December 11, 2000

Mr. James F. Mallay
Director, Regulatory Nuclear Affairs
Siemens Power Corporation
2101 Horn Rapids Road
Richland, WA 99352

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION - SIEMENS POWER CORPORATION TOPICAL REPORTS, EMF-2310(P), REVISION 0, "SRP CHAPTER 15 NON-LOCA METHODOLOGY FOR PRESSURIZED WATER REACTORS," (TAC NO. MA7192) AND EMF-2328(P), REVISION 0, "PWR SMALL BREAK LOCA EVALUATION MODEL, S-RELAP5 BASED" (TAC NO. MA8022)

Dear Mr. Mallay:

By letter dated November 22, 1999, Siemens Power Corporation (SPC) submitted Topical Report EMF-2310(P), Revision 0, "SRP Chapter 15 Non-LOCA Methodology for Pressurized Water Reactors," and by letter dated January 10, 2000, Topical Report EMF-2328(P), Revision 0, "PWR Small Break LOCA Evaluation Model, S-RELAP5 Based" for staff review. The primary document describing the S-RELAP5 code is EMF-2100(P), Rev. 2, "S-RELAP5 Models and Correlations Code Manual," dated January 2000. Review of the two topical reports involves reviewing the use of the S-RELAP5 code for application to the small break loss-of-coolant (LOCA) and non-LOCA transients.

In order for the staff to complete its review of the topical reports, the enclosed information pertaining to the S-RELAP5 computer code is required.

A mutually agreeable target date of within 30 days of the date of this letter for your response has been established. If circumstances result in the need to revise the target date, please call me at the earliest opportunity at 301-415-1480.

Sincerely,

/RA/

N. Kalyanam, Project Manager, Section 1
Project Directorate IV & Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 702

Enclosure: Request for Additional Information

December 11, 2000

Mr. James F. Mallay
Director, Nuclear Regulatory Affairs
Siemens Power Corporation
2101 Horn Rapids Road
Richland, WA 99352

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Sincerely,
/RA/
N. Kalyanam, Project Manager, Section 2
Project Directorate IV & Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 702

Enclosure: Request for Additional Information

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REQUEST FOR ADDITIONAL INFORMATION

SIEMENS POWER CORPORATION

TOPICAL REPORTS EMF-2310(P), REVISION 0, "SRP CHAPTER 15 NON-LOCA

METHODOLOGY FOR PRESSURIZED WATER REACTORS," AND

EMF-2328(P), REVISION 0, "PWR SMALL BREAK LOCA EVALUATION MODEL,

S-RELAP5 BASED"

PROJECT NO. 702

The following questions are in regard to Topical Report EMF-2100(P), Revision 2.

Comments/Editorials:

G.1 In several places including the first sentence on page 2-1, you stated that the S-RELAP5 code solves two-phase, two-fluid six equations plus one continuity equation for noncondensable gas and a boron tracking equation. S-RELAP5 actually includes a two-fluid model for a two-phase system. The sentence in your report implies that the code models two phases for two different fluids. This is not accurate.

Chapter 1: Introduction

1.1 On page 1-2 you stated that you have applied 2-D modeling to the downcomer, core, and upper plenum. Please explain why 2-D modeling of the lower plenum and lower head has not been applied.

1.2 On page 1-2 you stated that the modification made to the energy equations are more appropriate for analyses involving a containment volume. In Information Notice 92-02 the staff stated that codes in the RELAP5 series are not intended to be used as containment analysis codes. Containment analysis specific codes exist for that purpose. The primary purpose of the RELAP5 codes is analysis of the response of the nuclear steam supply system (NSSS) to accident and transient conditions. Please clarify the intent of your statement in light of the statement in the Information Notice.

1.3 On page 1-6 you stated that the steady-state option does not perform convergence tests and that users are required to set up the conditions for determining whether a steady-state is obtained. Please discuss the guidance provided to the users to aid them in doing this and identify where such guidance has been included.

Chapter 2: Fluid Field Equations and Numerical Solutions

2.1 Please provide a description of the major differences between S-RELAP5 and RELAP5/MOD2 pertaining to the Semi-Implicit Numerical Solution Scheme.

