TENNESSEE VALLEY AUTHORITY

CHATTANOOGA, TENNESSEE 37401
400 Chestnut Street Tower II

April 10, 1984

Director of Nuclear Reactor Regulation
Attention: Ms. E. Adensam, Chief
Licensing Branch No. 4
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Ms. Adensam:

In the Matter of) Docket Nos. 50-327
Tennessee Valley Authority) 50-328

Enclosed is our response to Question No. 1 transmitted by your August 18, 1983 letter to H. G. Parris regarding additional information on the hydrogen mitigation system for the Sequoyah Nuclear Plant. The response for the remaining questions was transmitted to NRC by my November 1, 1983 letter.

If you have any questions concerning this matter, please get in touch with Jerry Wills at FTS 858-2683.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

L M Mills

L. M. Mills, Manager
Nuclear Licensing

Sworn to and subscribed before me
this 10th day of April 1984
Paulette H. White
Notary Public
My Commission Expires 9-5-84

Enclosure
cc: U.S. Nuclear Regulatory Commission (Enclosure)
Region II
Attn: Mr. James P. O'Reilly Administrator
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30303

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ENCLOSURE

1. Question

With regard to the CLASIX code, the Staff has previously requested clarification of the structural heat sink heat transfer models. The following pertinent points have been derived from the responses:

A. Heat transfer is based on temperature difference determined by (T_{bulk} - T_{wall}).

B. Heat transfer coefficients for degraded core accident analysis are determined from a natural convection (stagnant) correlation applicable to condensation heat transfer.

C. CLASIX does not explicitly model mass removal due to condensation heat transfer.

Based on the description of the CLASIX structural heat sink model, it appears that the CLASIX model differs dramatically from generally accepted approaches and is not, as is claimed, consistent with standard methods such as those used in CONTEMPT. The differences are related to the treatment of the three items cited above. By comparison, previously accepted approaches are characterized by the following:

A. Heat transfer is based on (T_{sat} - T_{wall}), when the surface temperature of the heat sink is less than T_{sat} (i.e., T_{wall} less than T_{sat}.

B. Heat transfer coefficients are based on condensation only when T_{wall} less than T_{sat}.

C. Condensed mass removal is based on condensation heat transfer with provisions for revaporizing a small fraction of the condensate.

A more detailed description of accepted practice is contained in NUREG-0588 and NUREG/CR-0255.

The effect of the CLASIX models would appear to be the desuperheating of the atmosphere too rapidly thus reducing gas temperatures and possibly altering the combustion characteristics.

Based on the above discussion, provide justification for the models incorporated in CLASIX or provide the results of analyses with acceptable models as outlined above. The analyses should encompass selected sensitivity studies to assure that the effects of the changes are determined for both containment integrity and equipment survivability considerations.

Response

The following additional information is provided concerning the method by which CLASIX models heat transfer to the passive heat sinks.

A. The previously accepted approaches for heat transfer models described in your request for additional information were primarily developed for LOCA containment analysis which emphasized pressure response. Because the LOCA blowdown is introduced into the containment as saturated liquid (see reference 1), the containment atmosphere steam-water component is saturated, except for a brief early portion of the transient.

Consequently, the maximum temperature is the saturation temperature corresponding to the steam partial pressure at the maximum total pressure. Therefore, for a LOCA, the saturation temperature is equal to the bulk temperature so that either could be used to determine the energy removal. For a main steam line break or for hydrogen combustion, the containment atmosphere will consist of superheated air and steam. Therefore, the mass and energy removal models that were developed for LOCA analysis will not correctly predict the peak containment temperature for these events. Recognizing this, the NRC has sponsored research to establish acceptably conservative, yet mechanistically sound, models of heat transfer from superheated air and steam. This research (see reference 2) has shown that the temperature difference appropriate to passive heat sink heat transfer should be based upon the use of the atmosphere bulk temperature (as in the CLASIX code) rather than the saturation temperature.

