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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATING TO TOPICAL REPORT DPC-NE-3000

THERMAL-HYDRAULIC TRANSIENT ANALYSIS METHODOLOGY

FOR DUKE POWER COMPANY

OCONEE NUCLEAR STATION, UNIT NOS. 1, 2, AND 3

DOCKET NO. 50-269, 50-270, AND 50-287

1.0 INTRODUCTION

By letter dated July 1987, Duke Power Company (DPC), the licensee for Oconee Nuclear Station, Units 1, 2, and 3, submitted DPC-NE-3000, a topical report documenting DPC's use of the RETRAN computer code for McGuire/Catawba and Oconee. It was determined that DPC's use of the code was acceptable with respect to McGuire/Catawba; however, its use for Oconee licensing type analysis was restricted. DPC submitted supplemental information, dated October 16, 1991, and October 5, 1993, to qualify its RETRAN Oconee model.

International Technical Services (ITS), Incorporated, reviewed the topical and supplemental submittals, and provided a final Technical Evaluation Report (TER) to the staff. The primary aspects of the review focused on the ability of the RETRAN Oconee model to predict the primary and secondary side performance of the once-through steam generator (OTSG).

2.0 STAFF EVALUATION

Duke Power Company (DPC) developed two RETRAN models to analyze plant response for transient analysis. The two models were (1) the single loop model for cases when both loops have the same transient response, and (2) the two loop model for cases when the loops respond differently to transients. The difficulty in modeling the OTSG is due to the phenomena that occur during operation. The upper portion of the OTSG is super heated and the tubes are partially uncovered. This results in the primary-to-secondary heat transfer rate being a function of a two-phase mixture height in the steam generator (S/G). RETRAN is not capable of directly modeling the two-phase mixture; and the model of the secondary side of the S/G greatly affects the predicted plant response to transients. Therefore, it was necessary for the licensee to make compensations in the S/G model. The major compensations were the location of nodes in modeling the steam generator and timing of the emergency feedwater actuation signal.

Once the modeling changes were incorporated, the licensee verified the adequacy of the modified S/G model. The licensee demonstrated the adequacy of the base plant model by comparing the RETRAN analyses to the available plant data. Duke Power demonstrated that the differences in results using different nodalizations were small, and therefore concluded that the S/G nodalization in the base model is valid.

In using the model for the Final Safety Analysis Report type analysis, certain events cause specific plant responses. To compensate for the RETRAN model consistently overpredicting the primary-to-secondary heat transfer following a reactor trip, the licensee incorporated appropriate delays in the determination of the emergency feedwater actuation time.

The method of predicting the S/G mixture level in the RETRAN base code is non-conservative for once-through steam generators. Initially, DPC was not going to rely on the original RETRAN steam generator low level trip for actuation of the emergency feedwater system. However, DPC was able to modify the RETRAN control system to adequately simulate S/G level instrumentation. The ITS verified that the method used by DPC resulted in a conservative prediction of the S/G level for the time period of interest.

3.0 CONCLUSION

The ITS reviewed DPC-NE-3000 and the supplemental documents and provided separate TERs for the McGuire/Catawba plants and the Oconee plant. It was necessary to modify the RETRAN steam generator modeling to more accurately depict the response of Oconee's once-through steam generators. Duke Power provided a detailed justification and qualification of the RETRAN modifications including an explanation of the system impact due to inaccuracies in the modeling of primary-to-secondary heat transfer.

The steamline break modeling, although not part of this review, was briefly described as a modification of the Oconee base model nodalization. The descriptive method of steamline break analysis was found acceptable, but DPC stated that the specific details of the analysis will be submitted to the staff in a separate topical report.

The contractor has found the DPC approach to RETRAN modeling of the Oconee plant with compensating modeling techniques and transient assumptions to be acceptable. The approach is reasonable subject to the condition that the models are applied only to the Oconee plant. The staff concurs with the findings presented in the TER in that DPC has adequately modified the RETRAN computer code to simulate the response of the OTSG.

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SUPPLEMENTAL TECHNICAL EVALUATION: THERMAL-HYDRAULIC TRANSIENT ANALYSIS METHODOLOGY DPC-NE-3000 FOR DUKE POWER COMPANY OCONEE NUCLEAR STATIONS

1.0 INTRODUCTION

DPC-NE-3000, dated July 1987 (Ref. 1), documented results of a series of studies performed by Duke Power Company (DPC) to support the development of thermal-hydraulic transient analysis methodology. The transient analysis methodology documented in the topical report was based on the use of the RETRAN-02 (Ref. 2) and VIPRE-01 (Ref. 3) computer codes, subject to conditions for its Oconee plants (which are B&W plants) and its McGuire and Catawba plants (which are Westinghouse plants) (Ref. 4)

The NRC review of DPC-NE-3000 resulted in acceptance of the methodology for McGuire and Catawba analysis applications. However, its licensing application to Oconee analysis was restricted until further qualification of the RETRAN Oconee models and their uses (Ref. 4). The VIPRE portion of the submittal for both types of plant analysis was found to be adequate.

