TENNESSEE VALLEY AUTHORITY

CHATTANOOGA, TENNESSEE 37401

400 Chestnut Street Tower II

April 6, 1982

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

Dear Ms. Adensam:

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

Enclosed is our response to your letter to H. G. Parris dated February 12, 1982 regarding the request for additional information on hydrogen control for our Sequoyah Nuclear Plant. If you have any questions concerning this matter, please get in touch with J. E. Wills at FTS 858-2683.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

L. M. Mills

L. M. Mills, Manager
Nuclear Regulation and Safety

Sworn to and subscribed before me
this 6th day of April 1982

Paulette H. White
Notary Public
My Commission Expires 9-5-84

Enclosure
cc: U.S. Nuclear Regulatory Commission
Region II
Attn: Mr. James P. O'Reilly, Regional Administrator
101 Marietta Street, Suite 3100
Atlanta, Georgia 30303

B021 S/1

ENCLOSURE
RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION
REGARDING HYDROGEN CONTROL
SEQUOYAH NUCLEAR PLANT

Question 1. Provide a description of the HEATING5 computer code you used in calculating thermal response of the equipment during a hydrogen burn.

Response: HEATING5 is a heat conduction computer code written for the NRC-NRR by Oak Ridge National Laboratory (ORNL). The following description of the code is a copy of the abstract from the HEATING5 manual.

"HEATING5, a modification of the generalized heat conduction code HEATING3, is designed to solve steady-state and/or transient heat conduction problems in one-, two-, or three-dimensional Cartesian or cylindrical coordinates or one-dimensional spherical coordinates. The thermal conductivity, density, and specific heat may be both spatial and temperature-dependent. The thermal conductivity may be anisotropic. Materials may undergo a change of phase. Heat generation rates may be dependent on time, temperature and position, and boundary temperatures may be time-dependent. The boundary conditions, which may be surface-to-boundary or surface-to-surface, may be fixed temperatures or any combination of prescribed heat flux, forced convection, natural convection, and radiation. The boundary condition parameters may be time- and/or temperature-dependent. The mesh spacing can be variable along each axis. The code is designed to allow a maximum of 100 regions, 50 materials, and 50 boundary conditions. The maximum number of lattice points can be easily adjusted to fit the problem and the computer storge requirements. The storage requirements on an IBM 360 machine range from approximately 250K bytes for one lattice point to 1256K bytes for 6000 lattice points.

The point successive overrelaxation iterative method and a modification of the "Aitken delta squared extrapolation process" are used to solve the finite difference equations which approximate the partial differential equations for a steady-state problem.

The transient problem may be solved using any one of several finite difference schemes. These include an implicit technique which can range from Crank-Nicolson to the Classical Implicit Procedure, an explicit method which is stable for a time step of any size, and the Classical Explicit Procedure which involves the first forward time difference. The solution of the system of equations arising from the implicit technique is

accomplished by point successive overrelaxation iteration, and includes procedures to estimate the optimum acceleration parameter. The time step size for implicit transient calculations may be varied as a function of the maximum temperature change at a node. Transient problems involving materials with change-of-phase capabilities cannot be solved using the implicit technique with this version of HEATING5."

Question 2. In your response to item A.1.C in your letter dated August 27, 1981, you indicate that the temperature reached by the equipment during a hydrogen burn is below the qualification temperature for that equipment. Since the actual temperature reached by the equipment during qualification tests is not measured, demonstrate by analytical or experimental means that this temperature will exceed the temperature reached by the equipment during a hydrogen burn.

Response: Our submittal of December 1, 1981, included a section (2.2) on analytical model verification by comparison with results from another accepted computer program. Results of analyses were provided comparing the Westinghouse transmitter equipment qualification analytical model with the TVA transmitter model for MSLB conditions. The Westinghouse models are discussed in WCAP-8936. These analyses showed excellent agreement between the Westinghouse and TVA models (which were developed independently). The TVA analyses using the MSLB qualification heat flux resulted in higher transmitter temperatures than were produced in the analysis of hydrogen burns.

