October 15, 1982

Dr. T. W. Schnatz
UGRA Chairman
Middle South Services
P. O. Box 61000
New Orleans, Louisiana 70161

Dear Dr. Schnatz:

Subject: Request Number 2 for Additional Information on EPRI NP-1850-CCM

We are currently reviewing the Utility Group for Reactor Applications submitted licensing topical report EPRI-NP-1850-CCM entitled "RETRAN-02-A Program for Transient Thermal-Hydraulic Analysis of Complex Fluid Flow Systems."

As a continuing effort, our consultants at Argonne National Laboratory have identified the need for additional information indicated in the enclosure. These questions are the result of the review of those sections of the models/methods volume of the RETRAN-01 manual which were reported in the letter from the Utility Group for Regulatory Application to J. R. Miller (NRC), June 21, 1982, to describe RETRAN-01 modeling features different from those of RETRAN-02. As agreed in our January 13, 1982 meeting, we will forward the requests for additional information as they are developed. Accordingly, this is the second request and additional requests will be forwarded as they are prepared.

This information is necessary to complete the review - its expeditious submittal will, therefore, be to the advantage of UGRA.

Sincerely,

ORIGINAL SIGNED BY:

Cecil O. Thomas, Acting Chief
Standardization & Special
Projects Branch
Division of Licensing

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Chapter II Fluid Differential and State Equation

(1) Is the sign of the stress term $(\overline{\overline{T}} \cdot \tilde{v})$ of equation (II.1-20) correct?

(2) Are there errors in equation (II.1-25) and equation (II.2-30)?

(3) In RETRAN is cos α of equation (II.2-11) always ± 1?

(4) Summarize the layout of the two geometrical meshes, the momentum cell mesh and the energy/mass mesh and illustrate how the junciton angle for the vector momentum is defined in the generalized geometry.

(5) How is $\tilde{A}$ oriented with respect to the channel walls in the macroscopic momentum equation? Reference should be made to equation #(3) which poses the problem of the mass balance equation.

(6) The term F_{loc} is missing from equation (II.3-5). Why?

(7) Is there a typographical error in equation (II.3-17)?

(8) Is the sign of the next to the last term in the right-hand side of equation (II.3-18) correct?

(9) (a) In the variable channel area momentum balance equation, equation (II.3-23), the $F_{w,\ i+1}$ term needs to be corrected.
(b) Is there a typographical error in the last term of the right hand side.

(10) Show how equation (II.3-29b) is derived. Why is it correct to assume that the flow is isentropic? How is it reincorporated into the final flow equation? There are typographical errors in §3.3.2. Correct.

(11) Are there typographical errors in equation (II.3-30)?

(12) In equation (II.3-36), is there a typographical error in the second term of the right hand side?

Chapter III Constitutive Models

(1) The derivation of the mass balance, eq. (III.1-62) as presented in eqs. (III.1-56) - (III.1-61) is incorrect as the 1-D equations used cannot describe a 3-D situation with transverse junctions. A similar comment applies to the derivation for eq. (III.1-67). Discuss.

(2) Why do the production terms in eqs. (III.1-66) and (III.1-67) involve m's?

(3) The meaning of ϕ, in eq. (III.1-67) is inconsistent with its meaning in eq. (III.1-69). Why is it that in eq. (III.1-67) it is used as an area fraction while in eq. (III.1-69) it is used as a mass fraction?

(4) How and where is $\dot{M}_g$ in eq. (III.1-65) for the total steam mass balance determined?

(5) How are the inlet junction qualities in eq. (III.1-73) determined?

(6) There are errors in eqs. (III.1-79) to (III.1-80), eqs. (III.1-82) to (III.1-85), eq. (III.1-87) and eq. (III.1-89). Correct.

(7) Will RETRAN automatically switch between homogeneous and separated models during a transient?

(8) How are the control volume momentum and energy balance equations derived in Chapter 2 used in conjunction with the phase separation model?

(9) Equation (III.2-37) of the junction enthalpy model assumes that volume average properties are equal to volume center properties. Is

the same assumption made for all the thermal/hydraulic macroscopic balance equations?

(10) Why does the W_i term in eqs. (III.2-37) and (III.2-38) use A_k instead of A_i?

