TENNESSEE VALLEY AUTHORITY

CHATTANOOGA, TENNESSEE 37401

400 Chestnut Street Tower II

August 25, 1980

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Denton:

In the Matter of the Application of	)	Docket No. 50-327
Tennessee Valley Authority	)	

Enclosed is the additional information concerning TVA's Interim Distributed Ignition System (IDIS) for controlling hydrogen within the Sequoyah Nuclear Plant unit 1 containment. Enclosure 1 is a summary of the TVA hydrogen igniter test plan. These tests are to demonstrate that the igniter will initiate a volumetric burn of the hydrogen for a range of environmental conditions. The TVA test program for the Sequoyah hydrogen igniters will be conducted at the laboratory facilities of Fenwall Incorporated, Ashland, Massachusetts. We plan to begin the tests on September 8, 1980, and the test evaluation report will be submitted to the NRC within one month after completion of the tests.

Enclosure 2 addresses the accelerated portions of TVA study program to ensure the operational effectiveness of the IDIS.

Enclosure 3 is a summary of the tests to evaluate the suitability of an ac glow plug as the igniter in the IDIS. These tests were conducted at TVA's Singleton Laboratory for the purposes of assessing the endurance and the ignition capabilities of the selected ac glow plug.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

L. M. Mills

L. M. Mills, Manager
Nuclear Regulation and Safety

Sworn to and subscribed before me
this 25th day of Aug., 1980

Bryant M. Lowery
Notary Public

My Commission Expires 4/4/82

Enclosures

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SUMMARY

SEQUOYAH PLANT

HYDROGEN IGNITER TEST PLAN

1. Introduction

The following describes tests to be conducted on a type of hydrogen igniter to be installed in the Sequoyah Nuclear Plant. The igniter consists of a "glow plug" as used in diesel engines, the surface of which exceeds 1500° F and serves as a hot surface to initiate hydrogen burning, and a power transformer and an enclosure for the unit. The function of the igniters in the nuclear power plant containment is to burn hydrogen, in accidents where it could be released, when it reaches a burnable concentration thereby precluding its buildup to high concentration levels. The tests will be conducted by Fenwall, Incorporated, at their facilities in Ashland, Massachusetts. The unit, consisting of glow plug and enclosed transformer, will be placed in a test vessel and subjected to a range of environmental conditions (including hydrogen concentration, temperature, pressure, and steam), and its hydrogen ignition performance monitored.

1.1 Purpose of Tests

The primary purpose of the tests is to demonstrate that the igniter will initiate a volumetric burn of the hydrogen for the specified environmental conditions (pressure, temperature, water vapor). A secondary objective of the tests is to narrow down the hydrogen concentration range for which a volumetric burn of hydrogen will be initiated.

1.2 Acceptance Criteria

For the initial set of tests, the following acceptance criteria will be used:

1. Data generated are internally consistent (i.e., ignition at 8% consistently produces low pressure rise).
2. Data gathered confirm theoretical predictions.
3. Igniters reliably ignite mixtures at high (12%) concentration and provide relatively complete combustion.

2. Description of Igniter

The igniter is a General Motors Ac Division Model 7G glow plug (thermal resistive heating element) requiring 14V ac supply at a maximum of 8-1/2 amps. The surface temperature of the plug as measured by an optical pyrometer should be a minimum of 1500° F. TVA has measured 1720° F surface temperature on one of the glow plugs at their facilities. The igniter is powered by 120V ac stepped down to 14V ac. The power transformer is a Dongan Electric, Incorporated, Model 52-20-187 specially wound transformer having the following characteristics:

120Vrms ac on the primary side;
14Vrms ac on the secondary side;
200VrmsA minimum
Class H (High temperature insulation)
Open style with 18" flexible leads
Certified capability that transformer will operate at 220° C.

The igniter and transformer are mounted as a unit with the glow plug extending from the side. The unit is encased in a [illegible]-inch steel plate box type casing and sealed with a rubber seal for water tightness.

3. Description of Test Facility

The tests will be conducted by Fenwall, Incorporated, at their facilities in Ashland, Massachusetts.

3.1 Test Vessel

The igniter unit will be tested in a spherical vessel in excess of six feet in diameter. The internal volume of the test vessel is 1000 gallons (134 ft^3). The vessel is constructed of carbon steel (exterior) and is lined with stainless steel. The vessel is designed for a working pressure of 500 lb/in^2. The vessel is equipped with five 18" diameter access ports (four on circumference, 90° apart,

and fifth at the top), one of which is drilled to attach to a manifold with valves and connecting lines to air, steam, and hydrogen makeup sources.

