using analysis procedures to prove that thermal hydraulic instabilities are prevented by design." However, the Generic Letter concluded that BWR 1, 2, and 3s should have sufficient margin. It also stated that for cores which do not meet the analytical criteria (decay ratio less than 0.8), the operating limits of GE SIL 380 would be sufficient to provide for detection and suppression of flux oscillations in operating regions of potential instability adequate to demonstrate compliance with GDC 10 and GDC 12 for cores loaded with approved fuel designs.

Generic Letter 86-09 noted that the review of BWR (N-1) loop operation was complicated by potential thermal-hydraulic instability and jet pump vibration problems during single loop operation. In low flow operating regions, it was necessary to develop special operating procedures to assure that GDCs 10 and 12 were satisfied in regard to thermal-hydraulic instabilities. Plant Technical Specifications consistent with these procedures were accepted by the staff for reactors which were not demonstrably stable based on analyses using the then approved analytical methods; details of the operating limitations were developed for GE SIL 380 and contributed to the resolution of GI B-19. In addition, tests at Brown's Ferry demonstrated that single loop operation had similar stability characteristics as two-loop operation under the same power/flow operating conditions. The tests confirmed the staff's finding that Technical Specifications based on GE SIL 380 which were proposed for some BWRs were appropriate for the detection and suppression of thermal hydraulic instabilities. The staff expected to approve single loop operation for licensees who submitted the appropriate ECCS analysis.

Relevant Licensing Actions

The foreign event involving out-of-phase, divergent oscillations, resulted in issuance of a board notification (No. 84-062) in March, 1984. Stability tests demonstrated that "limit cycle oscillations" could occur within permissable operating space below the rated rod line at natural circulation flow. The high power level (120%) scram protection which is based on APRM signals would not necessarily prevent violation of critical heat flux limits if such local instabilities were to occur. The test demonstrated that local thermal hydraulic oscillations which are out of phase with the APRMs could occur. It was unclear at that time (1984) how high a local oscillation could reach before detection by an operating crew using then current monitoring procedures.

This board notification was made after the issuance of GE SIL 380, which is currently used as guidance to operators for these type of events. Plant Technical Specification changes were made for plants undergoing licensing hearings to address the concerns of this board notification.

Previous Vendor Recommendations

General Electric Co., had previously identified in GE SIL 380 and other documents that the condition of high rod line and low flow was susceptible to neutron flux/thermal-hydraulic oscillations. However, based upon analysis, Commonwealth Edison did not believe such oscillations would occur at LaSalle, and as a result, the SIL was not implemented.

Because this event at LaSalle involved large power oscillations, General Electric Co. has issued Rapid Information Communication Services Information Letter (RICSIL) No. 006 Revision 1 pertaining to BWR core thermal hydraulic stability. The RICSIL supplements GE SIL No. 380 Revision 1 on the same subject.

Concerns Regarding This Event

1. Stability analysis methods are highly uncertain. LaSalle 2's calculated decay ratio was approximately 0.6 for this fuel cycle. This means that that the transient reactor behavior that was observed during this event was predicted not to occur. The licensee's review of this event stated that the conditions present at the start of the oscillations appear to be only slightly more severe than the assumptions used to analyze the LaSalle decay ratio. There is also information that indicates that the stability analysis for Vermont Yankee was shown by stability tests as non-conservative (Ref. 6).

2. LaSalle operators were not trained for this type of event. Because GE analyses predicted that this event would not occur at LaSalle, GE SIL 380 was knowingly not in place and operators not trained on GE SIL 380 at LaSalle, as allowed by Generic Letter 86-02.

3. GDC 12 may have been violated. Although chemistry samples following the LaSalle event did not disclose any fuel damage, the event was potentially a violation of GDC 12 in that undampened power oscillations occurred and no procedures or methods were implemented to reliably and readily detect and suppress these power oscillations.

4. Other BWRs may have a susceptibility to unstable power oscillations. Because analyses similar to the ones used at LaSalle are used at other plants to meet GDCs 10 and 12, this transient response could occur at other BWRs with decay ratios less than 0.8. Like LaSalle, these other BWRs may not have implemented procedures to reliably detect and suppress power oscillations. At LaSalle, the operators allowed nearly two minutes of unstable operation before deciding to take action to shut down the unit.

5. GE SIL 380 Revision 1, even if implemented, is inadequate to ensure compliance with GDC-12. This raises the issue of the adequacy of GL 86-02 in assuring that GDC-12 is met for plants with predicted decay ratios greater than 0.8. The SIL has a number of inadequacies:

   --APRM "noise" and not actual rapid power changes is discussed as a result of flow instabilities.

