ENCLOSURE 2

MFN 06-079

TRACG Application for Anticipated Operational Occurrences Transient Analysis, NEDO-32906, Supplement 2-A, March 2006

Non-Proprietary Information

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This is a non-proprietary version of Enclosure 1 to MFN 06-079, which has the proprietary information removed. Portions of the enclosure that have been removed are indicated by an open and closed bracket as shown here [[ ]]

GE Energy
Nuclear

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NEDO-32906 Supplement 2-A
Class I
DRF 0000-0031-0728
March 2006

NON-PROPRIETARY INFORMATION

TRACG APPLICATION FOR ANTICIPATED OPERATIONAL OCCURRENCES TRANSIENT ANALYSIS

INFORMATION NOTICE

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IMPORTANT NOTICE REGARDING CONTENTS OF THIS REPORT

PLEASE READ CAREFULLY

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

March 24, 2005

Mr. George B. Stramback
Regulatory Services Project Manager
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175 Curtner Avenue
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SUBJECT: FINAL SAFETY EVALUATION FOR NEDE-32906P, SUPPLEMENT 2, "TRACG APPLICATION FOR ANTICIPATED OPERATIONAL OCCURRENCES TRANSIENT ANALYSIS" (TAC NO. MC5039)

Dear Mr. Stramback:

By letter dated November 3, 2004, General Electric Nuclear Energy (GENE) submitted NEDE-32906P, Supplement 2, "TRACG Application for Anticipated Operational Occurrences Transient Analysis." In this supplement, GENE proposed a change to the process used by TRACG for the calculation of critical power ratio during transients. This letter transmits the staff's final safety evaluation (SE). A draft version of this SE was issued on March 10, 2005, to allow GENE to conduct a proprietary information and factual error review. By e-mail dated March 11, 2005 (ML050740301), GENE replied that there were no issues with the technical content and that there was no proprietary information in the draft SE.

The staff has found that NEDE-32906P, Supplement 2, is acceptable for referencing in licensing applications for General Electric designed boiling water reactors to the extent specified and under the limitations delineated in the licensing topical report (LTR) and in the enclosed SE. The SE defines the basis for acceptance of the LTR.

Our acceptance applies only to material provided in the subject LTR. We do not intend to repeat our review of the acceptable material described in the LTR. When the LTR appears as a reference in the license applications, our review will ensure that the material presented applies to the specific plant involved. License amendment requests that deviate from this LTR will be subject to a plant-specific review in accordance with applicable review standards.
In accordance with the guidance provided on the NRC website, we request that GENE publish accepted proprietary and non-proprietary versions of this LTR within three months of receipt of this letter. The accepted versions shall incorporate this letter and the enclosed SE after the title page. Also, they must contain historical review information, including NRC requests for additional information and your responses. The accepted versions shall include a "-A" (designating accepted) following the LTR identification symbol.

If future changes to the NRC's regulatory requirements affect the acceptability of this LTR, GENE and/or licensees referencing it will be expected to revise the LTR appropriately, or justify its continued applicability for subsequent referencing.

Sincerely,

Herbert N. Berkow, Director
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Project No. 710
Enclosure: Final SE
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UNITED STATES
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FINAL SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

NEDE-32906P, SUPPLEMENT 2, "TRACG APPLICATION FOR ANTICIPATED OPERATIONAL OCCURRENCES TRANSIENT ANALYSIS"

GENERAL ELECTRIC NUCLEAR ENERGY

PROJECT NO. 710

1.0 INTRODUCTION

By letter dated November 3, 2004, General Electric Nuclear Energy (GENE) submitted NEDE-32906P, Supplement 2, "TRACG Application for Anticipated Operational Occurrences Transient Analysis." In this Licensing Topical Report supplement, GENE proposed a change to the process used by TRACG for the calculation of critical power ratio (CPR) during transients.