The vessel is heated externally via electrical heaters. The vessel will be equipped internally with a fan to promote mixing and also to create a draft at the igniter heating surface during testing when desired.

3.2 Instrumentation and Measurements

The vessel is instrumented with two pressure transducers to monitor the pressure including the pressure transient during the hydrogen burn. The output is carrier amplified and feeds to an oscillograph device. Thermocouples are provided which will monitor vessel atmosphere temperature prior to and after a burn. In addition, a thermocouple will be used to measure the temperature of its heated surface. Gas mixtures will be formed using pressure instrumentation and a partial pressure method in which a given gas is added until the appropriate partial pressure is indicated. Sampling capability exists via a 1-inch by 1-foot lecture bottle. Hydrogen and oxygen analyzers will be provided to measure pre- and post-burn concentrations of these gases:

	O_2 Analyzer	H_2 Analyzer
Manufacturer	Hays Republic	Hays Republic
Model	A 00632	SH-A-00643D
Range	0-5%/0-20%	0-5%/0-20%
Accuracy	± 1% F.S.	± 2% F.S.

4. Test Plan

4.1 Identification of Tests

The unit consisting of the glow plug and encased transformer will be positioned in the test vessel (via 18-inch port) with the glow plug heating surface located near the center of the test vessel. Various mixtures of H_2, steam, and air will be adjusted with pressure and temperature as specified and then the igniter turned on. The pressure transient will be recorded and the mixture analyzed for H_2 and O_2 content prior to and after the burn. The test matrix for the first series of 12 tests is shown in Table 1. Initial total pressures of 15, 21, and 27 lb/in^2 a will be covered at hydrogen concentrations of 8 and 12-volume percent. Initial temperature wil vary from 180° F (dry case) to 350° F (superheated steam) with most of the tests being conducted at saturation temperature corresponding to the pressure to be tested. In addition, a fan will be located in the test vessel to provide drafts of 5 and 10 FPS in the vicinity of the glow plug to simulate turbulence which may be developed in the vicinity of the igniters.

Further testing will be developed based on the outcome of test series #1, and may include addition of an instrumented transmitter and steel or concrete surfaces with thermocouples attached to measure temperature response on hydrogen burn. In addition, means to simulate spray droplet entrainment in the atmosphere are under investigation.

4.2 Test Procedure

The basic procedure is to adjust mixture concentration temperature and pressure, then energize glow plug and record the pressure and temperature transient. Hydrogen concentration after the burn will be measured to assess completeness of burn. The steps for the different tests are as indicated in Table .. In one of the tests with a steam environment, the glow plug will be energized after the steam, pressure, and temperature environment conditions are reached, but before hydrogen is added, and allowed to stand for two hours. Then the glow plug will be deenergized, hydrogen adjusted, and then the glow plug energized. The purpose of this is to allow for preburn exposure to the environment.

4.3 Test Schedule

The test schedule is tentatively planned as follows:

Facility Preparation	8/18 through 8/29
Test Series No. 1	9/8 through 9/12
Subsequent Tests	9/15 through 9/28
Test Evaluation (Test No. 1)	9/15 through 9/19
Test Report	10/1

TABLE 1

TEST SERIES NO. 1

Test	Temp (^{O}F)	Total Pressure* (Gauge, psi)	Hydrogen Concentration (Volume Percentage)	Fan Induced Flow Speed (fps)
1	180	0	12	0
2	180	0	8	0
3	Sat temp	6	12	0
4	Sat temp	6	8	0
5	Sat temp	12	12	0
6	Sat temp	12	8	0
7	Sat temp	6	12	5
8	Sat temp	6	8	5
9	Sat temp	6	8	10
10	Sat temp	6	12	10
11	350	12	12	0
12	350	12	12	10

*This is the total pressure due to air, hydrogen, and steam. For tests 1 and 2, the pressure will be higher than 0 due to the added hydrogen partial pressure and the evaluated temperature.

TABLE 2

TEST PROCEDURE

PROCEDURE FOR TESTS NO. 1 AND 2

1. Beginning at atmosphere in conditions (about 14.7 lb/in^{2}a, 80°F).

2. Add hydrogen until the hydrogen concentration reaches the desired concentration by volume. Do not let any air out in the process.

3. Heat the volume with a heater until it reaches 180° F. Circulate the content if needed. Record the pressure and leave it as is.