   --This noise is said to normally range between 4-12% (peak-to-peak) of rated power, whereas LaSalle reported power oscillations of nearly full scale (75% power).

   --Some of the terms are not defined or commonly understood by utility operations personnel, e.g. "limit cycle oscillation." This makes it difficult to use as the basis for operator guidance and procedures.

   --Power oscillations may not be readily identified and suppressed. During an event with numerous failures and alarms, it is not certain that operator attention will be promptly called to power oscillations, especially since the APRM instruments typically have large oscillations (noise up to 10% under normal 100% power steady state operation) and the APRM recorders do not show the full magnitude of power oscillations due to time delays. Operators might consider any indicated oscillations as normal.

--The basis for the proposed actions is apparently non-conservative or sensitive to small parameter changes.

--Guidance is provided without explaining in detail why the actions are taken or the bases for the actions. Even in the case where out-ot-phase oscillations were experienced, GE SIL 380 states that "very large margin to safety limits were maintained." This downplaying of the potential severity of thermal-hydraulic instabilities may mislead operators into thinking that the stability concerns are not important.

6. Operator training on recognizing and responding to power oscillations is poor. Few, if any, simulators used by utilities are capable of modeling the type of oscillations that occurred at LaSalle. Since the existing guidance in GE SIL 380 does not state that power oscillations from 0 to 120% power are possible and have been experienced, it is likely that very few licensed operators or training instructors were even aware that oscillation of this magnitude could occur. If operator action is necessary to ensure compliance with the GDCs, it is essential that licensed operators be trained regarding the assumptions, conditions, limitations, etc. of the operating concerns. However, simple guidance - such as: "reduction or loss of recirculation flow resulting in entry into a potentially unstable area, insert control rods to below the 80% rod line" - that ensures avoidance of the unstable or unanalyzed regions is preferable to reliance on operator memory to ensure operation within analyzed regions.

7. Improper operator actions could worsen the event. The operators at LaSalle tried to restart recirculation pumps because their training and procedures allowed them to do so. In this event, with a downcomer filled with cold feedwater and an unstable reactor, a successful restart of recirculation pumps would lead to further rapid reactivity insertion with potential adverse consequences. We are also concerned about the effects that would have occurred if additional reactivity insertion due to void collapse in response to a turbine trip or an MSIV closure had occurred during the power oscillations. Other operator actions, plant conditions, such as end of cycle or different power distribution, or plant transients may have resulted in fuel damage.

Several calculations using the BWR Nuclear Plant Analyzer were performed by Brookhaven at AEOD request. The simulation of the LaSalle event is shown in Figures 2 through 5. By parametrically increasing loop flow resistances, it was possible to generate power oscillations similar to those experienced at LaSalle. Preliminary results from these runs indicate that large reactivity changes occur during these events. The power oscillations experienced at LaSalle are cyclic interactions of core void formation, flow, and neutron power. The period of the oscillations is about 2.5 seconds while the thermal time constant of the fuel is 5 to 7 seconds; and consequently, direct gamma heating of the coolant is the likely energy feedback mechanism. This phenomena apparently begins with thermal-hydraulic instabilities arising due to relatively large two-phase resistance in the core, while the driving head and flow rate are low due to loss of forced circulation. Formation of voids then drives neutron power down which slows further void formation, resulting in lower two-phase flow resistance, and increased natural circulation flow into the bottom of the core. This cold water increases core reactivity and results in a power increase. The resultant void formation continues the cycle of oscillation. Large neutron power oscillations are the result of large reactivity changes.

Preliminary results from the Brookhaven analyzer indicate that large reactivity changes occur during these events. Figure 4, for example, represents the LaSalle base case, where the analyzer calculated 0.5 dollars total reactivity inserted just prior to the reactor trip.

8. The LaSalle event is an important precursor event. Although the consequences of this particular event were not serious, they could have been worse in other circumstances. First of all, the potential exists for localized power oscillations where one half of the core oscillates 180 degrees out of phase with the other half; and in that case the APRM trip would not trip the reactor until the amplitude of the local power oscillations was much greater. An actual event of this type is noted in the foreign operating experience. Secondly, the potential exists for operator action or plant equipment failure to worsen the event, for example, restart of a recirculation pump or MSIV closure could result in additional reactivity insertion.

9. Previous efforts taken in regard to ATWS mitigation may be inadequate. The action of tripping recirculation pumps automatically and inducing an event similar to the LaSalle event when it is not clear where the power oscillations would stop and what the effects of these oscillations would be in the absence of an automatic scram, necessitates that ATWS mitigation be reviewed in light of this event.