(11) Is not the sign of the Z_i term in eq. (III.2-51) incorrect?

(12) Does eq. (III.2-42) imply constant pressure?

(a) Why is eq. (III.2-51) used for junction enthalpy instead of eq. (III.2-49)?

(b) What is the physical interpretation of $\Delta h_{S_{ik}}$ in the steady state Bernoulli equation, eq. (III.2-38), when no heat or work is added?

(c) Can the enthalpy transport model be used with pump volumes? If so, justify.

(13) (a) Can RETRAN-01 be used as a blowdown and refill code?

(b) Can its heat transfer model be extended to the reflood analysis?

(14) (a) Why was the Baroczy model implemented as

$$\phi_{tp}^2 = 1.0 + [\phi_{tp,G=10^6}^2 - 1.0] F_G$$

when the original Baroczy model is

$$\phi_{tp}^2 = \phi_{tp,\ G=10^6}^2 F_G \ ?$$

(b) Has the value of the function F_G already been corrected in the Tables III.1-1 to III.1-5 to account for the change in the Baroczy model?

(15) The Berenson heat transfer coefficient and heat flux at the minimum film boiling are

$$h_{c,min} = 0.425 \left[\frac{K_{gf}^3 \rho_{gf} (\rho_{ls} - \rho_{gs}) g \Delta h_f}{\mu_{gf} (T_{w,min} - T_{sat}) \sqrt{\frac{g_c \sigma}{g (\rho_{ls} - \rho_{gs})}}} \right]^{1/4}$$

where the subscript gf denotes the value of the vapor properties at the vapor film evaluated at the average temperature of the hot surface and the saturated liquid. Why are all vapor properties in eqs. (III.2-16), the equivalent RETRAN equations for the Bereson heat transfer coefficient and heat flux, evaluated at the saturated condition?

(16) (a) Justify the use of the Berenson minimum temperature correlation in the case of turbulent boiling on oxidized surfaces under high pressure conditions.

(b) Is the Berenson minimum temperature correlation limited to pool boiling situations? If not, elaborate.

(c) According to Table III.3-1, the Berenson film correlation is utilized as one of the heat transfer modes in the forced convection option. Explain why this application in the forced convection zone is an appropriate one.

(17) The Groeneveld correlation as described by eq. (III.2-28) is used without Slaughterbeck's modifications.* Discuss the accuracy of the correlation without these modifications.

(18) The Bromley correlation is

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* D. C. Slaughterbeck, et al. "Flow Film Boiling Heat Transfer Correlation - Parametric Study with Data Comparisons," ASME 73-HT-50, ASME-AICHE Heat Transfer Conference, Atlanta, GA, Aug. 1973.

D. C. Slaughterbeck, et al., "Statistical Regression Analysis of Experimental Data for Flow Film Boiling Heat Transfer," ASME 73-HT-20, ASME-AICHE Heat Transfer Conference, Atlanta, GA, Aug. 1973.

$$h_c = 0.62 \; K_{gf}^3 \left[\frac{\Delta h_f \; \rho_{gf} \; g \; (\rho_l - \rho_v)}{\mu_{gf} \; (T_w - T_{sat}) \; D_r} \right]^{1/4}$$

where the subscript gf indicates evaluation of vapor properties at the average temperature of the hot surface and the saturated liquid. Why are all vapor properties in eq. (III.2-31), the RETRAN equation for the Bromley correlation, evaluated at the saturated conditions?

(19) Explain why heat transfer correlations such as Dengler and Addams [cf eq. (III.2-12a)], Guerrier and Tatty [cf eq. (III.2-13a)] and Shrock and Grossman [cf eq. (III.2-14)] should be used in preference to Chen's correlation.**

(20) (a) Can the use of the Dougall and Rohsenow correlation be extended to the pressure range of interest to LWR safety analysis? Justify.

(b) Can the correlation be applied in the dry wall mist flow regime where the flow is not in thermodynamic equilibrium?

(21) Discuss the adequacy of the Bennet flow regime map, presented in Fig. III.2-2, to calculate void fractions using the RETRAN dynamic slip model. In particular elaborate on the boundaries between the various flow regimes.

