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Docket Nos: 50-327
and 50-328

Mr. H. G. Parris
Manager of Power
Tennessee Valley Authority
500A Chestnut Street, Tower II
Chattanooga, Tennessee 37401

Dear Mr. Parris:

Subject: Requests for Additional Information on CLASIX Computer Program

Enclosed is a list of requests for additional information on the CLASIX Code (Topical Report No. OPS-07A35). This information is needed in order to complete our review of the hydrogen control systems in the Sequoyah units. We have also sent these requests to Duke and AEP.

Since this subject is generic to the ice condenser plants, we suggest a coordinated utility response by October 1, 1982.

The reporting and/or recordkeeping requirements contained in this letter affect fewer than ten respondents; therefore, OMB clearance is not required under P.L. 96-511.

Sincerely,

/S/

Thomas M. Novak, Assistant Director
for Licensing
Division of Licensing

Enclosure:
As stated

cc: See next page

OFFICE	DL:LB #4	LA:DL:LB #4	DL:LB #4	AD:L:DL			
SURNAME	CStahle/hmc	MDuncan	EAdensam	TNovak			
DATE	8/6/82	8/6/82	8/6/82	8/9/82			

SEQUOYAH

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REQUEST FOR ADDITIONAL INFORMATION
REGARDING THE CLASIX
TOPICAL REPORT NO. OPS-07A35

1) Provide additional details regarding the ice bed nodalization scheme used in CLASIX, specifically:

   a) It is not clear whether all or just part of the volume initially occupied by ice is added to the lower plenum volume as the ice melts. Clarify how the free volume and ice volume in the ice bed are handled in CLASIX, both initially and as the ice melts; and

   b) It is our understanding that the present version of CLASIX, unlike earlier versions, does not treat the ice bed as a separate volume. As a result combustion in the ice bed cannot be modelled. Combustion in this region can potentially be more severe than in the plenums due to the larger ice bed volume. Discuss the consequences of modelling the ice bed as a flow path rather than as an individual volume, and demonstrate that the CLASIX approach yields more conservative results than if combustion in the ice bed were permitted.

2) With regard to the CLASIX flow equations (A-4, A-8) provide the following information:

   a) Equation (A-4) is used until a Mach number of one is reached without adjusting the loss coefficient for the variation of compressibility over this range of Mach number. Please justify the assumption of a constant loss coefficient.

   b) The use of steady-flow equations assumes that the effects of transient phenomena, such as inertia, are not important. However, inertia would increase the pressure rise associated with a burn because pressure relief by outflow is reduced. Please describe the junction flow transients and transitions to sonic flow which occur at each of the flow junctions during blowdown and hydrogen burns, and justify that the steady-flow equations are valid for hydrogen burn transients.

c) The flow equations require a density and velocity. These should be the density and the velocity at the vena contracta (mininum flow area). However, the density defined by Equation (A-7) provides a density that is the average of the source and the sink volumes, which will not be the vena contracta density. In addition, the velocity used in Equation (A-4) is not defined. Please explain and justify the bases for the density and velocity used in the flow equations.

d) Two-phase flow conditions might result from 1) the breakflow or 2) a condensation fog from the ice condenser. As a result, the effects of mechanical (slip), thermal, and chemical (vapor diffusion) non-equilibria may become important. Justify the use of Equations (A-4) and (A-8) to estimate the transient flow of a two-phase fluid.

3) Justify the CLASIX assumpton that the breakflow can be assumed to separate immediately into a liquid portion tht falls to the containment floor and a vapor portion that is added to the inventory of the containment atmosphere.