10. The resolution of GIs B-19 and B-59 may be inadequate. The analyses which form the technical bases for the resolution of these issues have been challenged. The LaSalle event was predicted by analyses to be prevented by design, but it occurred.

Potential Actions to Address the Problem

1. We recommend that BWR licensees should be required to develop and implement procedures to:

a) Immediately insert control rods to below the 80% rod line following reduction or loss of recirculation flow or other transients which result in entry into potentially unstable regions of the power/flow map.

b) Increase recirculation flow during routine reactor startups and insert some control rods prior to reducing recirculation flow below 50% during shutdowns to avoid operation in potentially unstable areas of the power/flow map.

c) Immediately scram the reactor if a) or b) above are not successful in preventing and suppressing oscillations.

2. We also recommend that NRR revisit GIs B-19 and B-59 and ATWS mitigation in light of the LaSalle operating experience.

REFERENCES

1. Commonwealth Edison Company. LER 88-003, Docket No. 50-374, dated April 7, 1988.

2. PNO-III-88-18, dated March 10, 1988.

3. PNO-III-88-18A, dated March 17, 1988.

4. PNO-III-88-18B, dated March 25, 1988.

5. NRR Event Followup Report 88-03, dated March 30, 1988. (Not available in PDR)

6. Memorandum from L.E. Phillips (NRC) to M.A. Ring (NRC), dated April 7, 1988. (Not available in PDR)

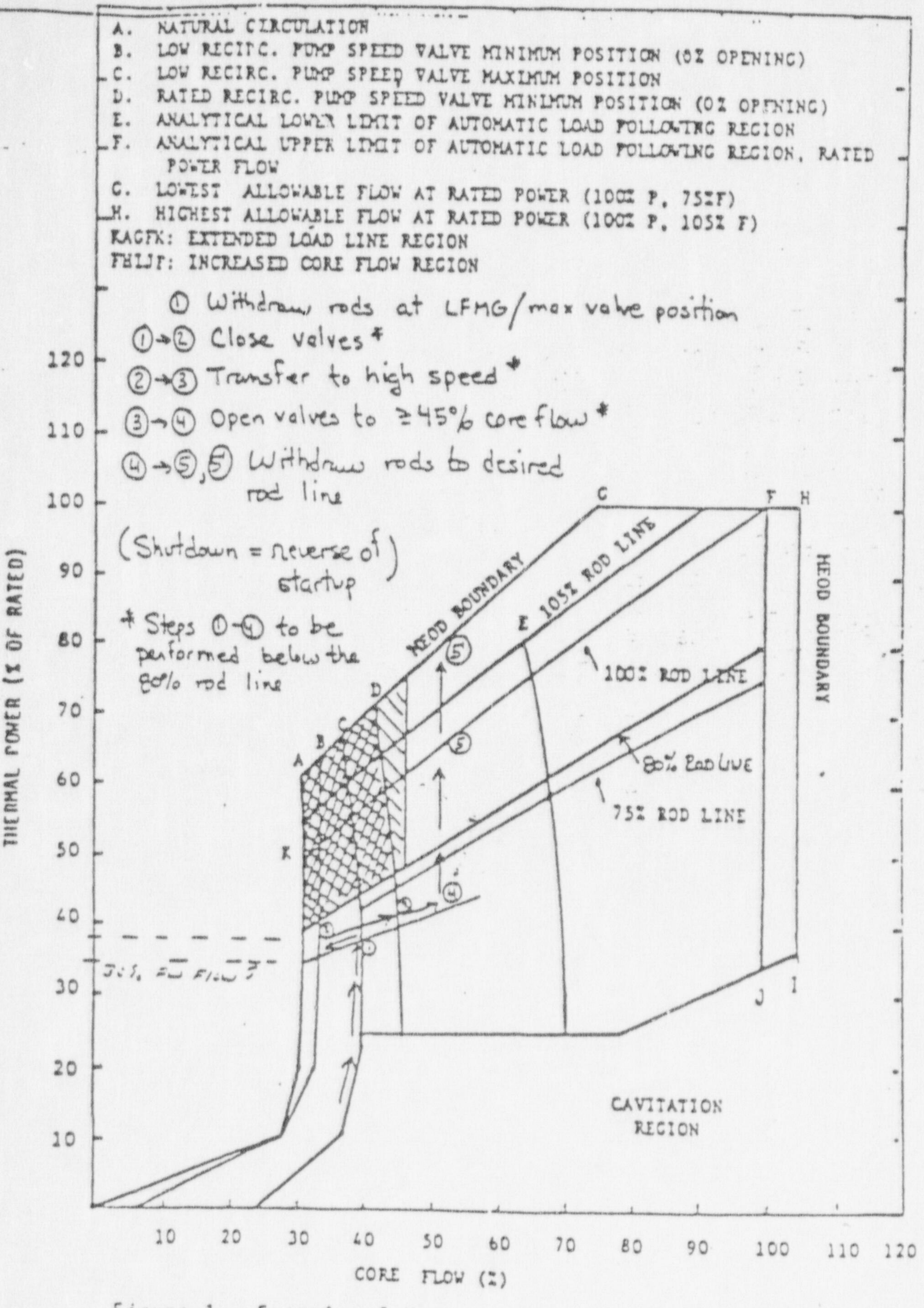


Figure 1. Example of Methods to Avoid Unstable Regions

MAXIMUM EXTENDED OPERATING DOMAIN POWER/FLOW MAP

LASALLE BASE CASE

Figure 2

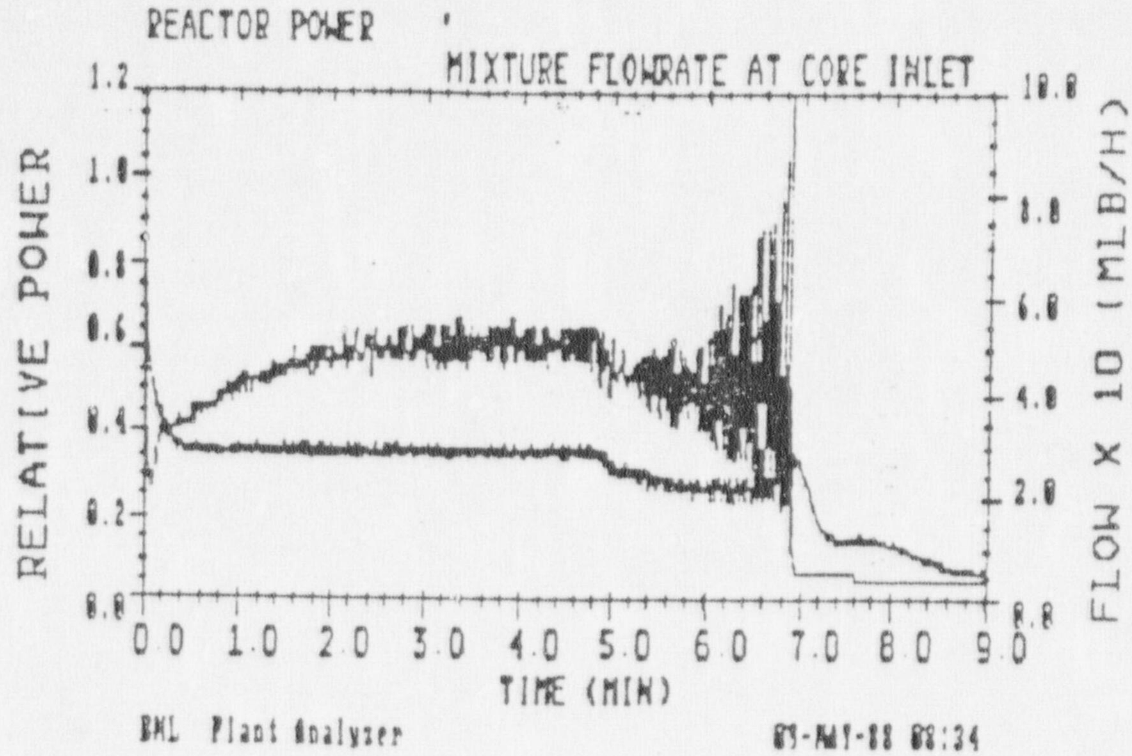
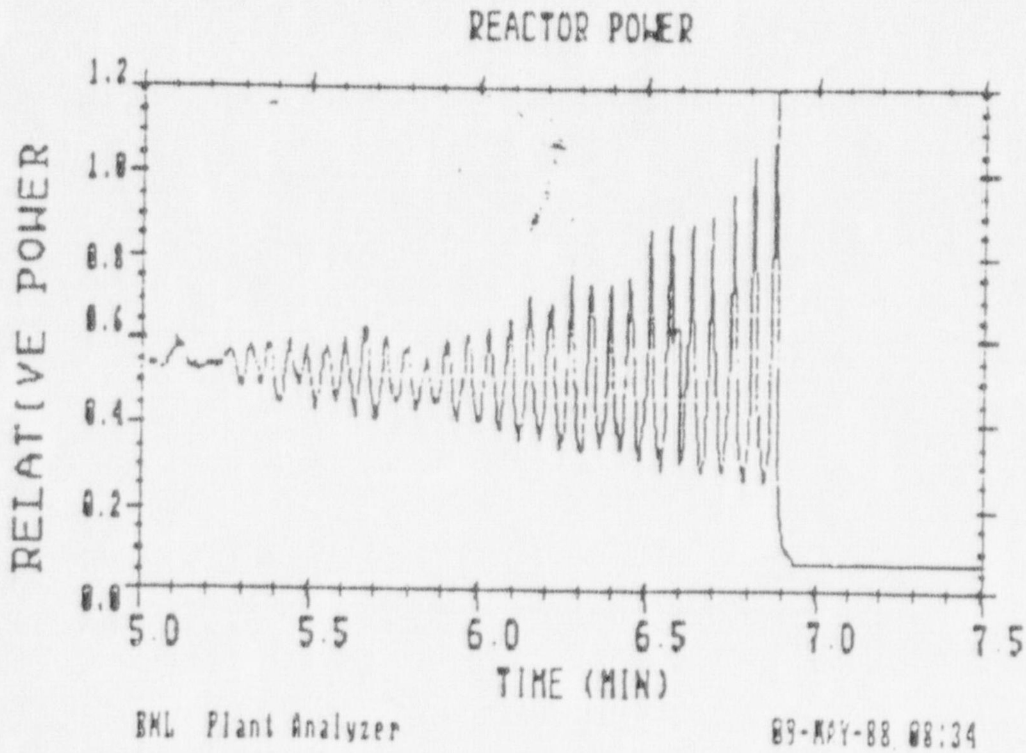