2.2 In the second paragraph on page 2-29, Section 2.6, it is stated that RELAP5/MOD2 was extended to include a two-dimensional flow solution scheme in S-RELAP5. Was this new scheme benchmarked or validated to ensure correct implementation and correctness of the scheme? Please discuss the benchmarking.

2.3 On page 2-54, the subject of time-step control is discussed. How does the time-step calculation in S-RELAP5 differ from that used in RELAP5/MOD2? In particular, discuss any differences in the way the error is measured within the two methods.

2.4 The energy equations presented do not include energy dissipations due to wall friction and pump effects. Please derive your energy equations to show how these terms are eliminated and/or justify the exclusion of these terms. Please justify your simplifying assumption included as Equation 2.13 in your report.

2.5 The energy equations presented assume that the enthalpy in the wall vaporization term ($\Gamma_w h$) is the saturation enthalpy. Please justify this assumption.

2.6 On page 2-6 you stated that under most circumstances, assessment calculations indicate that there are essentially no differences in the results of key loss of coolant accident (LOCA) parameters between the RELAP5/MOD2 energy equations and the energy equations provided in S-RELAP5. Please provide a discussion of the assessment calculations performed including a discussion of the key LOCA parameters that were assessed. In addition, please provide a discussion of the circumstances where differences were identified and justify your methodology in light of those differences. Also, provide similar discussions related to the other transients that you are proposing to analyze with the code.

2.7 Please provide a discussion of the heat transfer at the noncondensable gas-liquid interface and the effect of this on the energy equations. Please explain how this is modeled in your proposed methodology.

2.8 Under Section 2.4, State Relationships, you assume that the interface temperature is the saturation temperature. Please justify this assumption.

2.9 Please derive Equation 2.42 and justify your assumption that the extrapolated α is just the saturation value for both the superheated liquid and the subcooled steam.

2.10 Your statement that substitution of Equations 2.45 and 2.47 into Equation 2.48 yields Equation 2.50 does not appear correct. Please show how Equation 2.50 was obtained. Note that this error continues in later derivations.

2.11 Regarding Equations 2.101 and 2.102, why is the velocity at j+1 evaluated at time n+1 while being multiplied by the density and void fraction at j+1 from time n? Note that the velocity at j is evaluated at time n and multiplied by the density and void fraction at j from time n. Also, compare with Equations 2.103 through 2.105, wherein the velocity at j+1 is evaluated at time n+1 but multiplied by the density and void fraction at j+1 from time n. But velocity at j is evaluated at time n+1 and multiplied by density and void fraction at j from time n.

2.12 How are areas for the momentum flux terms in the 2-D components calculated? How is this conveyed to the user?

2.13 How are the variables (a_g) and (a_f) in Equation 2.116 defined?

2.14 Given the fact the rα is treated as r when using the (z,α) form of the 2-dimensional momentum equations, as opposed to the (z,r) form, how is the "r" defined?

2.15 Has the effect of violations of the material Courant limit been evaluated? What is the recommended value for $\alpha t_c(i)$ in Equation 2.212?

Chapter 3: Hydrodynamic Constitutive Models

Editorial:

3.1 Page 3-6, first paragraph states that Wallis asserted that $j_{g^*} \approx 0.9$. The star appears incorrectly placed. Consistent with the remainder of the text it appears that the star should be a superscript to j instead of g.

Technical:

3.2 On page 3-1, end of the second paragraph, it is stated that code-data comparisons for the key parameters are to be used for assessing the applicability of the interphase constitutive models. Earlier in the same paragraph it was stated that the key parameters are phasic temperatures, phasic velocities, phasic densities, mass flow rates, and void fractions. Please explain how the key parameters were identified and provide the assessments that were performed to confirm the applicability of the interphase constitutive models.

3.3 [This question is related to large break LOCA (LBLOCA) only and may be responded to at the time of the BE LBLOCA submittal].