4) Provide the following information regarding the CLASIX hydrogen burn model:

a) The burn time values used in CLASIX analyses submitted for two similar plants differ by as much as a factor of three for the same compartment and flame speed, thus suggesting an inconsistency in computing burn length. To clarify this point, describe the methodology for evaluating the burn length as it applies to containment analyses.

b) Discuss the rationale for precluding flame propagation in fan flow paths.

c) Describe how CLASIX might be applied to model containments with multiple ignition points within containments.

d) Equation (D-3) appears to be a calorimeter equation where the preburn mixture is at 70°F and the products of combustion are cooled to the same temperature. Equation (D-4) appears to represent the net energy addition rate due to hyrogen burning. Clarify these equations, and explain how they are applied. Specifically:

  i) Provide a more detailed description of the heat rate parameters, HR_E and HR in Equation (D-3), and discuss the significance of the specific heat terms used to "correct" the heat rate of combustion. Include approximate parameter values used in CLASIX analyses.

  ii) Discuss the relevance of Equation (E-3) for the typical CLASIX analysis in which the containment temperatures before and after a burn are very different; i.e., the products of combustion are not cooled to the initial temperature.

  iii) Provide a more detailed discussion and development of Equation (D-4). Describe the significance of the specific heat terms, and how Equation (D-4) is ultimately applied.

iv) Explain why in Equation (D-4) the effective heat rate is reduced due to the removal of hydrogen and oxygen but is not increased due to the formation of water vapor.

e) Describe where in the CLASIX calculations the mass inventory of oxygen and steam is adjusted due to combustion, and when in the calculations the energy released from a hydrogen burn is added.

f) It is our understanding that the hydrogen burn rate, $\dot{M}_B$, is determined upon ignition by Equation (D-2) and held constant for the duration of each burn, while the mass of hydrogen to be burned is updated each interval by Equation (G-20). Intuitively the burn rate should also be updated to reflect the mass of hydrogen present, which may be greater or lesser than that at the onset of burning depending on the hydrogen injection rate. Please justify the use of a constant burn rate in view of the changing hydrogen concentration during a burn.

5) Provide the following information regarding the calculation of heat and mass transfer to passive heat sinks:

a) Equation (B-1) provides for the use of either the Tagami or Uchida correlation to determine the heat and mass transfer to passive heat sinks. The Tagami correlation is for conditions very different from those expected for the application of CLASIX, that is, small-break containment analyses. The Uchida correlation is for natural convection heat transfer, including condensation, in the presence of a noncondensible gas. Clarify how Equation (B-1) is used and justify the use of the Tagami correlation.

b) The natural convection heat transfer correlation for $Gr < 10^9$ that is used in the Tagami/Natural convection heat transfer correlation Equation (B-6), yields heat transfer rates lower than other text book correlations by a factor of three. Please discuss this discrepancy.

c) Describe and justify the passive-heat-sink heat-transfer assumptions regarding (i) the temperature difference used with the film coefficients; (ii) the model used to account for the removal of mass that is condensed on the heat-sink surfaces; and (iii) the energy removal associated with the condensed mass.

6) Concerning the radiation heat transfer model used in CLASIX:

a) If the wall surfaces are assumed to be "black," the radiant heat transfer equation, (B-8), does not reduce to a classical expression of the form $Q_r = \sigma A (E_v T_v^4 - \alpha_v T_w^4)$ as it should.

Provide the development of Equation (B-8), and justify the use of the vapor and wall emissivities as multipliers on the T^4 terms.

b) It is conceivable that the breakflow or fog at the ice condenser exit might be introduced as a dispersion of fine drops that would be transported throughout the containment. The small drops might reduce the radiation from the water vapor to the heat sinks by affecting the beam length for radiation. Discuss the impact of this mechanism on the the radiant heat transfer calculation.

7) For the internal heat transfer model, provide additional details with regard to:

a) The procedure for updating the surface temperature of a wall with two nodes in the surface layer; and

b) The evaluation of Q_c in Equation (B-17) when NN=2 and NN>2. Also, describe the subscript notation for these cases.

