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RUSSELL,W.T. Region 1, Ofc of the Director

SUBJECT: Responds to NRC Bulletin 88-007, "Power Oscillations in BWRs."

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SEP 2 1 1988

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215/770-4194

Mr. William T. Russell
Regional Administrator, Region I
U.S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406

SUSQUEHANNA STEAM ELECTRIC STATION
RESPONSE TO BULLETIN 88-07
PLA-3090 FILES R41-1A/R41-2

Docket Nos. 50-387
and 50-388

Dear Mr. Russell:

Attachment 1 to this letter provides PP&L's response to NRC Bulletin 88-07, "Power Oscillations in Boiling Water Reactors (BWRs)". In addition, PP&L is taking this opportunity to provide the NRC our perspective and planned future actions regarding the core stability issue (Attachment 2).

We trust you will find this response acceptable; any questions should be directed to Mr. R.R. Sgarro at (215) 770-7916.

Very truly yours,

H W Keiser

H. W. Keiser

Attachments (2)
Affidavit

cc: NRC Document Control Desk (original)
NRC Region I
Mr. F. I. Young, Sr. Resident Inspector
Mr. M. C. Thadani, NRC Project Manager
Mr. L. Phillips, NRR
Mr. P. C. Wen, NRR

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AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA)
: SS
COUNTY OF LEHIGH)

I, HAROLD W. KEISER, being duly sworn according to law, state that I am Sr. Vice President - Nuclear of Pennsylvania Power & Light Company and that the facts set forth on the attached response to Bulletin 88-07, are true and correct to the best of my knowledge, information and belief.

Harold W. Keiser
Sr. Vice President - Nuclear

Sworn to and subscribed
before me this 21 day
of September, 1988.

Notary Public

NOTARIAL SEAL
Debra M. Gallagher, Notary Public
Allentown, Lehigh County
My Commission Expires Nov. 3, 1990

rmh/msc200368i

ATTACHMENT 1: PP&L Response to NRC Bulletin No. 88-07

PP&L's response to each of the requested actions specified in NRC Bulletin No. 88-07 is provided below:

Requested Action No. 1: "Within 15 days of receipt of this bulletin, all BWR licensees should ensure that any licensed reactor operator or Shift Technical Advisor performing shift duties has been thoroughly briefed regarding the March 9, 1988 LaSalle Unit 2 event."

PP&L Response: PP&L initiated this action in April, 1988 based on information obtained directly from LaSalle County Station and also through the BWR Owner's Group. A briefing was prepared which covered the details of the LaSalle event (including a review of the transient event recorder traces), and a review of related events at other facilities. This briefing was included as part of the licensed operator requalification training program; all licensed operators and Shift Technical Advisors were trained on it prior to July 5, 1988.

Requested Action No 2: "Within 60 days of receipt of this bulletin all BWR licensees should verify the adequacy of their procedures and operator training programs to ensure that all licensed operators and Shift Technical Advisors are cognizant of:

a. those plant conditions which may result in the initiation of uncontrolled power oscillations

b. actions which can be taken to avoid plant conditions which may result in the initiation of uncontrolled power oscillations

c. how to recognize the onset of uncontrolled power oscillations, and

d. actions which can be taken in response to uncontrolled power oscillations, including the need to scram the reactor if oscillations are not promptly terminated."

PP&L Response: To meet this requirement, PP&L has (1) reviewed industry reports to determine the GE, INPO, and NRC recommendations for procedures to prevent, detect, and suppress reactor instability, (2) reviewed the Susquehanna SES procedures to determine which recommendations were not implemented, (3) modified existing operating procedures and wrote a separate procedure for reactor instability to incorporate the GE, INPO, and NRC recommendations which were identified as appropriate for Susquehanna SES, (4) provided the licensed operators and Shift Technical Advisors a paper entitled "Core Stability Discussion" which reviewed the four reactor instability topics identified in NRC Bulletin No. 88-07 for immediate training, and (5) included this paper in the formal requalification training program. These actions were completed by August 19, 1988.

Requested Action No. 3: "Addressees should also verify the adequacy of the instrumentation which is relied upon by operators within their procedures."