The staff has reviewed the GENE reactor accident and transient analysis computer code TRACG02A for application to the analysis of anticipated operational occurrences in the operating fleet of Boiling Water Reactor (BWR)/2-6 with a modified process for calculating the CPR. GENE previously submitted both code model documents that describe the TRACG code and the code itself to assist the staff review of the TRACG application to anticipated operational occurrences (AOOs) (Reference 1). The staff review and approval of that application of the TRACG code is documented in Reference 2.

The TRACG code is a thermal/hydraulic analysis code intended to be used in a realistic analysis mode. The approach taken by GENE in qualification of the code for the proposed application is under the code scaling, applicability, and uncertainty evaluation methodology described in Reference 3.

The TRAC family of computer codes began as a pressurized water reactor analysis tool developed for the U.S. Nuclear Regulatory Commission (NRC) at the Los Alamos National Laboratory. A BWR version of the code was developed jointly by the NRC and General Electric (GE) at the Idaho National Engineering Laboratory as TRAC-BD-1/MOD1. GE, and later GENE, developed a proprietary version of the code designated as TRACG. The objective of the proprietary code development was to have the code capable of realistic analysis of transient, stability, and anticipated transient without scram events. The code was modified to include a three-dimensional kinetics capability in addition to the multi-dimensional, two-fluid thermal/hydraulics modeling.

The plant types for which the TRACG code is to be applied includes the operating BWR/2s, BWR/3s, BWR/4s, BWR/5s, and BWR/6s. This safety evaluation report is applicable only to the operating BWRs 2-6.

2.0 REGULATORY BASIS

The draft Regulatory Guide and draft Standard Review Plan (References 4 and 5) outline the approach and guidance the staff is using in the review of thermal-hydraulic analysis codes. In addition, the staff has stated its guidance for code uncertainty analysis in Reference 3. These documents provide the regulatory basis by which the staff reviewed the November 3, 2004, proposed change to the process used by TRACG for the calculation of CPR during transients.

3.0 TECHNICAL EVALUATION

Sensitivity studies performed by Global Nuclear Fuels (GNF), a subsidiary of GENE, subsequent to the staff's review and approval of TRACG for AOOs (Reference 2) have found that the change in CPR (ΔCPR) divided by the initial CPR (ICPR) can vary when the ICPR is increased above the operating limit. As a result, GNF developed a different approach to the process for use in TRACG by which the CPR is calculated during AOOs. The new process yields a more consistent results ratio (ΔCPR/ICPR) as a function of ICPR. GNF has stated that there is minimal impact of the new method in those cases where the minimum CPR approaches the safety limit.

Currently, the critical power is calculated from the GEXL correlation (Reference 1), which calculates the critical quality as a function of pressure, mass flux, boiling and annular lengths, R-factor and thermal diameter. Critical power is then defined as the condition where the equilibrium quality equals the critical quality. To determine the critical power, the power is increased to the fluid while holding all other parameters constant. However, as the heat flow to the fluid increases, the equilibrium quality decreases, resulting in the boiling boundary, the point at which the equilibrium quality becomes zero, moving down the fuel rod to a lower elevation. At the same time, the transition to annular flow also moves down the fuel bundle. At a given elevation, the boiling and annular lengths are increasing and the critical quality is also increasing. As the power is increased, the point in the fuel bundle at which the equilibrium and critical quality are equal yields the critical power. GNF then defines a thermal margin (TM) as a function of the critical quality to the equilibrium quality for the power and flow conditions present.

Sensitivity studies have found that under certain conditions, the TM to CPR relationship can result in errors in the ratio ΔCPR/ICPR. The process for calculation of the transient CPR has been modified to reduce the error. The new process uses actual calculated parameters rather than a pre-defined relationship to get the instantaneous conditions. In so doing the calculation of the transient CPR yields less error in the ΔCPR/ICPR ratio.

