TENNESSEE VALLEY AUTHORITY

CHATTANOOGA, TENNESSEE 37401

400 Chestnut Street Tower II

October 1, 1981

RECEIVED OCT 6 1981 U.S. NUCLEAR REGULATORY COMMISSION

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

As requested by R. L. Tedesco in a letter dated July 8, 1981 to H. G. Parris, enclosed is our response to the request for additional information on hydrogen control for the Sequoyah Nuclear Plant. If you have any questions, please call D. L. Lambert at FTS 857-2581.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

L M Mills

L. M. Mills, Manager
Nuclear Regulation and Safety

Sworn to and subscribed before me
this 1st day of October 1981
Paulette H. White
Notary Public
My Commission Expires 9-5-84

Enclosure

B021 S1/1

8110070267 811001
PDR ADOCK 05000327
P PDR

ENCLOSURE

RESPONSE TO R. L. TEDESCO'S REQUEST FOR INFORMATION
DATED JULY 8, 1981 TO H. G. PARRIS
SEQUOYAH NUCLEAR PLANT HYDROGEN CONTROL

NRC Question No. 1

Describe the permanent hydrogen igniter system installed inside containment. Provide and justify the criteria used for the system design. Include in your discussion the proposed surveillance testing, and technical specifications for the permanent system.

TVA Response

The Permanent Hydrogen Mitigation System (PHMS) is designed to be a reliable system of distributed ignition sources capable of igniting hydrogen at low volumetric concentrations in a post-LOCA environment. The gradual addition of the heat of combustion due to the controlled burning of the hydrogen allows the active and passive containment heat sinks to reduce the overall impact and maintain a sufficient margin of safety below the containment ultimate capability. Descriptions are provided below of the PHMS and its design criteria, surveillance testing, and technical specifications.

The principle of the controlled combustion concept selected for the PHMS is to ignite hydrogen at any containment location as soon as the concentration exceeds the lower flammability limit. To assure this, thermal igniters capable of maintaining a minimum surface temperature of 1500°F were specified. Such igniters as the GM AC glow plug have been shown to reliably initiate combustion of hydrogen mixtures of 5-10-percent concentration. Other types of thermal igniters are still being examined as potential candidates.

To assure adequate coverage, a total of 64 igniters will be distributed throughout the major regions of containment in which hydrogen could be released or to which it could flow in significant quantities. There will be at least two igniters, powered from separate trained sources, generally located near the top of each of these regions. See figures 1 through 7 for igniter locations. Justification of those regions in containment for which igniters were not provided is included in the response to Question No. 2.

Following a degraded core accident, any hydrogen which is produced would be released from a break or the pressurizer relief tank into the containment in the lower compartment inside the crane wall. To cover this source region, there will be 18 igniters (equally divided between trains) located high in the lower compartment inside the crane wall. Four of the igniters will be equally distributed around the interior of the crane wall between ice condenser inlet doors at elevation 730'. Two igniters will be located at the lower edge of each of the five steam generator and pressurizer enclosures at elevation 731'. A pair of igniters will be located in the top of the pressurizer enclosure at elevation 772'. Another pair of igniters will be placed above the reactor vessel in the upper reactor cavity at elevation 730'.

Any hydrogen not burned in the lower compartment would be carried up through the ice condenser and into the upper compartment. To cover these regions, there will be 26 igniters (equally divided between trains) located in the ice condenser and the upper compartment. Since steam would be removed from the mixture as it passed through the ice bed, thus concentrating the hydrogen, a nonflammable mixture in the lower compartment could become a flammable mixture in the ice condenser upper plenum. To provide controlled combustion in this region, ten igniters will be equally distributed around the upper plenum at approximately elevation 785'. A description and justification of the criteria used to determine the number and location of upper plenum igniters will be included in the response to Question No. 14. Six more igniters will be equally spaced on the crane collector rails above the ice condenser top deck blanket at elevation 809'. Four igniters will be located around the upper compartment dome at elevation 846'. Four more igniters will be spaced around the inside of the crane wall below the upper plenum exit at elevation 787'. An 'A' train igniter will be located above the 'A' train air return fan at elevation 755' and a 'B' train igniter will be located above the 'B' train fan at elevation 746'.