On Page 3-1, last paragraph, it is stated that the Electric Power Research Institute (EPRI) drift-flux correlations used in RELAP5/MOD3 are tuned mostly to the steady-state data with regular flow profiles and that there is little evidence that these fix-profile correlations produce good results in simulating LBLOCA transients which are highly irregular and chaotic in nature. It is also stated that the EPRI correlations do not cover the entire range of two-phase flow conditions. Based on this information, it was stated that S-RELAP5 did not adopt the same approach as used in RELAP5/MOD3 but that assessment examples are presented to show that the S-RELAP5 two-fluid formulation produces code-data comparisons that are as good as those obtained by RELAP5/MOD3 for steady-state and nearly steady-state cases. Since the concern stated with the EPRI drift-flux correlations was with the modeling of the LBLOCA transients which are highly irregular and chaotic in nature, please provide the assessments that were performed to ensure that the correlations used in S-RELAP5 are adequate for highly irregular and chaotic transient cases.

3.4 In Equation 3.7, you limited α_L to a minimum value of 0.1 and used $(D^*/19)^8$. Which experiments form the basis for choosing these values? Please justify the use of these values.

3.5 Please describe the tests used in the assessment and provide the assessments performed to validate the use of Equation 3.11 and the limits provided in the text that follows the equation on pages 3-6 and 3-7 in relation to the $\alpha_{S\text{-}A}$ criteria.

3.6 On page 3-7, end of the first paragraph, it is stated that introduction of transition regions may reduce the chances of occurrence and magnitude of discontinuities in interphase interaction terms, but it cannot completely eliminate the discontinuities. Please describe known discontinuities that still remain and how these are dealt with in the coding of S-RELAP5.

3.7 Please describe the information used to confirm the validity of the interpolation in Equation 3.15.

3.8 Under the vertical stratification section starting on page 3-8, there appear to be no flow/velocity criteria established for when vertical stratification may occur. Please explain how vertical stratification is detected.

3.9 Please describe how the mixture level model described under the vertical stratification section was validated.

3.10 Please describe the assessment performed to justify the method used for the transition region between the stratified and non-stratified flow (i.e., Equation 3.26 and associated restrictions and criteria).

3.11 Justify the choice of 0.9 for j_g^* for the boundary between slug and annular mist flow (Equation 3.28) in light of the wide range of 0.25 to 1.0 suggested by Wallis. What are the sensitivities of the results of the analyses of interest to the value of j_g^* and why is 0.9 appropriate in light of these sensitivities? What is the range of hydraulic diameters that this criterion is valid for? Please describe the assessment performed to cover the sensitivity to hydraulic diameter. Provide a comparison to applicable experimental data.

3.12 Please describe how the effect of condensation at the ECCS injection point is handled in S-RELAP5.

3.13 Please show how Equation 3.23 is derived from the material in the reference. Also, it appears in Equation 3.23 that the α_g is a subscript to α. Please confirm or correct this.

3.14 On page 3-48, it is stated that various assessment calculations indicate that Equations 3.98 and 3.99 function well. Please identify and discuss the tests that were used in the assessment calculations and the results of the assessment calculations.

3.15 Section 3.4.8 discusses the equilibrium option that exists in S-RELAP5. Please provide a table showing when (i.e., in what transient analyses) this option would be allowed and when it would not be allowed. Also, please provide a reference to the section in the

user's manual that directs the user to follow these restrictions. If allowed in any of the licensing analyses, please justify the values selected.

3.16 Section 3.4.9 discusses the effect of noncondensables on condensation rate. Please justify your use of Equations 3.169 and 3.165 in S-RELAP5 to handle the reduction of condensation rate in the presence of noncondensables. Please provide a description and results of assessment calculations that justify the use of these equations.

3.17 For time smoothing, it is stated on page 3-68 that the scheme implemented in S-RELAP5 is empirical and that various assessment calculations indicate that it works satisfactorily. Please describe the assessment calculations performed for confirming the time smoothing scheme. In addition, show how the assessment calculations provide a test for the scheme.