Question 3. The CLASIX analysis in your submittal is based on four arbitrarily chosen flame velocities of 1, 3, 6, and 12 fps. The 1 fps velocity case was chosen as a basis for the equipment survivability analysis. Although the 1 fps velocity flame would emit the largest amount of thermal energy to the equipment, it corresponds to only 6 burns in the lower compartment and 26 burns in the Upper Ice Condenser Plenum. In contrast, in some other cases analyzed more burns and higher containment temperature were predicted. Also, in some cases hydrogen burn in the Upper Containment was foreseen. For example: Case 1C (Table 18 in your submittal) predicts 19 burns in the Lower Compartment and 36 burns in the Upper Ice Condenser Plenum; Case 1F (Table 18) predicts 8 burns in the Upper Compartment and the base case in your sensitivity studies (Table 21) predicts containment temperature of 1578°F. In view of the fact that these parameters could have significant effect on the temperature reached by the equipment, show that considering the 1 fps flame velocity case (1-G) as a basis for your equipment survivability analysis is a conservative assumption.

Response: In May 1981, TVA submitted equipment survivability analyses. As a result of those submittals, a request for additional information from the NRC was sent to TVA. The request specifically stated that the "minimum flame front velocity" should be used.

The survivability analyses performed and submitted on December 1, 1981, were based on an 8 v/o ignition criteria. The adiabatic flame temperature of an 8 v/o mixture of hydrogen is 1400°F. Case 1C, discussed in your question, used a 6 v/o ignition criteria. The adiabatic flame temperature of a 6 v/o mixture of hydrogen [illegible]°F, which is much lower than the case used to anal[illegible] equipment. In addition, the burns in case 1C are o[illegible] much shorter duration, and the ambient atmospheric temperature is lower. Case 1F, which showed burns in the upper compartment, was based on an ignition criteria in the upper compartment of 4 v/o. Again, the associated adiabatic flame temperature is lower and the environment is less severe than the case used for equipment survivability analysis. Besides, there is no small critical equipment in the upper compartment other than igniters and cable in conduit. These have already been analyzed for multiple burns based on ignition at 8 v/o, which produces a much more severe environment than 4 v/o, and shown to be acceptable.

The S_2D event used to evaluate equipment used a maximum hydrogen release rate of 1.1 pounds/minute. As can be seen from the table in section C on scenarios, this mass flow rate is appropriate for real plant transients. The results presented in table 21 are for base case assumptions except that the mass flow rates for the blowdown are over three times the rate expected in a degraded core event. Therefore, this is another sensitivity study and should not be used for equipment survivability calculations. The containment transient based on the S_2D release rates provides a conservative environmental profile.

Thus, the case chosen as a basis for equipment survivability analysis is appropriate due to the substantially higher flame temperature and longer burn durations than would be found in other cases. We believe that it directly addresses your concerns with analyses submitted previously.

Question 4. In your submittal you describe analytical and experimental evaluations of a selected number of safety-related equipment which has to survive hydrogen burn environment. Provide a detailed justification of

your choice of equipment for these investigations. Show also that the results of the investigations will provide bounding information for all the equipment needed for safe shutdown of the plant.

Response: Our December 1, 1981, submittal includes a section "Equipment Selection" which provides our justification of the choice of equipment for evaluation. Lists of equipment required for safe shutdown have been provided in this submittal and justification provided for the acceptability of this equipment.

Question 5. List and discuss the assumptions (e.g. shape factors, emissivities, etc.) used in calculating the heat transfer from the stationary flame in the ice condenser. Provide a justification for your assumption that the temperature of hot gases below the flame front drops abruptly to 250°F (see figure 12-1 in the submittal).

Response: The following response was provided by Duke Power Company:

"The computer program HEATING5 was used to calculate heat transfer to the ice condenser wall. The capabilities of HEATING5 allow for heat transfer by conduction, convection, and radiation. This capability was utilized as follows:

1. For conduction, the necessary thermal conductivities were obtained for all materials and input to the code. No further programming work is required for the conducting mode.

2. For radiation, the geometry that was modeled was radiation between parallel planes. Even though the nearest ice basket is 0.5 feet from the wall, the flame and hot gas layer radiating to the wall was assumed to be one foot thick. Calculation of the necessary shape factors was then performed by HEATING5. The emissivity of the flame and hot gasses was 0.3, in accordance with information from Dr. Bernard Lewis.