Figure 3



LASALLE BASE CASE

Figure 4

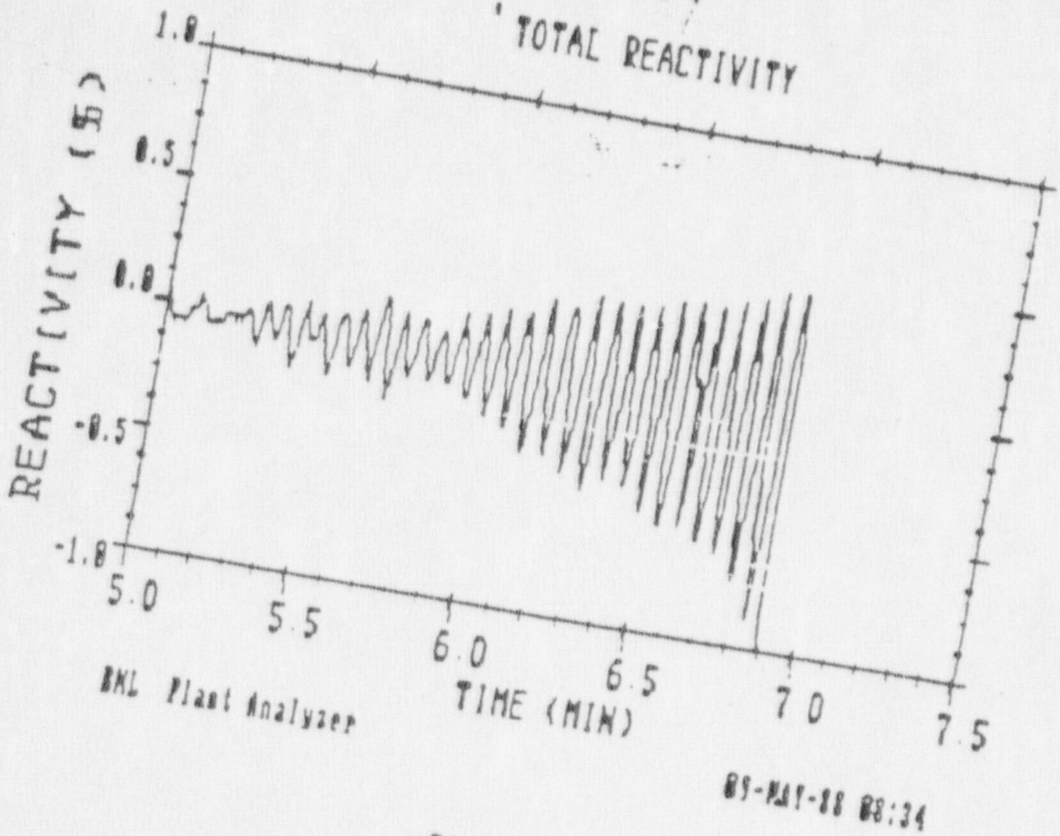


Figure 5

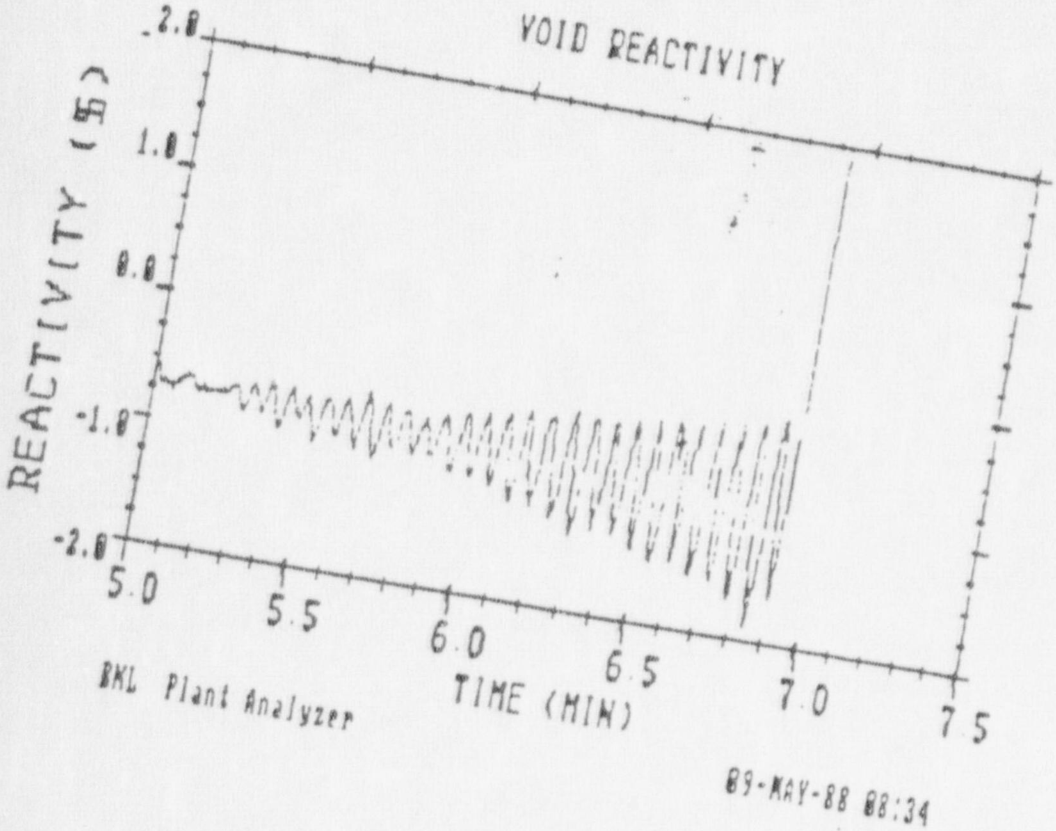


EXHIBIT 2

U.S. NUCLEAR REGULATORY COMMISSION

REGION III

Report No. 50-373/88008; 50-374/88008

Docket No. 50-373; 50-374 License No. NPF-11; NPF-18

Licensee: Commonwealth Edison Company
P. O. Box 767
Chicago, IL 60690

Facility Name: LaSalle County Station, Units 1 and 2

Inspection At: LaSalle Site, Marseilles, IL

Inspection Conducted: March 16 through 24, 1988

Inspectors: NRC Augmented Inspection Team

Team Leader: M. A. Ring [signature] 5/11/88
Date

Team Members: R. A. Kopriva [signature] for 5/6/88
Date

L. E. Phillips [signature] for 5/6/88
Date

P. Shemanski [signature] for 5/6/88
Date

B. A. Azab [signature] for 5/6/88
Date

Approved By: W. L. Forney, Chief
Reactor Projects Branch 1
Date

Inspection Summary

Inspection on March 16 through 24, 1988 (Report No. 50-373/88008(DRP); 50-374/88008(DRP))

Areas Inspected: Special Augmented Inspection Team (AIT) inspection conducted in response to the dual recirculation pump trip and subsequent core power oscillations resulting in a reactor trip on March 9, 1988, at LaSalle, Unit 2. The review included root cause determination, safety significance, performance of operators and equipment, adequacy of procedures, effects on the reactor, reporting actions and potential generic implications.