PP&L Response: An evaluation has been initiated to determine the adequacy of the instrumentation relied upon to perform the instability detection and monitoring function. Specifically, the neutron flux oscillations associated with a core reactivity instability exhibit a 2.5 second period. Therefore, any filters or time delays that exist in the instrumentation to prevent spurious alarms or reduce signal noise could result in alarms which actuate after the amplitude of the oscillations are significantly higher than the alarm setpoint and/or attenuation of the oscillation amplitude which is measured on the APRM recorders or LPRM meters. In general, PP&L expects that the filters and time delays will not prevent the operators from adequately responding to an instability event. This is based on the vast number of instability events that have occurred in foreign and domestic BWRs in which all were readily detected and suppressed (i.e., some were automatically suppressed) and none of them has resulted in a known fuel failure. Despite this general opinion, PP&L plans to perform a test on the APRM recorders and LPRM meters to determine the attenuation that will occur during an oscillation with a 2.5 second period and a range of amplitudes. In addition, GE has stated that a description of the standard GE Neutron Monitoring System was supplied to the NRC in (Reference 1) and was approved by the NRC in (Reference 2). Therefore, PP&L plans to verify that filters and/or time delays were not added to instruments and alarms supplied by GE. In addition, PP&L is performing an evaluation to determine the prudency of relying upon non-1E instrumentation and electrical equipment for detection and monitoring of core reactivity instability events. Following completion of the above testing, evaluations, and analyses, PP&L expects to conclude that the instrumentation available to the operators is adequate for detection and suppression of regional or core wide power oscillations which can result in conditions exceeding specified acceptable fuel design limits. PP&L will provide the results of this effort to the NRC by October 31, 1988.

1. G.A. Watford, "Compliance of the General Electric Boiling Water Reactor Fuel Designs to Stability Licensing Criteria", GE Proprietary Information, October 1984 (NEDE-22277-P-1).

2. Letter, C.O. Thomas (NRC) to H.C. Pfefferlen (GE), "Acceptance for Referencing of Licensing Topical Report NEDE-24011, Rev. 6, Amendment 8, 'Thermal Hydraulic Stability Amendment to GESTAR II'", April 24, 1985.

ATTACHMENT 2: PP&L Core Stability Perspective and Actions

General

PP&L has participated as a member of the BWR Owner's Group Stability Committee to assure all stability issues are addressed for Susquehanna SES. The discussion which follows provides PP&L's perspective on the various stability issues and identifies actions PP&L has taken or is currently performing to resolve these issues.

PP&L's reactor core stability perspective is based primarily on 10CFR50, Appendix A, General Design Criterion 12, "Suppression of Reactor Power Oscillations" which states:

> "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."

In general, PP&L believes that power oscillations could occur at Susquehanna SES during operation in the high power-low flow region of the operating map. For example, if the reactor was operating above the 100% rod line (i.e., in the Extended Load Line Limit Analysis region) and a two pump trip occurred, a reactor core instability is expected. However, we believe analysis techniques are not reliable enough to determine if specified acceptable fuel design limits (SAFDLs) could be exceeded during an instability event. In particular, PP&L believes the amplitude of very severe oscillations which can result in conditions exceeding SAFDLs is very sensitive to various computer code input parameters and assumptions. As a result, PP&L believes many sensitivity studies must be performed before an analysis that bounds all operating conditions (e.g., exposures, power shapes, etc) can be performed to reliably predict the maximum amplitude of oscillations during a core wide or regional instability event. At this time, PP&L does not rely on the design of the core and associated coolant, control, and protection systems to assure that power oscillations which can result in conditions exceeding specified acceptable fuel design limits are not possible. Instead, PP&L relies on Susquehanna SES plant operators to reliably and readily detect and suppress power oscillations which can result in conditions exceeding SAFDLs. This general perspective forms the basis for the specific approaches taken by PP&L to resolve the various stability issues.

Physical Characteristics

Since PP&L does not rely on analyses to demonstrate that reactor core instabilities which can result in conditions exceeding SAFDLs are not possible, the issues regarding the physical characteristics of the oscillations do not need to be resolved to comply with GDC 12. Specifically, the questions regarding the shape of each cycle for large amplitude oscillations (i.e., narrow peaks and broad valleys) and the maximum local power level are academic because operator actions are relied upon to suppress oscillations. However, PP&L is an active participant of the BWROG Stability Committee which has funded analyses to address these issues. PP&L will carefully review the results of the BWROG analyses prior to modifying the operational controls described below.