3. For convection, a convection boundary condition was imposed on the wall as represented by figure 12-1. The temperature of the convective boundary was conservatively assumed to be 250°F for the following reason. Recall that the ice condenser is an area of constant upward flow. A mixture of steam and noncondensible gasses enters the ice bed at the bottom through the lower inlet doors and passes up

through the ice at 1-2 feet/second. The ice bed lowers the temperature of this mixture and condenses some of the steam. The maximum temperature in this region of the ice condenser, as predicted by CLASIX, is about 200°F. A temperature of 250°F was selected as a worst case value to reduce the cooling effect of this flow on the wall and generate higher wall temperatures. The actual temperatures on the face of the duct immediately below the flame are, of course, higher than 250°F due to conduction and radiation from the hotter regions above, but this wall area is continuously cooled by the flow of the steam/gasses mixture from below. It is our judgement that figure 12-1 represents, therefore, a conservative convective boundary condition for use in HEATING5."

Question 6. In your submittal, you do not discuss the effect of pressure differentials developed during a hydrogen burn across the air return and hydrogen skimmer fans. What are the values of these pressure differentials calculated by the modified CLASIX Code? Show that they do not exceed the limiting pressure differentials which the fans can withstand.

Response: The submittal did not discuss the effect of pressure differentials developed during a hydrogen burn across the air return fans for two reasons. First, differential pressures across the fans from the upper compartment to the dead-ended compartments would only result from burns in the upper compartment which are not predicted by CLASIX to occur for base case or best estimate assumptions. Second, any differential pressures across the fans from the dead-ended compartments to the upper compartment would be prevented by the backdraft dampers below the fan assembly. The original design basis accident subcompartment load for the dampers bounds any differential pressures calculated during hydrogen burning.

TVA requested the air return fan supplier, Joy Manufacturing Company, to analyze the fans for overpressure in the direction of fan flow. Their analysis bounded any transient loading that would occur during a hydrogen burn by assuming an equivalent static load of 50 lb/in^2g imposed on the fan assembly in addition to the normal fan operating loads. For simplicity, any overspeeding of the rotor due to a turbine effect was neglected. Critical areas of the fan assembly were examined and the calculated stresses were not above yield. Therefore, the air return fans are judged to be structurally capable of withstanding any differential pressure calculated to occur during a hydrogen burn transient.

Question 7. Provide Table 2.1 and Figure 2.3-1 missing in your submittal.

Response: The requested information is provided in attachment 1.

Question 8. In the T_BB_2 scenario analyzed by TVA, it is not clear that the restoration of ac power and actuation of glow plugs (or random electrical ignition sources) would not come at a time when excessive amounts of hydrogen are present in the containment. In this connection, discuss for your particular utility grid whether the failure of all ac power to the plant is an event of such low probability that this type of scenario can be justifiably excluded from consideration. If it cannot be excluded, discuss the appropriateness of providing an additional reliable backup electrical supply for the igniters.

Response: MARCH runs of the T_BB_2 scenario were only performed as part of an analytical effort to scope hydrogen release rates to compare with the values chosen for the TVA blowdown sensitivity studies and not because we believe T_BB_2 to be a valid scenario for the Sequoyah plant. In this regard, it can be seen from the data in our December 1, 1981, submittal that the peak T_BB_2 hydrogen release rate is about two orders of magnitude lower than the rates used in our sensitivity studies. Further, only 35 pounds of hydrogen is released before core slump in the T_BB_2 scenario, which would be insufficient to allow a burn in the containment.

However, it should be emphasized that we consider the loss of all ac power at Sequoyah to be an extremely unlikely event. In order to have a loss of all ac power at the plant, both onsite switchyards or all 13 transmission lines to the plant must be disabled followed by a failure of both trains of the diesel generators. Because of this redundancy, the failure of all ac power to the plant is an event of such low probability that it may be excluded from consideration.