Results: No violations or deviations were identified; however, the licensee has committed to procedure and Technical Specification changes as well as further study in the areas of inherent shutdown mechanisms, instrumentation capability and uncertainties in the decay ratio calculations. The licensee's interim report, as required by the CAL, is included as attachment 5 to this report.

is needed to assess the nature and magnitude of neutron flux oscillations and the safety of restart after an instability event.

- LaSalle and some other BWRs do not have high speed data recording instrumentation which can be committed for availability during plant operation.

4. Oscillation Characteristics

Some characteristics of the LaSalle neutron flux oscillations were atypical of previous events and have led to concerns about the applicability of previous safety analyses. The magnitude of in-phase limit cycle oscillations previously observed on the APRMs during special stability tests and operating reactor events were typically in the range of 5% to 15% (peak-to-peak) of rated power, and as high as 25%. This compares to peak-to-peak values of about 100% at the time of the 118% neutron flux trip for LaSalle.

The estimated value of local power at the time of trip was greater than 310% and LPRM readings indicate that the core power peak shifted and increased by 25%. Even though the fuel LHGR limit of 13.4 kw/ft was not exceeded because of the thermal time constant of the fuel, the increased power peaking was unexpected based on Vermont Yankee stability tests, and was not factored into the generic safety evaluation performed by GE during review of the thermal hydraulic stability Generic Issue B-19.

The previous GE safety analyses considered several limiting moderate frequency transients which were initiated while the neutron flux was oscillating below the 120% scram setpoint, and included a rod withdrawal error with the flux oscillating up to the 120% scram level. Additional analyses were performed to evaluate the impact of oscillations that approached 300% of rated neutron flux (e.g., regional oscillations) without scram prior to rod insertion and termination of the event. All of these analyses showed that significant fuel thermal margin existed to safety limits. While there are several aspects of these analyses which differ from LaSalle (initial power level and amplitude of the oscillations; no change in bundle peaking factors due to the event, etc.), the AIT agrees that they are sufficiently representative and conservative to demonstrate that no fuel thermal or mechanical limits were exceeded during the event. However, reliable detection and suppression provisions are necessary to assure protection against future events which could involve regional oscillations to higher power levels.

The licensee was also asked to review the impact of the event on stability considerations addressed in the 1979 GE Generic ATWS report, "Assessment of BWR Mitigation of ATWS" (NEDE-24222).

The report does specifically investigate the sensitivity and potential impact of limit cycle neutron flux oscillations up to 500% of rated bundle power following recirculation pump trip. It was concluded that oscillations of this magnitude would not result in sufficient fuel clad temperature variation (130°F) to affect fuel integrity. It was further concluded that a loss of clad integrity due to prolonged exposure to limit cycles was an acceptable consequence in view of the importance of the recirculation pump trip (RPT) to minimize the energy deposited in the suppression pool (thereby maintaining containment pressure within limits) during an ATWS event.

In view of the large magnitude of the APRM oscillations in LaSalle, the AIT believes that the ultimate power level without scram is unknown, and that the 500% level assumed in the ATWS investigation may not be bounding. LPRM oscillation magnitudes more than seven times those of the APRMs have been observed in the case of regional oscillations. The licensee reports that the BWROG is discussing this issue (inherent power limits) and the licensee will provide a status report on July 1, 1988.

5. Additional Concerns

Several additional concerns were presented to the licensee in the form of questions. These questions and the licensee's response are contained in Attachment 5 to this report.

B. Recommendations

The AIT recommends that the concerns identified in items IV.A.1 through IV.A.5 of this report be examined by NRR for generic and LaSalle specific resolution. In the interim, the AIT recommends that revised stability TS as discussed in IV.A.2 be developed for LaSalle Units 1 and 2 and the licensee be authorizied via letter to modify interim operating procedures provided they remain consistent with the new T.S. The revised technical specifications and procedures should incorporate the changes summarized in Attachment 5 (Appendix A, Item 3), which include immediate insertion of high worth rods and observation of APRM/LPRM noise when no pumps are operating and power is above the 80% Rod Control Line. The reactor is to be tripped immediately whenever instability is suspected. It is expected that the time available (greater than 5 minutes) to instability following a two pump trip transient is sufficient to permit manual power reduction, avoiding the need for reactor trip unless the core is unstable by a large margin. Proposed procedures permit manual action for up to two minutes (prior to scram) to reverse operating actions which may result in small margins of instability when one or both pumps are operating.