The purpose of this review, which is based upon a review of the additional information (Refs. 1, 5, 6 & 7) provided by the licensee since the previous review, is to determine adequacy of the RETRAN Oconee plant model for use in licensing type calculations focusing upon the ability of the RETRAN Oconee model to predict the primary and secondary side performance of the once-through steam generator (OTSG).

Details of plant nodalization and transient benchmark calculations were presented in the original topical report and their review findings documented in Reference 4 and are unaffected by this supplement. In this report, only those changes which impact the previous review findings are presented. Review of actual licensing applications and associated conservative assumptions is beyond the scope of this review. Similarly, although a philosophical approach to the Oconee steam line break was provided, details of such transient analysis was stated by DPC to be beyond the scope of the topical report, and therefore detailed review of steam line break was not performed. DPC stated that a future topical report will detail this transient and others.

2.0 REPORT SUMMARY

The topical report was supplemented by submission of additional information provided by DPC to specifically address conditions regarding use of RETRAN for Oconee application cited in the earlier SER on DPC-NE-3000.

Supplemental materials focused upon further qualification of the RETRAN Oconee steam generator model. Details of the steam generator model including nodalization sensitivity studies were provided. In addition, an explanation and analysis of sources of overprediction of primary-to-secondary heat transfer was provided.

A philosophical approach to Oconee steam line break analysis was also provided.

3.0 EVALUATION

Adequacy of DPC's application of the RETRAN computer code for thermal-hydraulic calculations of the transient behavior of its Oconee plants with focus upon DPC's Oconee steam generator modeling is discussed below.

3.1 Oconee Plant Model

DPC developed two Oconee RETRAN models: (1) a one-loop plant model to be used where there is little asymmetry between loop responses; and (2) a two-loop plant model to be used when asymmetric conditions are expected in the analysis. Detailed descriptions of the plant nodalizations and models selected for use in the analysis are presented in Chapter 2 of the topical report.

In the one-loop model, DPC models both steam generators and the accompanying hot and cold legs by one hot leg, one once-through steam generator (OTSG) and one cold leg. The core and steam generator nodalizations are the same as those in the two-loop plant model.

The base two-loop Oconee plant model consists of two separate loops each containing one hot leg, an OTSG and two cold legs. The OTSG is nodalized with equal height shell and tube side volumes except at the bottom of the steam generator. DPC stated that the specific degree of detail selected (i.e. the number of nodes) for the OTSG is necessary to model the void distribution in the OTSG.

The modeling of OTSGs is very difficult because in normal operation the steam in the upper portion of the SG is super heated and the SG tubes are partially uncovered (in marked contrast to U-tube type plants). Therefore the primary-to-secondary heat transfer rate is a function of the two-phase mixture height on the secondary side and the predicted transient behavior is strongly dependent upon the two-phase modeling on the secondary side of the steam generator. The mixture interface location and its transient behavior are very difficult to model with RETRAN, facts which DPC has acknowledged (Ref. 8).

DPC indicated, in Reference 5, certain potential nodalization and model changes for FSAR analyses to obtain conservative results. Each of these changes should add conservatism. However, it is recommended that DPC should demonstrate that such implementation produces conservative results.

3.1.1 Oconee RETRAN Steam Generator Model Qualification

In DPC-NE-3000, DPC chose to demonstrate the adequacy of the base plant model for Oconee plants through comparison of RETRAN analyses to available plant data, providing reasonably thorough analyses of the transients analyzed. In the supplemental submittals, justifications of DPC's Oconee SG nodalization were documented. DPC performed SG nodalization sensitivity studies and demonstrated that the differences between the two nodalizations considered were small indicating that the SG nodalization in the base model is converged.

However, in the earlier benchmark analyses it was found that the Oconee RETRAN model consistently overpredicted primary-to-secondary heat transfer following reactor trip. In order to manage this inherent modeling difficulty with RETRAN, DPC classified the FSAR transients into four categories (Ref. 7) according to expected impact of overprediction of post-trip heat transfer.

Category 1 contains transients 15.2 through 15.7 and 15.12 for which this phenomenon has little impact. For the transients in Category 2 (15.13 and 10.4.7.1.7 (Feedwater Line Break)), overprediction of post-trip heat transfer will result in a conservatively higher initial rate of overcooling. Computation of the source term in the steam generator tube rupture event (Category 3) over a 2-hour time period is not significantly affected by the overprediction of the initial post-trip heat transfer since the secondary inventory boil-off during the 2-hour time period will remain essentially the same.