The proposed process has been evaluated and assessed versus ATLAS fuel bundle transient tests typical of a pressurization event, as well as the Peach Bottom turbine trip 1, which was conducted at 47 percent power and 100 percent flow. The Peach Bottom turbine trip used for the assessment is the test with the lowest power to flow ratio, that is, the highest ICPR for the fuel bundles. The assessment cases presented indicate a significant improvement in the ΔCPR/ICPR. Finally, the case presented in the Reference 1 submittal, the Hatch 1 Cycle 14 turbine trip event, was run using the new methodology. The change in the ΔCPR/ICPR ratio is small but does improve.

The staff has reviewed the proposed change in the process used in the TRACG code to calculate CPR using the regulatory basis described in Section 2.0 above and finds it acceptable. Use of the proposed methodology will result in less errors in the calculation of the CPR during AOOs.

4.0 CONCLUSIONS

GNF developed an improved approach to the process for use in TRACG by which the CPR is calculated during AOOs. The new process yields a more consistent results ratio (ΔCPR/ICPR) as a function of ICPR. GNF has stated that there is minimal impact of the new method in those cases where the minimum CPR approaches the safety limit. The staff has reviewed the submittal using the regulatory basis described in Section 2.0 above and finds the proposed methodology acceptable.

The staff finds NEDE-32906P, Supplement 2, "TRACG Application for Anticipated Operational Occurrences Transient Analysis," to be acceptable for referencing in license applications. This safety evaluation report is applicable only to the operating BWRs 2-6. The staff does not intend to repeat our review of the matters described in NEDE-32906P, Supplement 2, when the report appears as a reference in licensing applications, except to ensure that the material presented is applicable to the specific plant involved. Our acceptance applies only to the matters described in NEDE-32906P, Supplement 2.

5.0 REFERENCES

1. NEDE-32906P, Rev. 0, *TRACG Application for Anticipated Operational Occurrences (AOO) Transient Analyses*, January 2000.

2. *Safety Evaluation Report by the Office of Nuclear Reactor Regulation for NEDE-32906P "TRACG Application for Anticipated Operational Occurrences (AOO) Transient Analyses"*, June 2002.

3. *NUREG*/CR-5249, *Quantifying Reactor Safety Margins: Application of Code Scaling Applicability, and Uncertainty Evaluation Methodology to a Large-Break, Loss-of-Coolant Accident*, December 1989.

4. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, Draft Regulatory Guide, DG-1096, "Transient and Accident Analysis Methods," December 2000.

5. Nuclear Regulatory Commission, Draft Standard Review Plan, Section 15.0.2, "Review of Analytical Computer Codes," December 2000.

Principal Contributor: R. Landry

Date: March 24, 2005

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1.0 INTRODUCTION

GNF has developed an improved process for use in TRACG for the calculation of the critical power ratio (CPR) during AOO transients. The improved process leads to more consistent results for the change in critical power ratio over initial critical power ratio (ΔCPR/ICPR) as function of ICPR. The impact of the change in numerical method is insignificant for transients where the minimum critical power ratio (MCPR) approaches the safety limit (SL).

The purpose of this paper is to describe the background material that prompted the development of the improved method, to describe the current and improved process for the calculation of the transient CPR, and to show the testing of the improved process.

Finally, a licensing evaluation of this change in the process for the calculation of transient CPR has shown that the change is within the constraints and limitations of the approval of TRACG [1]. The impact of the change is insignificant for events where the MCPR equals the SL. The impact, however, can be significant for events where the MCPR is greater than the SL.

2.0 BACKGROUND

In the application methodology for TRACG described in Reference 1, [[

]]

Recent sensitivity studies with TRACG have shown that the ΔCPR/ICPR can vary when the ICPR is increased above the operating limit. An example of this is shown in Table 2-1.

Table 2-1 ΔCPR/ICPR Sensitivity to ICPR

Event	Power/Flow (%)	Multiplier on hot bundle power	ICPR	MCPR	ΔCPR/ICPR
[[					
					]]

[[

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[[

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Figure 2-1 Typical Relationship Between TM and CPR

Details of the definition of TM and the current numerical method for the calculation of the CPR during transients are given in Section 3.