B. Heat transfer coefficients were never determined from a natural convection (stagnant) correlation applicable to condensation heat transfer in any CLASIX analysis we performed. The CLASIX condensing heat transfer coefficients are based on the stagnant portion of the Tagami heat transfer correlation when $T_{wall} < T_{sat}$. A comparison of the heat transfer coefficients from this correlation with the Uchida correlation used in CONTEMPT4/MOD3 (reference 4) is provided in Table 1. An option available in CLASIX is to compare the rate of heat transfer from the Tagami coefficient to the rate of heat transfer from the natural convection coefficients from Kreith (reference 3) and then use the larger of the two rates. However, since we never selected this option, the heat transfer coefficients are based on condensation only for T_{wall} less than T_{sat}.

C. In CLASIX, condensate mass is not explicitly removed from the atmosphere by condensation at the walls but is instead based upon a mechanistic evaluation of the thermodynamic state of the atmosphere using the total internal energy in the atmosphere at the end of a time step. The iterative procedure which determines the rate of condensate mass removal is described fully on pages 38-46 of reference 5. CLASIX's condensate model does not include any provision for revaporizing an arbitrary fraction of the condensate. This treatment is conservative because it takes no credit for an atmospheric temperature decrease resulting from a reduction in specific energy due to condensate revaporization.

It is asserted in your question that the effect of the CLASIX passive heat sink model would appear to be the desuperheating of the atmosphere too rapidly, thus reducing gas temperatures and possibly altering the combustion characteristics. The period of greatest interest in the analysis of hydrogen burns is during and immediately following a burn.

During this period, the CLASIX condensate removal model does not significantly affect the results since the heat sink surface temperature in the compartments in which hydrogen burning occurs is quickly elevated above the saturation temperature due to energy deposition from convective and radiative heat transfer. Hence, the fact that CLASIX does not explicity model condensate mass removal at the wall is irrelevant since no condensate would form on the walls during this period.

More importantly, the principal cooling mechanism for the lower compartment atmosphere is the cooler air flow from the upper compartment due to operation of the air return fan. The cooling effect of the air return fan will cause the formation and subsequent deentrainment of water droplets from the atmosphere. The thermodynamics condensation model in CLASIX should accurately predict this phenomena.

In summary, CLASIX handles heat transfer in a manner consistent with the physical processes occurring in the containment atmosphere. In addition, the conservatism of the CLASIX heat transfer coefficients and the technical support provided for the structural heat transfer models provide sufficient assurance that the current CLASIX results are conservative without any further analysis.

REFERENCES

1. Wheat, L. L., Wagner, R. J., Niederauer, F. G., Obenchain, C. F., "CONTEMPT-LT: A Computer Program for Predicting Containment Pressure-Temperature Response to a Loss of Coolant Accident," Aerojet Nuclear Company Report, ANCR 1219 (June 1975) and SDR-83-76 (April 1976)

2. Lamkin, D., Koestel, A., Gido, R., and Baranowsky, P., "Containment Main Steam Line Break Analysis," NUREG/CR-1511, June 1980

3. Kreith, F., "Principles of Heat Transfer," 2nd Edition, International Textbook Company, Scranton, Pennsylvania, May 1967

4. Cheng, T. C., Metcalfe, L., Hartman, J., Mings, W., and Crail, A., "CONTEMPT4/MOD3, A Multicompartment Containment System Analysis Program," NUREG/CR-2558, December 1982

5. Fuls, Martin, G., et al., "The CLASIX Computer Program for the Analysis of Reactor Plant Containment Response to Hydrogen Release and Deflagration," Document No. OPS-07A35, Offshore Power Systems, Jacksonville, Florida.

TABLE 1

HEAT TRANSFER COEFFICIENTS

Mass of Steam / Mass of Noncondensible	H (CLASIX) (Btu/hrft^2 $^\circ$F)	H (CONTEMPT4) (Btu/hrft^2 $^\circ$F)
0.02	2.0	3.0
0.05	4.5	8.0
0.10	7.0	14.0
0.20	12.0	21.0
0.25	14.5	24.0
0.33	18.66	29.0
0.43	23.74	37.0
0.56	29.77	46.0
0.77	40.46	63.0
1.25	64.5	98.0
2.0	102.0	140.0