ATTACHMENT 1

TABLE 2-1

SEQUOYAH CLASIX S_2D EQUIPMENT SURVIVABILITY CONTAINMENT RESPONSE SUMMARY
FLAME SPEED = 1 ft/s

Number of Burns	LC	6
	UP	26
	UC	0
Magnitude of Burns (lbm)	LC	101
	UP	33
	UC	-
Total H_2 Burned (lbm)		1086
H_2 Remaining (lbm)		451
Peak Temperature (^{o}F)	LC	884
	UP	1114
	UC	150
	DE	170
Peak Pressure (lb/in^{2}a)	LC	24.8
	UP	24.5
	UC	24.3
	DE	24.8
Ice Remaining (lbm)		7.71×10^5

RTD AND THERMOCOUPLE
SINGLETON TEST PROFILE

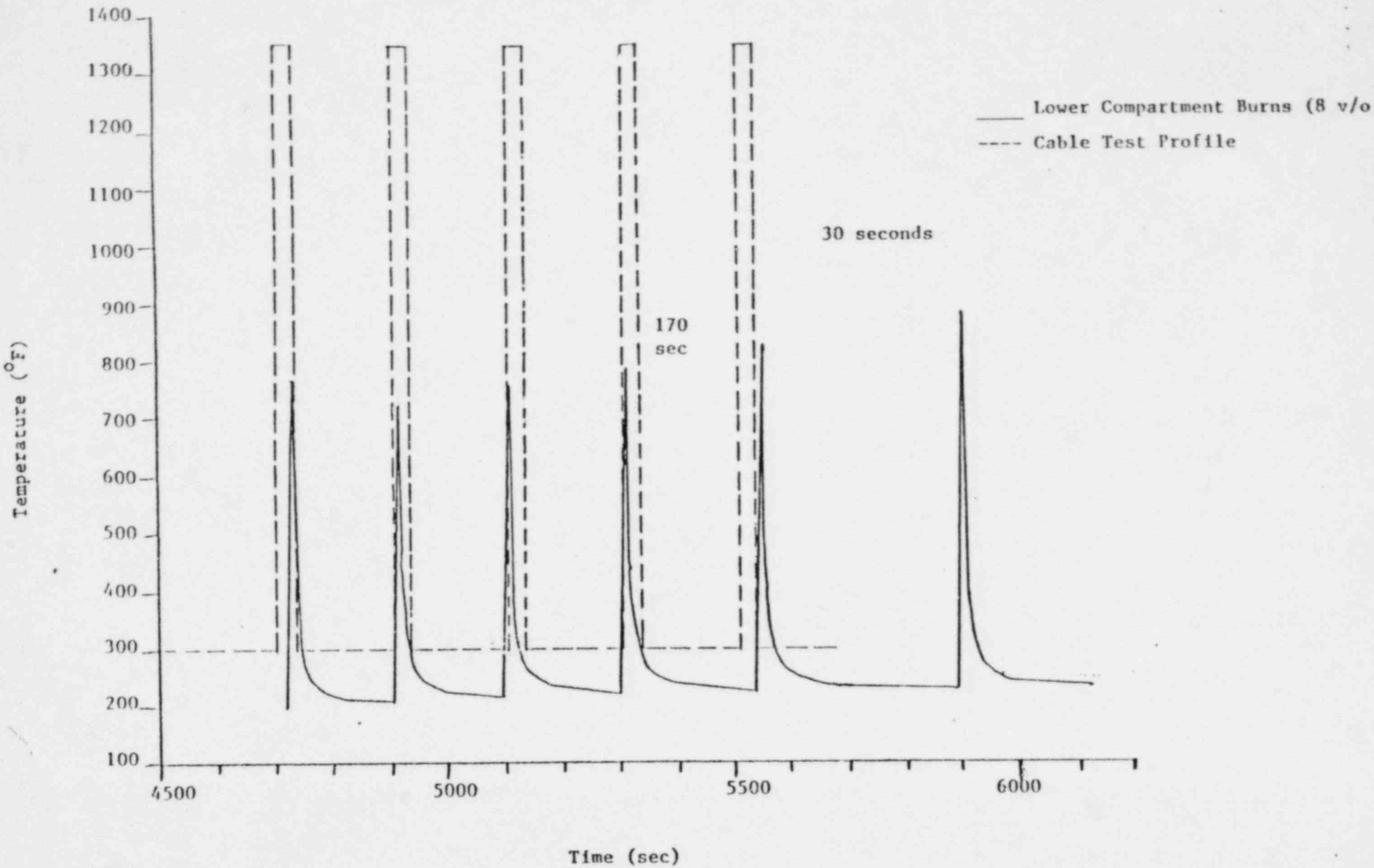

Figure 2.3-1