8) Regarding the analysis of heat transfer in the ice bed:

a) The assumption that no condensation occurs in the ice bed if the water vapor is superheated, and that condensation only occurs when the vapor is saturated does not seem realistic because (a) both heat and mass transfer can occur simultaneously if there is both a temperature and a concentration gradient; and (b) the vapor concentration gradient can extend into the superheated region. Provide justification for this assumption, perhaps via an analysis of the mass transport occurring in the superheated and in the saturated sections of the ice bed.

b) The possibility exists to produce a condensate fog in the ice bed capable of being convected along with the flowing gas instead of collecting on the surface of the ice bed. Provide analyses or cite relevant studies which would justify the assumption that no condensate fog leaves the ice condenser.

c) Provide additional details of the CLASIX ice bed heat transfer solution process, specifically, the procedure by which the ice condenser is subdivided into incremental lengths, and the superheat and saturated heat transfer correlations are applied.

d) In the condensing region of the ice bed, Equation (C-26) is applied until the flow temperature is equal to the outlet plenum temperature.

Explain why the outlet plenum temperature is used as a cutoff point for the saturated heat transfer correlation rather than some fixed temperature.

e) The film coefficient correlation for heat transfer to the ice, Equation (C-1), was developed based on ice bed inlet conditions typical of design basis accidents, i.e., relatively low flow velocities and saturated to slightly superheated vapor qualities. Inlet velocities and degree of superheat resulting from a postulated lower compartment burn will be significantly higher than for the design basis accidents. Justify the use of the correlation under hydrogen burn conditions.

f) Specify the parameter dimensions, condensate length, and flow area assumed in Equation (C-1). Also provide some typical calculated values for the film coefficient in the superheated and condensing regions.

g) Discuss the basic differences between the CLASIX treatment of the ice bed heat transfer and the treatments used in other ice condenser codes such as LOTIC and TMD. Describe the method of handling the heat and mass transport under superheated and saturated conditions in each code.

9) Regarding the ice condenser melt water:

a) Discuss the heat transfer analyses and assumptions used to determine the melt water temperature on exit from the ice condenser. Provide approximate values of the melt water temperature for CLASIX analyses.

b) In the CLASIX description it is not clear whether ice melt water is transferred to the sump or assumed to remain at the ice node. Describe the melt water treatment and sump model used in CLASIX, especially with regard to how the lower compartment volume is adjusted due to the addition of water from melted ice and containment sprays.

c) Describe the effect of the reduced lower compartment volume (due to added water) on containment pressure and temperature response.

10) With regard to the CLASIX spray model:

a) The mass, momentum, and energy transfer accounting seems to be incomplete. For example, the equations should account for the simultaneous occurrence of either vaporization or condensation with or without a change in the spray-drop temperature. Please verify the CLASIX spray model by comparison with a spray model that includes a more thorough accounting for the mass, energy, and momentum transfers, such as the model developed by G. Minner.*

b) The assumption that spray drops will desuperheat completely from the drop initial temperature to the saturation temperature corresponding to the total pressure results in a certain fraction of the drop mass immediately "flashing" to the atmosphere. It is possible that liquid drops can sustain superheats as much as 8°C, which will reduce the fraction of mass transferred by "flashing." Justify the CLASIX assumption and describe what effect a sustained superheat would have on reported results.

* G. L. Minner, "Reactor Containment Spray Calculation," Thermal Reactor Safety CONF-770708 (July 1977), Vol. 1, pp. 569-582.

c) Heat and mass transfer during droplet fall is characterized as occuring in two regimes -- sensible heating at constant drop volume, and vaporization at constant drop temperature (with excess heat removal). Describe how the times at which each of these mechanisms occur, t_1 and t_2 respectively, are defined in the computations.

d) Please indicate whether the droplet velocity used in CLASIX is user-specified or calculated internally based on the input droplet diameter. Specify the velocity values used/calculated in the spray verification runs. Also, specify the input values for the spray film coefficient.