The two air return fans provide recirculation flow from the upper compartment through the accumulator rooms, pipe chase, and HVAC rooms (the sum of which are referred to as the 'dead-ended' volume) and back into the main area of the lower compartment. To cover these regions, there will be 20 igniters (equally divided between trains) distributed throughout the rooms through which the recirculation flow passes. Four igniters will be equally spaced around the pipe chase at elevation 689'. A pair of igniters will be located in each of the four accumulator rooms, the two HVAC rooms, the instrument room, and the heat exchanger room between elevations 700' and 716'.

The PHMS will be qualified environmentally and seismically. The components inside containment will be qualified to maintain their functional capability under the full range of main steam line break and post-LOCA temperatures, pressures, humidity, radiation, and chemical sprays present in the containment. These components of the system must survive the effects of multiple hydrogen burns and will be protected from containment spray impingement and flooding. All components of the system outside containment will be qualified to operate in the environment in which they are located. In addition, the PHMS will meet the requirements of seismic Category I.

The igniters in the PHMS are equally divided into two redundant groups. Each group has independent and separate control, power, and igniter locations to ensure adequate coverage even in the event of a single failure. In addition, the current PHMS design has 16 separate circuits per group with only two igniters on each circuit. This feature adds an extra degree of independence to the system.

Separate control of each group of igniters will be provided in the main control room (MCR). Manual actuation capability for each group will be provided in the MCR, and the status (on-off) of each group will be indicated there. Further details of system actuation are provided in the repsonse to Question No. 4.

Separate trains of electrical power will be provided for each group of PHMS igniters. Power is supplied from the 480V ac control and auxiliary building vent boards which are part of the Class 1E ac auxiliary power system and automatically would be loaded onto the diesel generators upon loss of offsite power. Group A igniters receive power from the train A diesels and group B igniters from the train B diesels. Power from the 480-volt vent boards is routed to the 480/120V ac igniter transformers located in the auxiliary building and from the transformers to the 120V igniter distribution panels, also located in the auxiliary building. Power at each of the 120-volt distribution panels is monitored and alarmed in the main control room if an undervoltage condition is detected. Also, the position of each of the 120-volt breakers is monitored and alarmed in the main control room if any breaker is not in the closed position. Each igniter assembly is powered directly from the 120V distribution panel. Each 120-volt circuit supplies power for only two igniters, making a total of 32 circuits (16 per group). A failure in one of the circuits of the group will not prevent the remaining circuits in that group from performing their function. In addition, the Class 1E auxiliary power system will be protected from failures in the PHMS.

Surveillance testing proposed for the PHMS is similar to the testing currently performed for the IDIS. Testing will consist of energizing the system from the main control room and taking voltage and current readings at the igniter distribution panels located in the auxiliary building. These voltage and current readings will be compared to readings taken at the distribution panels during preoperational testing of the system. The comparison of the two readings will indicate whether or not all the igniters on each circuit are operational. If the readings do not compare favorably, then the igniters on that circuit will be checked visually for on-off status. Since the measured presence of the proper baseline voltage and current on a circuit assures that the igniters on that circuit are operational at the minimum temperature, there is no need to measure the temperature of each igniter as part of the surveillance testing. In addition, access to some of the more remote igniter locations in close enough proximity to allow temperature measurements would be difficult.

The operability of at least 31 of the 32 igniters per train will maintain an effective coverage throughout the containment, providing any inoperable igniters are not on corresponding redundant circuits which provide coverage for the same region. The two trains of igniters should be operable during operational modes 1 and 2.

