ENCLOSURE

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
RELATING TO TOPICAL REPORT PL-NF-89-005
"QUALIFICATION OF TRANSIENT ANALYSIS METHODS
FOR BWR DESIGN AND ANALYSIS"
PENNSYLVANIA POWER & LIGHT COMPANY
SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 AND 2
DOCKET NOS. 50-387 AND 50-388

1.0 INTRODUCTION

By letter from H. W. Keiser to W. R. Butler (NRC), dated January 22, 1990, Pennsylvania Power and Light Company (PP&L) submitted topical report PL-NF-89-005, "Qualification of Transient Analysis Methods for BWR Design and Analysis," for NRC review. The methodology described in the report was intended as a technical basis for the PP&L qualification to perform transient analyses for the two Susquehanna Steam Electric Station GE BWR-4 reactors. Subsequently, PP&L modified the proposed methodology to explicitly model a time-varying axial power distribution in the hot fuel bundle. PP&L intends to use this modified methodology (Method 2) starting with Susquehanna Unit 2 Cycle 6. The original methodology (Method 1), which assumes a constant axial power distribution in the hot bundle model, will only be used for the Susquehanna Unit 1 Cycle 7 reload analysis.

The NRC staff was supported in this review by our consultant, Brookhaven National Laboratory. The staff has adopted the findings recommended in our consultant's technical evaluation report (TER) which is attached. In addition, the staff's safety evaluation of the modified methodology (Method 2) which incorporates a time-varying axial power distribution follows.

2.0 EVALUATION

The attached TER provides the evaluation of the original methodology which assumes a constant axial power distribution in the hot bundle and will be used by PP&L only for the Susquehanna Unit 1 Cycle 7 reload analysis (Method 1). Calculations of limiting transients for Susquehanna Unit 1 Cycle 7 were performed with both the new approach (explicit treatment of time-varying axial power distribution) and the original method (constant axial power distribution) and have demonstrated the conservatism of the minimum critical power ratio (MCPR) operating limits generated with the original method. Therefore, based on the attached TER, the staff finds the original method (Method 1) acceptable for the Susquehanna Unit 1 Cycle 7 reload analysis.

For the revised methodology, the NRC-approved RETRAN02 MOD4 (Ref. 1) computer code was modified to explicitly model a time-varying axial power distribution in the hot bundle. In addition, a revised gap conductance methodology was used to model the hot bundle with the NRC approved ESCORE code (Ref. 2). As described in Reference 3, the axial power distribution and bundle power history used as input to ESCORE are derived from a SIMULATE-E (Ref. 4) cycle step-out calculation for the cycle being analyzed. This results in a power history of 6 kw/ft or less for most of the cycle.

During the NRC review of ESCORE, emphasis was on its application in LOCA analyses (e. g., conservatism in predicting fuel temperature during a transient) and benchmark data for operation below 6 kw/ft were not assessed. The staff, therefore, questioned the validity of ESCORE gap conductance predictions for the low power levels associated with the Susquehanna 9x9 fuel design. Although PP&L has indicated their predicted hot bundle fuel rod gap conductance is higher and, therefore, conservative relative to that calculated using a method previously approved by the NRC, comparisons with independent calculations and with benchmark cases presented for other codes resulted in values on the order of 10% to 20% higher than those obtained with ESCORE. The Safety Evaluation Report for ESCORE (Ref. 5) requires a calculational uncertainty to be determined in plant-specific applications and included explicitly as a conservative adjustment or used to confirm the adequacy of existing conservatism in fuel limits. Since no uncertainty

estimates were provided for the ESCORE gap conductance, a 10% uncertainty multiplier (1.10) will be imposed on the calculated gap conductance. If appropriate benchmark information which validates the ESCORE calculated gap conductance at these lower powers is obtained at a later date, the staff will consider removing or revising this 10% uncertainty factor.