11) In the evaluation of the effect of a separate spray time domain, it is stated that: 1) the CLASIX spray model always predicts conservatively high containment pressure and temperature responses; and 2) the difference in the heat removal calculated using the CLASIX spray subroutine and the finite difference subroutine approaches zero as the transient progresses. In light of this,

a) Discuss why the CLASIX spray model underpredicts heat removal as the first statement implies. Holding compartment ambient conditions constant on an increasing temperature ramp would seem to support this. However, if ambient temperature would expose droplets to higher temperatures on the average, resulting in greater CLASIX spray heat removal. Provide additional comparisons of the rates of heat removal for the two models assuming increasing containment ambient conditions, decreasing ambient conditions, and postulated hydrogen burn conditions; i.e., a rapid ambient temperature increase followed by a gradual temperature decrease.

b) With regard to the second statement, describe the effect that non-linearities in heat transfer/thermodynamic processes have on the agreement between the two models.

12) Regarding the temperature and pressure responses (Figures D-1 and D-2) presented in the spray comparison, discuss the reason for the sudden change in slope between 120 and 125 seconds.

13) In the CLASIX-TMD comparison presented in Appendix A, the response of an ice condenser plant is modelled using both TMD and CLASIX. However, the input parameters for TMD (Taables A-1 and A-2) and CLASIX (Tables A-3 and A-4) do not seem analogous in several respects, and do not accurately represent Westinghouse ice condenser design. Specifically:

a) The upper compartment volumes used in the two analyses are not in agreement, presumably due to a typographical error in the CLASIX value (Table A-3). Even so, the value of 698,000 ft^3 used in the analyses actually represent the sum of the upper compartment (651,000 ft^3) and upper plenum (47,000 ft^3) volumes. The upper compartment volume should not include a contribution from the upper plenum since the latter is represented as a separate mode in both analyses.

b) In TMD the ice is distributed in the three ice bed compartments and the upper plenum (total volume = 88,499 ft^3), while in CLASIX all the ice is assigned to the single ice bed node (volume = 36,830 ft^3) and no ice is present in the upper plenum.

c) The lower plenum volume in TMD is 22,100 ft^3 versus 36,830 ft^3 in CLASIX. Equivalent volumes would seem to be more appropriate.

d) In TMD a loss coefficient of 0.5 is specified for each of the ice bed and plenum flow paths (paths 1 through 5 in Figure A2). To be consistent with the CLASIX analysis, TMD loss coefficients should be approximately 0.1 for paths 2 through 5 and 2.0 for path 6.

Discuss the aforementioned differences in the TMD and CLASIX input parameters, and verify the TMD-CLASIX comparison via revised analyses as appropriate.

14) For the CLASIX-COCOCLASS9 comparison:

a) Explain why a transient hydrogen burn case wasn't considered in addition to the single burn case analyzed.

b) Specify the surface film coefficient assumed in cases 2 and 5 of this comparison, and discuss whether or not this value would account for pre-burn pressures and temperature in cases 2 and 5 being less than in cases 3 and 6, respectively.

15) With regard to the comparison of CLASIX results with test measured results (Appendix C):

a) Complex burn-control parameter adjustments were required to predict conservatively the peak pressure for tests that had (1) a single non-uniform burn (CLASIX Case 10), and (2) multiple burns (Fenwal Case 2-2-2 Transient).

(i) Describe the burn-control parameter adjustments made for these cases;

(ii) Discuss the corresponding parameter adjustment procedure that would be used to perform an analysis for a nuclear power plant containment that has non-uniform or multiple burns; and

(iii) Provide results of CLASIX predictions for these two cases under a best-estimate single set of burn parameters applied over the entire burn event. Compare the pressure trace to that obtained from (1) the "revised" CLASIX model; and (2) the actual test results.

b) Sensitivity studies with CLASIX are cited in Appendix C but few test results are provided. Please provide more details, specifically, the ranges over which the parameters were varied, and the results for the bounding cases.

16) Justify that mass and energy are conserved by CLASIX for a large problem time and for the problem time steps used. Describe quantitatively the time steps and their variation during a typical problem.