(22) Justify the statement made on pp. III-30 that the Bennet map is believed to be more independent of pressure if the thermodynamic quality is converted to the homogeneous volume fraction when the relationship between quality, x and the homogeneous volume fraction α is

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** J. Chen, "A Correlation for Boiling Heat Transfer to Saturated Fluids in Convective Flow," ASME 63-HT-34, 1963.

$$\alpha = \frac{x/\rho_{gs}}{(1-x)/\rho_{ls} + x/\rho_{gs}}$$

and ρ_{ls}, ρ_{gs} are functions of pressure.

Chapter V Power Generation

(1) Eqs. (V.1-1) and (V.1-2) are missing factors of π and ν. Correct.

(2) Why are there no π's in the adjoint equation, eq. (V.1-4)?

(3) There are ν's and "'" missing in eqs. (V.1-6) , (V.1-8) and (V.1-10). Correct.

(4) Define v used in eq. (V.1-12).

(5) Where is G(t) used in eq. (V.1-14) defined?

Chapter VI System Compnents Models

(1) Is the statement N=W in the nomenclature of Page VI-1 a typographical error?

(2) Should the term $M(\bar{\alpha})$ be $N(\bar{\alpha})$ in the equation VI.1-4?

(3) Should ρ be replaced by $\bar{\rho}$ in equation VI.1-5?

(4) What is the accuracy of the difference curves/head multiplier procedure used for the two-phase pump model?

(5) What is the error involved in using "steady state" characteristics in the pump formulation presented during transient situations?

(6) In the equation VI.1-8, how are the i^{th} coefficient of friction torque, $(T_{fr})_i$ obtained? Are they build-in values?

(7) Should the equation VI.1-10 be expressed as follows: $T = T_{hr} + T_{fr} - T_m$?

(8) Is there a typographical error in the first term on the right-hand side of equation VI.2-5? Should it be as follows:

$$\frac{A}{I} \int_{t_o}^{t} P(\tau)\, e^{\frac{K}{I}\tau}\, dt?$$

(9) Is there a typographical error in the second term in the right-hand side of equation VI.2-6? Should it be as follows:

$$\frac{AP(t)}{K}\left(1 - e^{-\frac{K}{I}t}\right)?$$

(10) Should the first term on the right hand side of equation VI.2-7 be θ_o instead of θ?

(11) Discuss how valves are included in the momentum balance equations with emphasis on the numberical scheme involved.

(12) What is the physical interpretation of eq. VI.3-4?

Chapter VII Operational Transient Models

(1) Is the lag compensation formula for y_i in Table VII.1-1 correct? Justify.

(2) Illustrate the use of the transport delay model with a Y and all possible combination of flow directions.

(3) Why are there no condensate terms in the energy equations, eq. (VII.3-3) and eq. (VII.3-4)?

(4) Show how $(\dot{M}_g)$ of eq. (III.1-65) used in the determination of the flashing mass flux, eq. (VII.3-8) is related to the primary variable $[P, M_1, M_2, U_1, U_2]^{\dagger}$ of the pressurizer model?

(5) How are the momentum balance equations of Chapter 2 coupled to the pressurizer mass/energy equations?

(6) Present the mass and energy balance equation when the first spray option is chosen; spray in the vapor region.

(7) Discuss the numerical behavior of the pressurizer model solution when the pressure is used for the convergence criteria.

(8) Discuss step 3 of the solution technique in detail, in particular, the linear equations for each region. Is the term $\left.\frac{\partial r}{\partial p}\right|_h$ a typographical error?

(9) What is done when the pressurizer completely fills or completely empties?

(10) Show how the phase separation model described in Chapter III is used in conjunction with the pressurizer model.

(11) How is the engineering enthalpy rise factor computer and how is it used?

(12) How is the complete transient energy equation option activated when eq. (VII.4-3) is inadequate for a hot channel calculation? Discuss the option.

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† Notation of Chapter VIII.

(13) There is a typographical error on Page VII-24. VII.5-8 should be replaced by VII.4-5.

Chapter VIII Numerical Solution Methods

(1) Explain the order of the operators on the right hand side of eq. (VIII.1-7).

(2) (a) How is the F_j^n term in the momentum equation, eq. (VIII.1-9) derived?

(b) Why are there no cosine factors for the gravity term?

(c) Justify the second term. Define S_{gn}?