3.0 CURRENT CALCULATION FOR STEADY-STATE AND TRANSIENT CPR

The critical power is calculated from the GEXL correlation [2, 3]. The GEXL correlation calculates the critical quality as function of pressure, mass flux, boiling and annular lengths, R-factor and thermal diameter:

$$x_c = x_c(P, G, L_B, L_A, R, D_Q) \tag{3-1}$$

Critical power or boiling transition is then determined as the condition where the equilibrium quality equals the critical quality:

$$x_e = x_c \tag{3-2}$$

For a bundle with a power Q a typical equilibrium quality and critical quality as function of axial elevation may look as shown in Figure 3-1.

[[

]]

Figure 3-1 Typical Equilibrium Quality and Critical Quality for a Fuel Bundle

The critical power is then determined by increasing the power or heat flow to the fluid while all other parameters such as pressure, inlet fluid conditions and power shapes are kept constant. The equilibrium quality will increase as the heat flow to the fluid is increased. As a result of the increased quality, the boiling boundary, defined as the point where the equilibrium quality equals zero ($x_e = 0.0$) is reached at a lower elevation in the bundle. Similarly, the transition to annular flow, which is determined from the [[ ]] correlation, will move downwards in the bundle as the heat flow and equilibrium quality is increased. Consequently, for a given elevation z, the boiling and annular lengths will increase, and there will be a corresponding increase in the critical quality. The power or heat flow to the fluid is increased until, at some point in the bundle, the equilibrium quality equals the critical quality. The power Q_c at this condition is the critical power. For a bundle with a critical power of Q_c, a typical equilibrium quality and critical quality as function of axial elevation may look as shown in Figure 3-2.

[[

]]

Figure 3-2 Typical Equilibrium Quality and Critical Quality at Critical Power

[[

]]

It is convenient to introduce the following parameters: critical power ratio (CPR) and thermal margin (TM):

$$CPR = \frac{Q_c}{Q} \tag{3-4}$$

$$TM = \frac{x_c + \frac{\Delta h_s}{h_{fg}}}{x_e + \frac{\Delta h_s}{h_{fg}}} \tag{3-5}$$

where Δh_S is the inlet subcooling. Note: $x_{inlet} = -\frac{\Delta h_s}{h_{fg}}$

From the above equations it is seen that critical power corresponds to CPR=1 and TM=1.

During a transient, the CPR is calculated as described in the TRACG Model Description, Section 7.5.5 [4]. [[

]]

[[

]]

Figure 3-3 Typical Relationship Between TM and CPR for Pressurization Transient

[[

]]

4.0 IMPROVED PROCESS FOR THE CALCULATION OF TRANSIENT CPR

[[

]] An improved process for the calculation of the transient CPR has been developed for TRACG in order to reduce this error.

[[

]]

5.0 QUALIFICATION

The improved process for the calculation of transient CPR has been extensively tested by comparisons to transient ATLAS tests and by comparison to the current method for typical plant cases.

5.1 TRANSIENT ATLAS TESTS

The transient ATLAS tests are designed to simulate the transient response of a fuel bundle during a typical pressurization event such as a turbine trip. [[

]]

The MCPRs from the associated transient CPR calculations are shown in Table 5-1.

Table 5-1 MCPR for Transient ATLAS Tests

Transient CPR	Test	
	ATA 127B R61 – GE11	ATA 231C3 R209 – GE9
Current Process	[[	
Improved Method		]]

[[

]]

[[

]]

Figure 5-1 Transient ATLAS Test ATA 127B R61 – GE11

[[

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Figure 5-2 Transient ATLAS Test ATA 231C3 R209 – GE9

5.2 PEACH BOTTOM TURBINE TRIP 1

Peach Bottom turbine trip 1, conducted at 47% power and 100% flow, is the test with the lowest power to flow ratio and, therefore, also the test with the highest ICPRs for the fuel bundles. Comparisons of the transient CPRs, calculated using the current process and the improved process for three different powered channels (ICPRs ranging from 2.4 to 3.8) are shown in Figures 5-3 to 5-4 and Table 5-2.