4. Energize the glow plug and recording instrumentation.

5. Record pressure and temperature transients before, during, and after the burn.

6. Measure hydrogen concentration after burn.

PROCEDURE FOR TESTS NO. 3, 4, 5, AND 6

Replace Step 3 above with:

3A. Increase steam until the content is saturated with steam and is at the specified total pressure. Circulate the content if needed.

PROCEDURE FOR TESTS NO. 7, 8, 9, 10, AND 12

Use Steps 1, 2, 3A, 4, 5, and 6 above. Add Step 3B between Steps 3A and 4:

3B. Energize the small "draft simulating" fan (2-speed or variable speed).

ACCELERATED PORTIONS OF PHASE II PROGRAM FOR ASSURANCE OF EFFECTIVENESS OF THE CONTROLLED IGNITION OF HYDROGEN INSIDE CONTAINMENT

Criteria	Methodology
1. The hydrogen source term (generation rate inside containment) used must be proven to be conservative and/or reasonable for a fair range of core damage accidents.	A system transient analysis, together with the MARCH code, will either confirm that S2D is appropriate or generate a hydrogen source term for further studies.
2. The computer analyses (using the hydrogen source term above) must demonstrate that the pressure and temperature transients are within the capability of the containment.	The CLASIX code or other equivalent code will be modified, written, and checked. Effects of burn location and non-uniform concentrations will be addressed.
3. The computer model used must be proven conservative reasonable.	Factors such as compartment modeling, heat sinks, steam flow effect, flame speed, etc., will be studied.
4. The ignition assumptions and data used in the computer analyses must be proven conservative or reasonable by published literatures and/or tests	Assumptions such as ignition thresholds and other parameters will be confirmed.

Notes:

A. Published scientific data will be used where possible and will not be duplicated by tests. As an example the famous T-ernery diagrams of steam, air, and hydrogen for flamability and detonation limits will not be duplicated.

B. Any deviation from these acceptance criteria will be considered on a case-by-case basis, justified, and documented. Any nonconformance, unreviewed safety questions, etc., will be handled through established procedures within TVA.

ENCLOSURE 3

PRELIMINARY TESTING TO IDENTIFY COMMERCIALLY AVAILABLE IGNITERS

TESTING CONDUCTED AT TVA'S

SINGLETON LABORATORIES

1.0 Introduction

TVA has a testing program which is being conducted at TVA's Singleton Laboratory to obtain preliminary information about the performance of commercially available igniters. The purpose of these tests was to screen alternative igniters and to gain a degree of confidence that the igniters could ignite hydrogen. The tests were not run under normal laboratory test conditions since the objective was to identify which igniters, if any, were most promising as subjects for more detailed testing and evaluation. Nontheless, TVA gained considerble information and assurance that commercially available igniters could ignite hydrogen.

2.0 Preliminary Screening

A number of igniter types were evaluated, ranging from high energy spark igniters to large diameter (1-1/2" I.D.) heater coils. Although the spark plug type igniter was considered an excellent candidate for this application, it was rejected prior to preliminary testing due to potential problems with electromagnetic interference (EMI) with critical instrumentation. TVA's Electrical Engineering Branch is researching the problems associated with EMI generators, and spark type igniters may be considered at a later date for use in Sequoyah unit 2 or Watts Bar.

Two other potential candidates, both coil heaters, were rejected after the first one, a large diameter (1-1/2" I.D.) coil, could not reach sufficient surface temperature, and the second one failed at the connector in less than five minutes. Therefore, testing was restricted to diesel engine glow plugs, since they were known to be capable of achieving the 1500°F minimum surface temperature desired by TVA and because of their rugged design.

TVA determined that at 12 volts ac, acceptable surface temperatures could be achieved but that considering line losses, variances in system voltages, possible plug cooling due to high humidity, and other effects, TVA would need to operate the plugs at 13 volts ac ± 1 volt.

Since the possibility existed that TVA could overstress the plugs by overvoltage, TVA consulted glow plug manufacturers and identified two types of failure modes which could be expected. The first type of failure caused by overstressing would be the failure of the heater wire within the glow plug sheath. This type of failure due to the breaking of the circuit would outwardly cause the plug to discontinue glowing. The second type of failure caused by overstressing would involve offgassing of the glow plug tip. Unlike the first type of failure after offgassing, the glow plug may continue to glow; however, the surface temperature would drop significantly.