Decay Ratio Calculation Uncertainties

The uncertainty of the fuel vendor decay ratio calculation is factored into the Susquehanna SES stability monitoring Technical Specifications. PP&L reviews its current fuel vendor, Advanced Nuclear Fuels Corporation (ANF), analyses to assure the decay ratios are calculated for the worst axial power distribution and cycle exposure expected during the cycle. The Technical Specification stability monitoring region is then defined as the region in GE SIL 380 Rev. 1 as modified to assure the ANF calculated decay ratio is less than 0.75 in the unmonitored region. PP&L has taken neutron noise data near the boundary of this region at the 100% rod line which was used to determine the actual core (i.e., "measured") decay ratio. Each set of data analyzed to date has demonstrated that large stability margins exist at those operating conditions. At the conditions where large stability margins exist, the "measured" decay ratios have agreed very well with ANF's analytical results. Therefore, the ANF analyses and Susquehanna SES tests demonstrate that the reactor will be stable for all operation outside the stability monitoring region.

Operational Controls

Since PP&L relies on Susquehanna SES operators to detect and suppress power oscillations, an evaluation of the plant procedures, operator training, and stability monitoring Technical Specifications must be performed to assure the operators are (1) aware of and avoid the instability regions, (2) recognize the onset of uncontrolled power oscillations, and (3) take the appropriate actions in response to an uncontrolled power oscillation. PP&L has modified its operating procedures and training program to assure the operators and Shift Technical Advisors (STAs) are cognizant of the above items. Specifically, the key instructions provided in the revised procedures and training are:

1) reactor instabilities are most likely to occur in the region above the 80% rod line with total core flow less than 45 million lbs/hr (Unit 2 region is slightly larger), this instability region should be avoided, and two pump trips from above the 100% rod line will probably result in a core reactivity instability event;

2) an instability can be quickly detected by an increase in the amplitude of the noise in the APRM signal seen on the APRM strip chart recorder, an increase in the amplitude of the noise in the LPRM meter signals, and/or an actuation of LPRM downscale, LPRM upscale, and/or APRM upscale alarms; and

3) actions that must be taken to suppress the oscillation include (a) an immediate manual scram if the APRM oscillations reach 10% of rated peak-to-peak or if two or more LPRM upscale alarms are flashing and clearing on a one to five second period (i.e., indicative of a

possible regional oscillation) and (b) immediate insertion of a predetermined set of high worth control rods (i.e., CRAM rods) or an increase of recirculation pump speed (pump start is not allowed during a reactor instability) if the oscillations are not severe enough to result in APRM signals 10% peak-to-peak or LPRM upscale alarms.

The second instruction above was developed based on the signals received during the La Salle instability event which occurred on March 9, 1988. PP&L believes the current Technical Specifications for stability monitoring are too cumbersome to implement if a reactivity instability is in progress. In other words, by the time the operator pulls out the procedure to determine which nine control rods to select for LPRM monitoring, the oscillation amplitudes may increase to an unacceptable level. In addition, if the operator already knows that an instability is in progress, he should be taking steps to suppress the instability instead of performing the cumbersome Technical Specification surveillance to determine if an instability exists. Therefore, procedure changes were made to direct the operator to monitor for reactor instability via the APRM recorders, LPRM meters (i.e., if a control rod is selected), the LPRM downscale alarms, and the LPRM upscale alarms. Operators will use these indicators to rapidly perform an evaluation to determine the appropriate actions as discussed in the third instruction above. We also believe it is important to monitor for an instability much more frequently than currently required by Technical Specifications (i.e., currently, after a 5% power increase and every 8 hours). Therefore, in addition to the Technical Specification surveillance, PP&L procedures require the operator to monitor the APRM recorders, LPRM meters, and LPRM alarms during all power changes to determine that power oscillations are not occurring. PP&L is also considering a Technical Specification change request to eliminate the requirement to perform the current Technical Specification surveillance when in the instability region if an instability is in progress. This Technical Specification change request would also provide the actions discussed in the third instruction.