[[

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Figure 5-3 Peach Bottom Turbine Trip 1 – Transient CPR

[[

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Figure 5-4 Peach Bottom Turbine Trip 1 – ΔCPR/ICPR

Table 5-2 Peach Bottom Turbine Trip 1

	Current process			Improved process		
	ICPR	MCPR	ΔCPR/ICPR	ICPR	MCPR	ΔCPR/ICPR
Channel 16	[[					
Channel 17						
Channel 18						]]

[[

]]

5.3 TRACG AOO Application Methodology, NEDE-32906P-A

A turbine trip event for Hatch 1 Cycle 14 was evaluated as a demonstration case in the TRACG AOO Application Methodology LTR [1]. The results are shown in Table 8-1 of Reference 1. This case has been repeated here and the results are shown in Table 5-3

Table 5-3 Hatch 1 Cycle 14 TTNB – Channel 27

	Current Process NEDE-32906P-A Table 8-1	Improved process
ICPR	[[	
MCPR		
ΔCPR/ICPR		]]

[[

]]

5.4 Brunswick 1 Cycle 15

The sensitivity studies that led to the discovery of the sensitivity of the ΔCPR/ICPR to the ICPR for large ICPR have been repeated with the improved process for the transient CPR. These results are shown in Table 5-4.

Table 5-4 ΔCPR/ICPR Sensitivity to ICPR with Improved Process

Event	Power/Flow (%)	Multiplier on hot bundle power	ICPR	MCPR	ΔCPR/ICPR	ΔCPR/ICPR Current Process from Table 2-1
[[						
						]]

Comparing these results to Table 2-1, which contains the same cases for the current process, shows:

[[

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6.0 LICENSING EVALUATION

The major conclusions from the previous sections are:

[[

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It is desirable to implement the improved process as an optional method for the transient CPR calculation due to the more consistent results obtained with this method. However before the improved process can be implemented, it must be determined whether review and approval by the USNRC is needed. A licensing evaluation following the 10CFR50.59 rules [8] and the NEI guidelines [9] is given in the following paragraphs. This licensing evaluation consists of a three-step process containing a determination of applicability, a screening, and an evaluation for NRC review.

6.1 APPLICABILITY

This step determines if an NRC approved methodology is involved. The TRACG application methodology is NRC approved and documented in Reference 1. Therefore, the 10CFR50.59 rules apply.[1]

6.2 SCREENING

The screening is done to determine if the change is adverse and requires evaluation for NRC review. This screening consists of two parts.

Is the change within the constraints and limitations associated with the approved methodology? Section 2.6 In Reference 1, as approved by NRC, describes what changes can be made to TRACG without NRC review and what changes require NRC review and approval before they are implemented. This section is included in Appendix A.

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[1] If another regulation applied, such as 10CFR50.46 for loss of coolant accident analysis, the evaluation would have to be performed according to these rules. This is not the case for the TRACG application to AOO transients.

Section 2.6.1 of Reference 1 states that changes to basic models may not be used in AOO licensing calculations without NRC review and approval, but changes to the numerical methods to improve code convergence may be used without NRC review and approval. The improved process is considered a change to the numerical method, since the improved process does not involve a change in the critical power correlation, but only a change in the calculational process to determine the transient CPR. Therefore, the change is considered to be within the constraints and limitations of the approved methodology.

The second part involves a determination of whether the change has an adverse impact on critical safety parameters and if an evaluation for NRC review is required. Since the improved numerical method for the transient CPR calculation will change the results, no matter how small this change is, an evaluation for NRC review is required.

6.3 EVALUATION

The evaluation involves a determination if the change is conservative or essentially the same. [[

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Consequently, it is concluded that the change in the process for the calculation of the transient CPR cannot be implemented without NRC review and approval.