The staff also believes that the use of a best estimate power history in the transient analysis hot bundle gap conductance method may tend to underestimate the predicted gap conductance. If the actual hot bundle power exceeds the maximum bundle power assumed in the gap conductance analysis, more permanent pellet relocation would probably occur causing a higher hot bundle gap conductance than assumed. A hot bundle power 10% higher than the maximum power assumed in the gap conductance calculations would produce a gap conductance that is also approximately 10% higher. However, the net effect of a less than 10% increase in hot bundle gap conductance in conjunction with a similar increase in core average gap conductance is not expected to have a significant effect on the calculated change in critical power ratio (delta-CPR) for limiting events. Therefore, changes in hot bundle power which do not have peak powers greater than 110% of the maximum value used in the gap conductance calculation will not have a significant impact on minimum critical power ratio (MCPR) operating limits. PP&L has committed to reevaluate the MCPR operating limits in the event of occurrences which could potentially increase the hot bundle power by at least 10% above the value assumed in the licensing analysis of hot bundle gap conductance (Ref. 6). Those events which would require an evaluation are divided into three categories; core wide events, local power events, and changes in planned operation.

For core wide events, any plant event which increases reactor power to a value greater than 110% of rated power will require an evaluation of the MCPR operating limits. Examples of potential events which could cause this type of core wide power change are the generator load rejection, feedwater controller failure, and loss of feedwater heating events.

For local power events, any plant transient which produces a bundle power greater than 110% of the maximum bundle power assumed in the hot bundle gap conductance licensing analyses will require an evaluation of the MCPR operating limits. Examples of potential events which could cause this type of local power change are the rod withdrawal error, rod drop event, and rod drift.

Any change to the planned operation of the cycle which would result in bundle powers greater than 110% of the maximum bundle power assumed in the hot bundle gap conductance licensing analyses will require an evaluation of MCPR operating limits.

Based on this, the staff finds the revised PP&L transient methodology which incorporates an explicit modelling of the time dependent hot bundle axial power distribution (Method 2) acceptable for analysis of future Susquehanna reloads.

3.0 CONCLUSIONS

The staff has reviewed the PP&L transient methods topical report PL-NF-89-005 and the supporting documentation provided in response to our requests for additional information. Based on this review, the staff concludes that the PP&L transient methods and uncertainty estimates (Method 1) are acceptable for use in the Susquehanna Unit 1 Cycle 7 reload licensing analyses under the conditions stated in the attached TER.

The staff has also reviewed the revised methodology which incorporates an explicit modelling of the time dependent hot bundle axial power distribution (Method 2) and finds it acceptable for analysis of future Susquehanna reloads with the following provisions:

(1) The calculated value of gap conductance shall be increased by a 10% uncertainty factor. The staff will consider removing or revising this uncertainty at a later date if appropriate data becomes available to validate ESCORE calculated gap conductance values at these lower powers.

(2) The MCPR operating limits would require a reevaluation for any core wide event which increases reactor power to a value greater than 110% of

rated power or for any local power event or change to planned operation which produces bundle powers greater than 110% of the maximum bundle power assumed in the licensing analyses of gap conductance.

4.0 REFERENCES

1. "Acceptance for Referencing Topical Report EPRI-NP-1850 CCM-A Revisions 2 and 3 Regarding RETRAN-02/MOD-003 and MOD-004", Letter from A. C. Thadani (NRC) to R. Furia (GPU Nuclear), October 19, 1988.

2. EPRI NP-5100-L-A, "ESCORE-The EPRI Steady State Core Reload Evaluator Code: General Description", April 1991.

3. PLA-3729, "Susquehanna Steam Electric Station, Response to RAI on Transient Analysis Methods", Letter from H. W. Keiser (PP&L) to C. L. Miller (NRC), February 12, 1992.

4. EPRI-NP-2792-CCM, "SIMULATE-E Computer Code Manual", March 1983.

5. "Acceptance for Referencing of Licensing Topical Report EPRI-NP-5100, 'ESCORE-The EPRI Steady-State Core Reload Evaluator Code: General Description'", Letter from A. C. Thadani (NRC) to C. R. Lehmann (PP&L), May 1990.

6. PLA-3748, "Susquehanna Steam Electric Station, Response to Question on Gap Conductance Methodology", Letter from H. W. Keiser (PP&L) to C. L. Miller (NRC), March 16, 1992.