3.18 In Section 3.4.10, in relation to mass error, it is stated that S-RELAP5 implements a strategy which forces only condensation to take place when the amount of liquid in a volume is small and subcooled and the vapor is superheated. In addition, this strategy forces only evaporation to take place when the amount of vapor in a volume is small and subcooled and the liquid is superheated. It is stated that these limits have no significant effects on physical results as one would expect from such a diminishing amount of liquid or vapor and that these limits reduce mass error substantially. Please justify your strategy for dealing with the mass error. In your justification, please discuss any assessments that were performed, the tests used in the assessments, and the results.

3.19 In Section 3.4.10, in relation to subcooled nucleate boiling, it is stated that S-RELAP5 implements a strategy which lowers the interphase heat transfer coefficients in order to eliminate situations where the total mass transfer rate, Γ_g, becomes negative. Please justify your strategy for dealing with this situation. In your justification, please discuss any assessments that were performed, the tests used in the assessments, and the results. In addition, the last paragraph on page 3-70 states that there is no guarantee that the final solution at the end of each time step meets all the conditions or limits described in the section. Please explain what is meant by this statement and explain and justify what is done in S-RELAP5 when the conditions or limits are not met.

3.20 Please provide a list of the figures of merit and important phenomena in relation to each of the transients and accidents to be analyzed with S-RELAP5. Please also describe how these figures of merit and important phenomena were designated as important for the relevant analyses.

3.21 In Sections 3.4.1 through 3.4.7, heat transfer correlations, limits on these correlations, and transition equations are presented for different flow regimes. However, no justifications are provided. Please provide justifications for the material presented in these sections and provide a discussion of assessments performed to confirm the adequacy of correlations used in S-RELAP5.

3.22 Page 3-11, last paragraph, it is stated that "...some calculations with RELAP5/MOD2 indicated that the range of stratified flow is too small. Kukita et al suggested that the vapor velocity on the left side of Equation 3.22 be replaced by the relative velocity (v_g-v_f).

This approach along with an additional constraint to exclude high mass flux conditions was implemented in the previous S-RELAP5 code versions. Recent experience with small break test cases and plant calculations indicated that the new approach might increase code variability. Therefore, the approach of replacing the vapor velocity with relative velocity is abandoned."

Since the approach was abandoned, what was done to address the concern that the range of stratified flow was too small and how was that justified? Please provide comparisons of your approach to data to justify the adequacy of your approach.

3.23 [This question is related to LBLOCA only and may be responded to at the time of the BE LBLOCA submittal].

For dry-wall flow regimes, please justify your use of 0.1 for the $\alpha_{IA\text{-}IS}$ criterion in light of the information provided in the text preceeding Equation 3.13 that indicates that the transformation of the three wet-wall flow regimes into inverted annular, inverted slug, and mist flow regimes should be used.

Chapter 4: Heat Transfer Models

4.1 In reviewing Section 4, Heat Transfer Models, it is apparent that this section is totally different to any comparable heat transfer section in RELAP5/MOD2. Contributions from various known sources constitute the basis for this heat transfer model. Please provide qualitative (and quantitative) justification for the formulation of this particular heat transfer model (i.e., assumptions, mass flow rates, pressure, enthalpy, etc.).

4.2 On page 4-2 of the S-RELAP-5 Models and Correlations Code Manual, the last sentence of the last paragraph discusses the issue of reflood being turned off and on. Who decides when or where the option is turned on or off at the appropriate time?

4.3 Please provide an explanation of the difference between the data and the calculational results in Figure 4.3

4.4 How does RELAP-5/MOD2 or MOD3 compare to the same data as that presented in RAI 4.3 above? A comparison of S-RELAP5 and RELAP5/MOD2 against the data and on the same page would help.

Chapter 11: Point Kinetics Model

11.1 On page 11-16, the last equation has a term missing. The term " $\mathbf{-V_{01}}$ " is missing. Compare with Equation 7.6-21 in NUREG/CR-5535, V1.

The following question is in regard to Topical Report EMF-2328(P), Revision 0.

SB.1 Please justify use of 0 percent fuel clad preoxidation in the SBLOCA analysis.