3.0 Description of Glow Plugs

Glow plugs manufactured by three different companies have been tested to date. They include:

General Motors AC Division, Model 7G, 12 Volt

BOSCH 10.5 Volt

ISUSI 10.5 Volt

4.0 Endurance and Temperature Tests

Diesel glow plugs are not usually intended for continuous service in an air environment. Therefore, TVA undertook tests to determine that the plugs:

- could reach and maintain the desired temperature;
- the effect of overvoltage on life and temperature; and
- that the plugs could operate for extended periods of time at high temperatures.

4.1 Testing Equipment

For these tests the plugs were bench mounted and operated for various periods of time. The power source was 120 V ac wall socket which was reduced by a variable transformer (Variac, model no. Staco, Inc., type 3 P/N 1010L) to the appropriate voltage levels for each test. The voltage levels both on the primary and secondary side and at the plug were measured by a digital voltmeter (Fluke model number 8024A), and the current levels were measured by an amp meter (Triplett model number 10 type 2). The surface temperature of each of the glow plugs was measured by either a thermocouple (type S) connected to a potentiometer (Leeds and Northrop model number 8690-2) in contact with the surface of the plug or by an optical pyrometer (Pyro model number 85). A total of 12 plugs have been tested to date.

4.2 Surface Temperature

A GMAC model 7G plug was operated at 12, 14, and 16 volts ac. Surface temperatures as measured by the thermocouple were 1480, 1550, and 1650°F, respectively. Since the thermocouple would be expected to increase local heat loss and hence reduce the measured local surface temperature of the thin-walled plug sheath, these valves were probably somewhat lower than actual surface temperatures. This conclusion was supported by later readings with the pyrometer while testing another GMAC model 7G at 14 volts ac and getting 1720 $\pm$ 15°F.

A Bosch plug has been tested at 13 volts ac. It produced a surface temperature of 1700°F as measured by an optical pyrometer. Based on these results, TVA concluded that the diesel glow plugs could produce the desired surface temperatures.

4.3 Voltage Tests

Voltage tests have been completed on only the GMAC model 7G plugs. Based on tests on 5 GMAC 7G plugs, reliable operation at 14 volts was confirmed by two other 7G plugs failed at 16 volts ac after a few minutes.

Inconclusive testing on 2 Bosch plugs resulted in failure when operated at 14 volts ac; however, one Bosch plug cperated satisfactorily at 13 volts ac. One Isusi plug was tested at 14 volts ac but lasted for only 30 minutes.

4.4 Extended Operation

Endurance tests 'ıave been performed on only two plugs for extended periods of time. A GMAC model 7G plug was operated continuously for 148 hours without failure and was later used in the hydrogen burning tests. A Bosch 10.5 volt plug was operated at 13 volts for 90 hours, then cooled down for two hours and turned back on. It has been running continuously after being reenergized since August 20, 1980, at 10 a.m.

5.0 Hydrogen Testing

One igniter (AC 7G) was installed in a "PARR" (229HC6-T316-031579-

5142) pressure vessel in order to determine feasibility of igniting hydrogen in a sealed container. The vessel lid has a silicone rubber sealed gas injection sampling port. Hydrogen concentrations in the vapor phase were determined before and after ignition intervals. An ignition interval is the time current flows through the igniter circuit. The hydrogen was measured by a Perkin-Elmer gas chromatograph equipped with 3920 thermal conductivity dector and an M-2 integrator. The chromatic graph was standardized with hydrogen and air mixtures prepared from research grade hydrogen and laboratory air.

Temperature measurements were made with a mercury and glass (484635, ASTM 9C) thermometer. Temperatures reported are ambient for tests 1 through 3. Prior to tests 4-10, 100 grams of water was added to the vessel. The vessel was heated by a temperature adjustable hot plate to saturation temperature of the water and maintained throughout the test. The reported temperature is the water temperture after completion of the test. Results of the 10 ignition tests are given in table 1.

TABLE 1

HYROGEN IGNITION TESTS

Test No.	Vessel Contents	Temp. (°F)	Initial Hyd. Conc. (% Hyd.)	Final Hyd. Conc. (% Hyd.)	Ignition Intervals (Min.)
1	Hyd., Air	90	12.5	0.1	5
2		80	7	0.1	5
3		80	3.5	0.1	5
4	Hyd. Air, Water	120	12	0.1	3
5		180	14	0.5	3
6		180	4	2.5	1
7		180	2.5	1.5	1
8		180	1.5	1.3	1
9		180	11	5	1
10		180	5	2	1.3

Vessel Volume 1.1 dm^3 (0.039 ft^3)

Operating Voltage 12V dc

E50239.07