7.0 SUMMARY AND CONCLUSION

An improved process for the calculation of transient CPR has been developed for TRACG. [[ ]]

A Licensing evaluation of the change has been performed, and it has been determined that the change cannot be implemented without NRC review and approval.

8.0 REFERENCES

1. TRACG Application for Anticipated Operational Occurrences Transient Analysis, NEDE-32906P-A, Rev. 1, April 2003.

2. General Electric Thermal Analysis Basis (GETAB): Data Correlation and Design Application, NEDE-10958_PA, January 1977.

3. Letter, A. C. Thadani (NRC) to J. S. Charnley (GE), Acceptance for Referencing of Application of Amendment 15 to GE LTR NEDE-24011-P-A, "GE Standard Application for Reactor Fuel", MFN-47-87, March 14, 1988.

4. TRACG Model Description, NEDE-32176P, Rev 2, December 1999.

5. Qualification of the One-Dimensional Core Transient Model for Boiling Water Reactors, NEDE-24154-P-A, Volume 1, August 1986. Qualification of the One-Dimensional Core Transient Model for Boiling Water Reactors, NEDE-24154-P-A, Volume 2, August 1986. Qualification of the One-Dimensional Core Transient Model for Boiling Water Reactors, NEDE-24154-P-A, Volume 3, August 1988.

6. TASC03A, A Computer Program for Transient Analysis of a Single Channel, NEDC-32084P-A, July 2002.

7. TRACG Qualification, NEDE-32177P, Rev 2, January 2000.

8. NRC Regulations, Title 10, Code of Federal regulations Part 50, Section 59, "Changes, Tests and Experiments", 10CFR50.59 December 14, 2001.

9. Guide Lines for 10CFR50.59 Implementation, NEI 96-07, Revision 1 [Final Pre-Publication Draft], September 22, 2000.

10. Methodology and Uncertainties for Safety Limit SMLCPR Evaluations, NEDC-32601P-A, August 1999.

APPENDIX A NEDO-32906-A, SECTION 2.6

2.6 Review Requirements For Updates

In order to effectively manage the future viability of TRACG for AOO licensing calculations, GE proposes the following requirements for upgrades to the code to define changes that (1) require NRC review and approval and (2) that will be on a notification basis only.

2.6.1 Updates to TRACG Code

Modifications to the basic models described in Reference 4 may not be used for AOO licensing calculations without NRC review and approval.

Updates to the TRACG nuclear methods to ensure compatibility with the NRC-approved steady-state nuclear methods (e.g., PANAC11) may be used for AOO licensing calculations without NRC review and approval as long as the ΔCPR/ICPR, peak vessel pressure, and minimum water level shows less than 1 sigma deviation difference compared to the method presented in this LTR. A typical AOO in each of the event scenarios will be compared and the results from the comparison will be transmitted for information.

Changes in the numerical methods to improve code convergence may be used in AOO licensing calculations without NRC review and approval.

Features that support effective code input/output may be added without NRC review and approval.

2.6.2 Updates to TRACG Model Uncertainties

New data may become available with which the specific model uncertainties described in Section 1 may be reassessed. If the reassessment results in a need to change specific model uncertainty, the specific model uncertainty may be revised for AOO licensing calculations without NRC review and approval as long as the process for determining the uncertainty is unchanged.

The nuclear uncertainties (void coefficient, Doppler coefficient, and scram coefficient) may be revised without review and approval as long as the process for determining the uncertainty is unchanged. In all cases, changes made to model uncertainties done without review and approval will be transmitted for information.

2.6.3 UPDATES TO TRACG STATISTICAL METHOD

Revisions to the TRACG statistical method described in Section 1 may not be used for AOO licensing calculations without NRC review and approval.

2.6.4 UPDATES TO EVENT SPECIFIC UNCERTAINTIES

Event specific ΔCPR/ICPR, peak pressure, and water level biases and uncertainties will be developed for AOO licensing applications based on generic groupings by BWR type and fuel type. These biases and uncertainties do not require NRC review and approval. The generic uncertainties will be transmitted to the NRC for information.