V. AIT CONCLUSIONS

The AIT finds that the core power oscillations observed on LaSalle Unit 2 on March 9, 1988, were initiated by a personnel error resulting in the

EXHIBIT 3

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D.C. 20555

June 14, 1989

The Honorable Lando W. Zech, Jr.
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Chairman Zech:

SUBJECT: BOILING WATER REACTOR CORE POWER STABILITY

During the 350th meeting of the Advisory Committee on Reactor Safeguards, June 8-10, 1989, we discussed the issue of core power stability in boiling water reactors (BWRs). We had the benefit of presentations by representatives of the BWR Owners Group (BWROG), the General Electric Company, the NRC staff, and contractors to the NRC. This topic was also discussed at a meeting of the combined Thermal Hydraulic Phenomena/Core Performance Subcommittees on May 23, 1989. Attention has been drawn to this issue by an event which occurred in March 1988 at the LaSalle County Station, Unit 2. The chief purpose of our recent meetings was to review the general program outlined by the BWROG and the staff to address this issue. The Committee had previously considered this matter during its meeting on December 15-16, 1988. We also had the benefit of the documents referenced.

Although it is well known that BWRs can experience core power oscillations under certain conditions, the magnitude and divergent nature of the oscillations during the LaSalle event were unexpected. BWRs have inherent feedback mechanisms that tend to constrain power increases. But, if the feedback becomes out of phase with power generation, as can occur under certain operating conditions, this inherent constraint can be lost. Core power oscillations can involve the entire core behaving as a whole, or behaving in a manner where one region is increasing in power while another region is decreasing.

Such oscillations pose two threats to reactor safety. First, if peak local power becomes great enough during an oscillation, local fuel damage from overheating can occur because of a local loss of effective heat transfer through the phenomenon known as Departure from Nucleate Boiling (DNB). Substantial numbers of fuel pins could fail in such an event. This can occur even if total reactor power has not increased significantly. In the LaSalle event, the peak local neutron power exceeded 300 percent of rated core average although there was no evidence of fuel overheating or damage. A second class of threat is, we believe, of greater significance. If core power oscillations are large and continue for an extended period, the suppression pool may become overheated and the integrity of the containment might be threatened.

Because a reactor scram terminates oscillations, the latter threat exists only if the scram fails, for example, if an anticipated transient without scram (ATWS) event triggers a severe power oscillation. Local damage from DNB could result following the onset of large oscillations if the capability for making the reactor subcritical is lost.

Following the LaSalle Station event, the staff issued two generic letters to BWR licensees. These letters endorsed a series of actions that had already been proposed by the BWROG and added some additional short-term requirements. For the longer term, it was agreed that the BWROG would develop further actions that would be reviewed by the staff and implemented on a schedule to be agreed upon later this year.

The initial BWROG action was the imposition of new administrative controls on operating BWRs that define power/flow regions of unacceptable operation. These are regions where analysis or experience has indicated potential for oscillations. The administrative controls provide that these operating regions be avoided completely, or that special actions be taken if such a region is entered during operating maneuvers. We were told that these administrative controls are now in place at all operating BWRs. The staff has added a requirement that a manual scram be initiated in certain classes of BWRs upon occurrence of an inadvertent loss of operation of two reactor recirculation pumps.

For the longer term, the BWROG and the General Electric Company have developed a provisional list of alternatives that will be made available to individual licensees. This approach is intended to recognize that differences exist among the plants and that an optimal solution will be based on plant-specific parameters. These proposed alternatives range from further administrative controls to the addition of new automatic shutdown circuits that would detect the inception of oscillations or the entry into potentially unstable regions of operation. Our understanding is that the staff will review and approve proposals developed for each individual plant.

We believe that the general program outlined by the BWROG and the staff is sound and represents an adequate response to the issue. Local fuel damage caused by DNB, is most certainly something plant owners will want to avoid, but the safety implications are limited. In general, the potential for power oscillations of the sort being considered does not represent a significant risk to public health and safety, except in combination with an ATWS, as we have discussed above.

We believe it is important that considerable attention be given in the longer term to the development of an improved understanding of the conditions that can lead to an ATWS compounded by core power oscillations. We are disappointed, given the many years that BWRs have been operating in this country, with the present limited state of knowledge and the inadequacy of existing analytical tools. We note that in European BWR programs a more aggressive approach seems to have been taken to studies of core power instabilities and to incorporation of provisions for monitoring and controlling them.

Sincerely,

Forrest J. Remick
Chairman

References:
1. U.S. Nuclear Regulatory Commission, NRC Bulletin Number 88-07: "Power Oscillations in Boiling Water Reactors (BWRs)," June 15, 1988
2. U.S. Nuclear Regulatory Commission, NRC Bulletin Number 88-07, Supplement 1: "Power Oscillations in Boiling Water Reactors (BWRs)," December 30, 1988