It should also be noted that the Susquehanna SES Training Simulator is currently being modified to meet the requirements of Regulatory Guide 1.149. As part of this modification, PP&L has included a requirement to model regional and core wide reactivity instability events.

<u>Instrumentation</u>

The previous paragraph discusses the use of instrumentation to detect an instability event and to determine the severity of the neutron flux oscillations. An evaluation must be performed to determine the adequacy of this instrumentation to perform the instability detection and monitoring function. Specifically, the neutron flux oscillations associated with a core reactivity instability exhibit a 2.5 second period. Therefore, any filters or time delays that exist in the instrumentation to prevent spurious alarms or reduce signal noise could result in alarms which actuate after the amplitude of the oscillations are significantly higher than the alarm setpoint and/or attenuation of the oscillation amplitude which is measured on the APRM recorders or LPRM meters. In general, PP&L expects that the filters and time delays will not prevent the operators from adequately responding to an instability event. This is based on the various instability events that have occurred in foreign and domestic BWRs in which all were readily detected and suppressed (i.e., some were automatically suppressed). None of these instability events has resulted in a known fuel failure. Despite this general opinion, PP&L plans to perform a test on the APRM recorders and LPRM meters to determine the attenuation that will occur during an oscillation with a 2.5 second period and a range of amplitudes. In addition, GE has stated that a description of the standard GE Neutron Monitoring System was supplied to the NRC in Reference 1 and was approved by the NRC in Reference 2. Therefore, PP&L plans to verify that filters and/or time delays were not added to instruments and alarms supplied by GE. In addition, PP&L is performing an evaluation to determine the prudency of relying upon non-1E instrumentation and electrical equipment for detection and monitoring of core reactivity instability events. Following completion of the above testing, evaluations, and analyses, PP&L expects to conclude that the instrumentation available to the operators is adequate for detection and suppression of regional or core wide power oscillations which can result in conditions exceeding specified acceptable fuel design limits.

Since PP&L will avoid operation in the instability region and the existing instrumentation is expected to be adequate for stability detection, PP&L does not believe a stability monitoring system (e.g., ANF ANNA system) should be installed at Susquehanna SES. A stability monitoring system would be useful if Susquehanna SES was frequently operated (i.e., during normal startups and shutdowns) in the instability region. During unanticipated pump trips or other events which result in operation in the instability region, the plant operators will be checking instrumentation to assure an instability is not in progress and taking immediate action to exit the instability region. The stability monitor would provide an estimate of the stability margin after a few minutes of data collection. The stability margin is useful information but is not required if actions are being taken to exit the region. Typically, intentional operation within the instability region only occurs during stability testing. To date these stability tests have demonstrated large stability margin (i.e., a decay ratio of approximately .40).

PP&L does not believe any post event recording instrumentation is required to comply with GDC 12. However, since Susquehanna SES has a GE Transient Analysis Recording System (GETARS) for each unit, the plant procedures were modified to assure that eight LPRMs at various radial locations in the core and the six APRMs will be recorded during an instability event. The information recorded by GETARS would facilitate the evaluation of an instability event and determination of whether a core wide or regional oscillation occurred.

Anticipated Transients Without Scram

Occurrence of an Anticipated Transient Without Scram (ATWS) will result in an automatic trip of both recirculation pumps for any scram failure of sufficient severity to threaten containment integrity. If the transient results in closure of the Main Steam Isolation Valves (MSIVs), the reactor water level will fall to Level 2 (L2) at which point RCIC and, at a slightly lower level, HPCI will initiate. These two systems in combination with CRD pump flow will cause water level to stabilize a few feet above the top of the upper plenum.

In the event of MSIVs remaining open, the operators are instructed to trip two of the three feed pumps and run the third back to 3 x 10^6 lbs/hr. This flow is equivalent to HPCI plus RCIC flow.

This flow rate corresponds to a steaming rate of about 21% of design which is within the capacity of the bypass system when it is available which eliminates any immediate concern over high suppression pool temperatures. When bypass is not available, the 21% steaming rate allows adequate time for boron injection when the operators follow procedures and initiate SLCS at a suppression pool temperature of 110°F. Calculations performed by PP&L indicate adequate time for boron injection even with failure of one of two pumps to inject, and PP&L simulator measurements of operator performance indicate that all Susquehanna SES crews will reliably initiate SLCS at a suppression pool temperature of 110°F or before.