If one train of the PHMS should become inoperable, it should be restored to operable status within seven days or the surveillance interval to verify that the other train is operable should be reduced to at least once per week. If both trains of the PHMS should become inoperable, at least one train should be restored to operable status within seven days or be in at least hot standby within the next six hours. At least once every 92 days, the PHMS should be demonstrated operable by energizing the igniters and verifying that at least 31 igniters per train are operable. If an inoperable igniter is detected, it should be confirmed that the corresponding redundant circuit does not contain an inoperable igniter.

NRC Question No. 2

List the rooms within containment for which there is no direct coverage by igniters and justify exclusion of these regions.

TVA Response

As stated in the response to Question No. 1, the principle of the controlled combustion concept selected for the PHMS is to ignite hydrogen at any containment location as soon as the concentration exceeds the lower flammability limit. To assure adequate coverage, 64 igniters will be distributed throughout the major regions of containment which have potential hydrogen sources or transport mechanisms. All major regions within the containment have at least two redundant igniters, except for the four steam generator enclosures and the reactor cavity below the reactor vessel.

No hydrogen source exists in the steam generator enclosures since the reactor coolant inlet and outlet nozzles are located in the main lower compartment region at the bottom of the steam generators approximately 36 feet below the entrance to the enclosures. Any primary system leaks in the steam generator would be into the secondary side and not into the containment. No significant hydrogen transport path exists through the steam generator enclosures since any hydrogen released in the main region of the lower compartment would have to bypass the pair of redundant igniters located at the entrance to each of the enclosures at elevation 731' without being ignited. There is no concentrating mechanism within the enclosures themselves that would transform mixtures below the lower flammability limit into flammable ones. Any nonflammable mixtures that enter any of the enclosures simply would be transported up through the enclosure, out the top, and back to the main region of the lower compartment by the air return fans of the hydrogen skimmer system.

No hydrogen source exists in the lower reactor cavity, discounting a break in the vessel or its nozzles. No significant hydrogen transport path exists through the lower reactor cavity following an accident in which hydrogen is released in the main region of the lower compartment. The reactor building fan coolers that ventilate the reactor cavity during normal operation will be shut off on a containment isolation signal following the accident, making the lower reactor cavity relatively isolated from the rest of the lower compartment. In addition, this region is below the expected flood elevation following a design basis LOCA, including ECCS inventory and ice melt.

NRC Question No. 3

Discuss the effects of igniter operation in lean (0-4 v/o) hydrogen mixtures for sustained durations (24 hours) on the ability of the igniter to subsequently perform its intended function. Describe the testing performed to evaluate the temperature effects of surface recombination and possible igniter degradation.

TVA Response

The testing to evaluate temperature effects on igniter operation in lean mixtures is still in progress. A report on the results will be provided in our next submittal scheduled for October 30, 1981.

NRC Question No. 4

Provide a complete discussion of the accident symptoms which will result in actuation of the igniter system. Considering a spectrum of accidents, identify the minimum time period in which actuation is required. Identify and justify the mode of actuation, i.e., automatic or remote manual.

TVA Response

TVA plans to actuate the PHMS on any condition which causes the operator to use the Emergency Operating Instruction 'Immediate Actions and Diagnostics' (EOI-0). This instruction presents the automatic actions, the immediate operator actions (including actuation of the PHMS), and the diagnostic sequence to be followed in the identification of:

(a) Spurious Actuation of the Safety Injection System
(b) Loss of Reactor Coolant - Both Large and Small Breaks
(c) Loss of Secondary Coolant and
(d) Steam Generator Tube Rupture

The instruction lists the following 20 symptoms as typical of those which may arise in a plant undergoing accidents b, c, and d listed above:

1. Low Pressurizer Pressure
2. Low Pressurizer Water Level
3. High Pressurizer Water Level
4. High Containment Pressure
5. High Containment Radiation
6. High Condenser Vacuum Pump Exhaust
7. High Steam Generator Blowdown Radiation
8. Steam Flow/Feedwater Flow Mismatch
9. Letdown Isolation/Pressurizer Heater Cutout
10. Low-Low Reactor Coolant System Average Coolant Temperature
11. High Containment Recirculation Sump Water Level
12. Low Steamline Pressure (one or all Steamlines)
13. Low Steam Generator Water Level
14. Increasing Steam Generator Water Level
15. Rapidly Changing Reactor Coolant System Average Coolant Temperature
16. Increased Charging Flow
17. High Steam Flow (one or all Steamlines)
18. High Containment Humidity
19. High Containment Temperature
20. Low Feedwater Pump Discharge Pressure

Any of these symptoms or a combination of symptoms, as well as an unexplained reactor trip or safety injection, would cause the operator to implement this procedure (EOI-0). Once this procedure is begun, there are 11 actions or system statuses that must be verified prior to the instruction to energize the PHMS. Actuation of the PHMS is done prior to the operator beginning accident diagnostics. Manual actuation of the PHMS takes place in the main control room immediately following the verification of automatic safety-related equipment operation.

The length of time the operator has to actuate the PHMS varies with the accident. For an event such as an intermediate size LOCA with no emergency coolant injection (ECI), hydrogen production could begin approximately 1600 seconds into the event. The operator would then have at least another 1000 seconds in which to actuate the PHMS before a 4-percent hydrogen concentration would be approached in the containment. For transient cases, the operator would have several hours in which to actuate the PHMS before hydrogen production could begin. Events which result in rapid hydrogen production (such as a LOCA with no ECI) would cause several of the parameters listed earlier to alarm in less than 100 seconds into the event. Thus, the operator would have sufficient time to manually actuate the PHMS for any event in which it would be required. TVA believes that this early actuation is a prudent approach since early operation of the igniters or operation even though eventually not needed is neither detrimental to the plant nor makes the accident worse.

NRC Question No. 5

With regard to the Fenwal igniter test program pr vide the following information:

a) Summary of the data from the Phase 2 Fenwal tests in a format similar to that provided f the Phase 1 tests in the TVA Core Degradation Program Report, Vol. 2. Include the calculated P/ P max value.

b) Description of justification of the scaling of the spray flow tests to the ice condenser upper or lower compartment sprays.

c) Description and justification of the scaling of the steam-hydrogen transient injection tests.

TVA Response

A summary of the Fenwal Phase 2 test data, including the calculated $\Delta P/\Delta P$ max value, is provided in the following table. A description and justification of the test spray flow scaling to the containment sprays and the test hydrogen-steam flow scaling to calculated primary system accident blowdowns is provided below.

Spray Flow Scaling

The Sequoyah containment spray flow rate (4700 gpm x 2 pumps = 9400 gpm) was scaled down by the ratio of the test volume (134 ft^3) to the upper compartment volume (approximately 700,000 ft^3).

$$W = 9400 \text{ gpm} \times \frac{134 \text{ ft}^3}{700{,}000 \text{ ft}^3} = 1.8 \text{ gpm} = 2 \text{ gpm}$$

Hydrogen Release Scaling

The H_2 release for the reference S_2D transient shows a total of 750 lb-moles being released over a period of about one hour. The maximum slope is about twice this (750 lb-moles per 30 minutes) and was selected as the H_2 release to scale for these tests. The volume selected for the scaling was the lower compartment volume of about 300,000 ft^3. The test vessel volume is 134 ft^3. The scaled hydrogen flow is thus:

$$\frac{750 \text{ lb-moles}}{30 \text{ min}} \times \frac{350 \text{ SCF}}{\text{lb-mole}} \times \frac{134 \text{ ft}^3}{300{,}000 \text{ ft}^3} = 4 \text{ SCFM}$$

Steam Release Scaling

It is assumed that the above hydrogen is generated and released as the bottom six feet of cor water boils off. The cross-sectional flow area of the core and downcomer totals about 100 ft^2, hence about 600 ft^3 of water or 30,000 pound is boiled off. This corresponds to 1600 lb-moles of water which is approximate double the H_2 release in lb-moles. Therefore the steam release for the test should be equivalent to about 8 SCFM or 0.4 lb/min. The actual value in the tests was limited by equipment capability of 0.3 lb steam per minute.