Category 4 consists of loss of main feedwater (LOMFW), LOMFW with loss of offsite AC power, LOMFW with loss of onsite and offsite AC power and loss of electric power accidents. For these transients, there is a potential for the post-trip heat transfer to have an impact on the acceptance criteria (MDNBR and peak system pressure) being met. In order to prevent a premature injection of emergency feedwater due to faster boil-off in the LOMFW event caused by overprediction of primary-to-secondary heat transfer, an additional delay in the EFW start time is used. For the loss of electric power events in which the RCP's are tripped off, in order to maintain the required SG liquid level for natural circulation in the RCS, the EFW is assumed to open immediately to increase SG levels after adequate delay times.

DPC stated that the use of compensatory conservative assumptions will assure that the overprediction of primary-to-secondary heat transfer following a reactor trip will result in overall conservative predictions. DPC further stated that the specific sizes of delay and other corresponding conservative assumptions will be addressed in a future topical report. This approach is reasonable.

3.1.2 Steam Generator Mixture Level Prediction

In the previous review, DPC stated that the steam generator level trip would not be relied upon for actuation of the emergency feedwater system (EFW).

However, during this review, DPC revised the earlier position by stating its intent to use this setpoint. Thus closer examination of the manner in which the SG level is computed was conducted.

EFW actuates on MFW pump trip or on low SG level. DPC used a RETRAN control system to simulate SG level instrument function by calculating a differential pressure between the location of the two taps used by the instrument.

Benchmark analysis presented in DPC-NE-3000 showed that at the time period of interest, the predicted SG level compared well against the plant data. Prior to reaching that low level, the prediction tended to show a lower level than the data indicated, but this underprediction had minimal impact on the transient scenario as long as the minimum SG level was maintained.

3.1.3 Steam Line Break Modeling

In order to conservatively model the licensing type analysis of the steam line break event, DPC modified the base model Oconee RETRAN nodalization. These modifications include a split core and reactor vessel incorporating cross flow junctions. Although limited descriptive details of how the steam line break analysis would be performed by DPC were provided in Reference 7 and found to be reasonable, no quantitative information related to qualification of the methodology was provided. DPC stated that the specific details regarding the analysis are beyond the scope of DPC-NE-3000 and will be submitted to the NRC in a separate topical report.

4.0 CONCLUSIONS

DPC topical reports DPC-NE-3000 and its supporting documents, including the DPC responses to NRC questions, were reviewed. These responses addressed conditions cited in the earlier SER issued on DPC-NE-3000. Of four conditions cited, modeling deficiency with respect to the steam generator was the most serious. DPC provided detailed justification and qualification of its Oconee steam generator models using RETRAN. Thorough explanation of sources of predicted bias in the primary-to-secondary heat transfer was provided and found to be reasonable.

It is DPC's intent to overcome RETRAN modeling problems with compensating modeling techniques and transient assumptions. Review of actual licensing applications and associated conservative assumptions was beyond the scope of this review, since such details are to be presented in a future topical report. Similarly, because DPC stated that the specific details regarding the analysis are beyond the scope of DPC-NE-3000 and will be submitted to the NRC in a separate topical report, detailed review of an Oconee split core model for the steam line break analysis was not performed as part of this review and should be performed as part of the review of a subsequent topical report.

This approach is reasonable subject to the following conditions:

1. Acceptability of use of the DPC RETRAN transient analysis methodology is applicable only to Oconee plants.

2. When these models are used in licensing calculations, DPC should demonstrate that the models are adequately modified, where appropriate, to incorporate sufficient conservatisms so that the resulting analysis is conservative. Furthermore, DPC should demonstrate that the compensatory assumptions and delay times which it introduces to offset the over-prediction of post-trip heat transfer produce adequately conservative results.

4.0 REFERENCES

1. "Thermal-Hydraulic Transient Analysis Methodology," DPC-NE-3000, July 1987.

2. Letter, C.O. Thomas (NRC) to T.W. Schnatz (UGRA), September 4, 1984, (Transmittal of RETRAN-02 Safety Evaluation Report).

3. "Acceptance for Referencing of Licensing Topical Report VIPRE-01: A Thermal-Hydraulic Code for Reactor Cores, EPRI NP-2511-CCM Vols. 1-4," May 1, 1986.

4. Safety Evaluation on Topical Report DPC-NE-3000 "Thermal-Hydraulic Transient Analysis Methodology," November 15, 1991.

5. Letter from H.B. Tucker (DPC) to USNRC, "Handouts Presented in the October 7 & 8, 1991 Meeting with NRC Staff and Contract Reviewers, October 16, 1991.

6. Letter from H.B. Tucker (DPC) to USNRC, "Thermal-Hydraulic Transient Analysis Methodology," March 11, 1992.

7. Letter from M. S. Tuckman (DPC) to USNRC, "Thermal-Hydraulic Transient Analysis Methodology, DPC-NE-3000" October 5, 1993.

8. Letter from H.B. Tucker (DPC) to USNRC, "Duke Power Response to NRC Questions Regarding Steam Generator Heat Transfer Modeling with the RETRAN Code," August 9, 1989.