This response strategy was developed by PP&L in early 1985 and submitted as a safety evaluation (Reference 3) for implementation of Revision 3 of the BWROG Emergency Procedures Guidelines (EPGs). The basis for the PP&L strategy included consideration of possible reactivity transients and unstable operation. The PP&L strategy minimizes changes in cold water injection after water level has fallen below the feedwater spargers, and it maintains water level above the top of the upper plenum where the downcomer cross sectional flow area is 300 ft^2 as opposed to 88 ft^2 below the top of the upper plenum. This approach minimizes pressure transients caused by changes in injection flow into the steam space, since the feedwater sparger must become uncovered, and maintains water level in a region where the level response (and therefore driving force for core flow) is less sensitive to changes in reactor power.

While limit cycle operation may occur, we believe this response strategy will minimize the severity of the power transients which may occur. Further, with prompt initiation of SLCS, which we believe will reliably occur, the boron is quickly mixed in the lower plenum and swept into the reactor core so that any oscillating behavior will be increasingly dampened as boron is injected.

We have considered the concerns which have been expressed with regard to the possibility that average power increases as a result of severe power oscillations that could occur during an ATWS event. There are two considerations which should be made in regard to this concern:

1. the threat to the containment, and

2. the threat to fuel cladding integrity.

However, the average power cannot increase because the amount of water being provided to convert to steam is constant unless the reactor water inventory decreases. This is a self limiting process because as reactor inventory decreases, water level must fall, and core flow and reactor power must decrease accordingly.

In very low probability ATWS scenarios where even more severe equipment failures occur, loss of high pressure injection, loss of SLCS, or both, the reactor must be depressurized. In the case of loss of high pressure injection, we would depressurize to about 600 psia and use a condensate pump if possible. This choice was made because the flow is immediately controllable and less chance of a reactivity transient is involved. If a condensate pump is not available, a low pressure Emergency Core Cooling System (ECCS) pump would be used, but our procedures instruct the operator to prevent injection until the 5 minute timer, which prevents throttling of injection flow, has timed out. This provision reflects our view that a short period of inadequate core cooling is preferable to the possibility of a severe reactivity transient caused by unrestricted injection flow. With core cooling restored in a controlled manner, SLCS operation would quickly reduce power and our primary exposure would be to a short period of inadequate core cooling.

Should SLCS fail with adequate high pressure injection, our procedures instruct the operators to achieve shutdown by manual rod insertion. In such a case, the suppression pool would reach the heat capacity temperature limit (HCTL) which requires reactor depressurization in order to reduce reactor power. We believe this will certainly take the reactor into an unstable operating regime of unknown severity. We intend to limit the depressurization to the range of 150 to 200 psia so that HPCI and RCIC operation can be maintained.

In the case of loss of SLCS and high pressure injection, the procedures instruct the operators to depressurize the reactor to reduce power and restore core cooling as described above and to achieve shutdown by manual rod insertion.

In our risk assessment activities, we have postulated mechanical cladding failure in these low probability ATWS events. We do not at present have analysis results which can be used to evaluate the potential severity of cladding damage during these events. Nevertheless, we believe our response strategy has minimized our exposure to unstable reactor behavior in ATWS events considering the actions necessary to prevent containment failure. The details of our evaluations are available in our Individual Plant Evaluation for Susquehanna SES.

1. G. A. Watford, "Compliance of the General Electric Boiling Water Reactor Fuel Designs to Stability Licensing Criteria", GE Proprietary Information, October 1984 (NEDE-22277-P-1).

2. Letter, C. O. Thomas (NRC) to H. C. Pfefferlen (GE), "Acceptance for Referencing of Licensing Topical Report NEDE-24011, Rev. 6, Amendment 8, 'Thermal Hydraulic Stability Amendment to GESTAR II'", April 24, 1985.

3. Letter, N. W. Curtis (PP&L) to W. R. Butler (NRC), "Emergency Procedures Generation Package," May 13, 1985.