TVA FENWAL TESTS ROUND 2

	Initial Conditions[1]					Results			
Test	H_2 %	H_2O %	Temp °R	Press lb/in^2a	Fan Vel ft/sec	P lb/in^2	P/ P_{max} (calc.) %	Time to Ignite	Time to P_{max}
Series 2 Part 1									
2-1-1	9.02	12.68	596.0	20.567	–	38.75	72.7	15.8	6.85
2-1-2[2]	8.02	13.35	598.0	20.567	–	3.1	6.5	15.9	5.4
2-1-2A	7.58	13.84	689.9	23.683	–	16.0	35.7	--	–
2-1-3	7.03	13.86	600.0	20.541	–	1.5	3.5	15.5	5.5
2-1-4	6.03	14.67	602.0	20.688	–	1.0	2.6	17.0	11.0
2-1-5	4.99	15.35	604.0	20.806	–	0.25	0.8	17.0	3.0
2-1-6	8.02	13.23	598.0	20.761	5	36.0	74.4	15.0	4.0
2-1-7	6.04	14.73	602.0	20.670	5	14.0	37.6	17.0	9.0
2-1-8	10.00	40.98	672.0	20.655	–	30.0	62.9	17.0	9.6
2-1-9[3]	5.99	40.82	672.0	20.655	0	0.78	2.6	16.5	–
2-1-9A	5.86	40.99	697.8	21.433	5	2.66	8.9	–	–
2-1-10[4]	6.0	40.45	670.	20.655	0.0	0.2	0.7	19.75	1.88
2-1-10[4]	5.97	40.49	676.	20.855	5.0	3.2	10.4	6.0	5.88
Series 2 Part 2 - Transient Tests[5]									
Series 2 Part 3									
2-3-1	10.0	0.32	502.	16.544	0	56.25	96.7	–	–
2-3-2	10.0	0.48	542.	16.302	0	50.0	94.6	11.59	.56
2-3-3	6.05	0.36	540.	15.418	0	31.2	96.3	22.0	1.56
2-3-4		Transient Test[5]							
2-3-5	10.01	0.36	533.	16.533	0	42.2	77.2	15.0	1.13
Series 2 Part 4									
2-4-1	11.65	10.55	589.	20.541	0	58.0	86.1	26.8	.70
2-4-2	11.67	10.56	589.	20.519	0	60.0	89.0	27.1	.64
2-4-3	11.65	10.55	589.	20.546	0	61.0	90.5	27.2	.60
2-4-4	11.66	10.56	589.	20.522	0	63.0	93.5	25.8	.55
2-4-5	9.98	13.24	606.	21.141	0	49.0	81.0	27.8	1.69
2-4-6	9.98	13.24	606.	21.141	0	50.0	82.7	56.0	1.50
2-4-7	11.65	10.55	589.	20.546	0	58.0	86.1	26.3	.65

[1] For notes on initial conditions for Part 1 tests, see Round 1 test summary.
[2] Test 2 experiencd two burns. Initial conditions for 2A calculated from 2.
[3] Test 9 was performed as follows: The vessel was initially loaded and ignited; then, the fan was initiated with plug continually energized which resulted in a subsequent burn. 9A was analyzed similar to test 2A.
[4] This test experienced two burns. The initial burn occurred without fans. After this burn was completed, the fan was started, resulting in a second burn.
[5] HYFIRE is not capable of modeling the transient tests.

NRC Questions 6 through 14

The responses to these questions will be provided in our update report which we anticipate transmitting to the NRC on the following schedule.

Question No.	Submittal to NRC
6	November 16, 1981
7	"
8	"
9	"
10	"
11	October 30, 1981
12	"
13	"
14	"

Note: Question 3 will also be provided on October 30, 1981.