TENNESSEE VALLEY AUTHORITY

CHATTANOOGA, TENNESSEE 37401

400 Chestnut Street Tower II

December 24, 1980

Director of Nuclear Reactor Regulation
Attention: Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Schwencer:

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

During a meeting with your staff on the hydrogen issue on December 18, 1980, TVA committed to provide information on equipment survivability for Sequoyah Nuclear Plant. Enclosed is the information you requested.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

L. M. Mills

L. M. Mills, Manager
Nuclear Regulation and Safety

Sworn to and subscribed before me
this 24th day of Dec. 1980

Paulette H. White
Notary Public

My Commission Expires 9-5-84

Enclosure

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ENCLOSURE

CALCULATED HEAT SINK TEMPERATURE WITH BURN
(DERIVATION OF CURVE D FROM FIGURE B.1 OF TVA QUARTERLY REPORT)

A concern with Class 9 events is the potential temperature effects on equipment inside containment. One way to address this concern is to analyze an event and obtain an atmospheric temperature versus time profile and then impose this profile on a piece of equipment. Determining a temperature profile with reasonable levels of conservatism for a design basis large LOCA is relatively easy at this time because computer codes have been developed over the years that model the important phenomena involved in the accident. This is not the case for events that result in core degradation. The computer codes available to evaluate Class 9 events are in developmental stages and important models are not yet available. As an example, the CLASIX code does not model heat sinks within the containment. Energy and mass are added to containment and CLASIX calculates atmospheric temperatures after a hydrogen burn (Figure B.1, Curve E). If heat sinks are included, energy that was used to obtain high air temperatures would be absorbed by the structures and equipment. This means the calculated air temperature must go down or energy is not conserved.

Since the amount of energy determines the temperatures in either the atmosphere or the structures and equipment, an energy balance approach was chosen to evaluate temperatures inside containment. The energy releases are then partitioned between the various heat absorbers in the containment (i.e., the ice, heat sinks, and atmosphere).

To obtain curve D, a small break LOCA with no high pressure injection (S_2D) was modeled with the MARCH computer code to obtain the mass and energy releases needed for the analysis (the MARCH output was also used in the CLASIX run). The first 2500 seconds of the accident was analyzed with a conventional containment computer code (LOTIC). This code showed an atmospheric temperature of 160°F. It was assumed that all the heat sinks were also at 160°F at 2500 seconds. The analysis was terminated when 75 percent of the zirconium in the core had been oxidized (9250 sec).

The MARCH results showed, for the time period of interest (2500-9250 sec), 142100 pounds of steam were released with a total energy of 1.56 $\times 10^8$ Btu and 1620 pounds of hydrogen were released with an energy of 3.14×10^6 Btu because of the high temperature of the gas as it leaves the core. In addition curve D was generated assuming all the hydrogen burned with a heat rate of 61,000 Btu/lb resulting in a burn energy of 9.88×10^7 Btu. Summing the energy releases provides the total energy release of 2.58×10^8 Btu. Based on results from CLASIX, it was determined that 1.48×10^8 Btu was removed from the steam condensed in the ice bed. The air return fan also circulates air through the ice condenser at a rate of 4.8 million cubic feet per hour. This gives a maximum flow rate of 480,000 pounds per hour based on the upper compartment air density and the air return fan flow rate. It was assumed in the analysis that the air entering the ice condenser was on the average 200°F hotter than the air exiting to the upper compartment. This air flow results in the removal of 4.5×10^7 Btu.

Taking the total energy from MARCH and subtracting off the energy removed in the ice bed leaves 6.49×10^7 Btu which must be distributed between the atmosphere and the heat sinks. It was decided to neglect the heat capacity of the atmosphere to maximize the temperature rise in the heat sinks. The heat sinks used are listed in Table 1 and represent the structural steel in the Sequoyah lower compartment and the exposed portions of the steel containment shell in the dead-ended compartments. The volumetric heat capacity of the steel was calculated and an energy balance was used to calculate the heat sink temperature (as energy was released it was added to the heat sinks which would exist if one had an infinite heat transfer coefficient). The results of this analysis showed the heat sink temperature increased by 115°F. This was added to the 160°F initial heat sink temperature giving a maximum temperature of 275°F.

There are several conservatisms and considerations in the analysis that warrant further discussion. The results provided above assumed all the hydrogen generated (1620 pounds) was burned. The CLASIX results for this event showed only 940 pounds of hydrogen burned. This represents a 40 percent conservatism in the energy released because of burning (9.88×10^7 Btu to 5.7×10^7 Btu). Taking credit for only the steel heat sinks is also conservative, since concrete surfaces are neglected. The results presented are based on a steel heat sink surface area of 50,000 ft^2. The total surface area of the major steel and concrete heat sinks in the lower and dead ended compartments is 140,000 ft^2.

Curve D is a conservative and technically correct assessment of the energy distribution at Sequoyah during an S_2D event.

TABLE 1

MAJOR CHARACTERISTICS OF STRUCTURAL HEAT SINKS
INSIDE SEQUOYAH NUCLEAR PLANT CONTAINMENT - DEAD-ENDED COMPARTMENT

Structure	Heat Transfer Area (Ft^2)	Thickness and Material (As Noted)
Containment Shell	3,045	7.8 mils coating 0.78 in. carbon steel
	4,305	7.8 mils coating 1.1 in. carbon steel
	4,305	7.8 mils coating 1.25 in. carbon steel
	3,780	7.8 mils coating 1.37 in. carbon steel
	4,305	7.8 mils coating 1.51 in. carbon steel
Crane Wall	7,255	1.6 ft. concrete
	3,801	6.3 mils coating 1.58 ft. concrete
Containment Floor	4,809	6.3 mils coating 2.1 ft. concrete
Interior Concrete	9,870	1.1 ft. concrete
	3,948	6.3 mils coating 1.1 ft. concrete
	5,376	1.58 ft. concrete

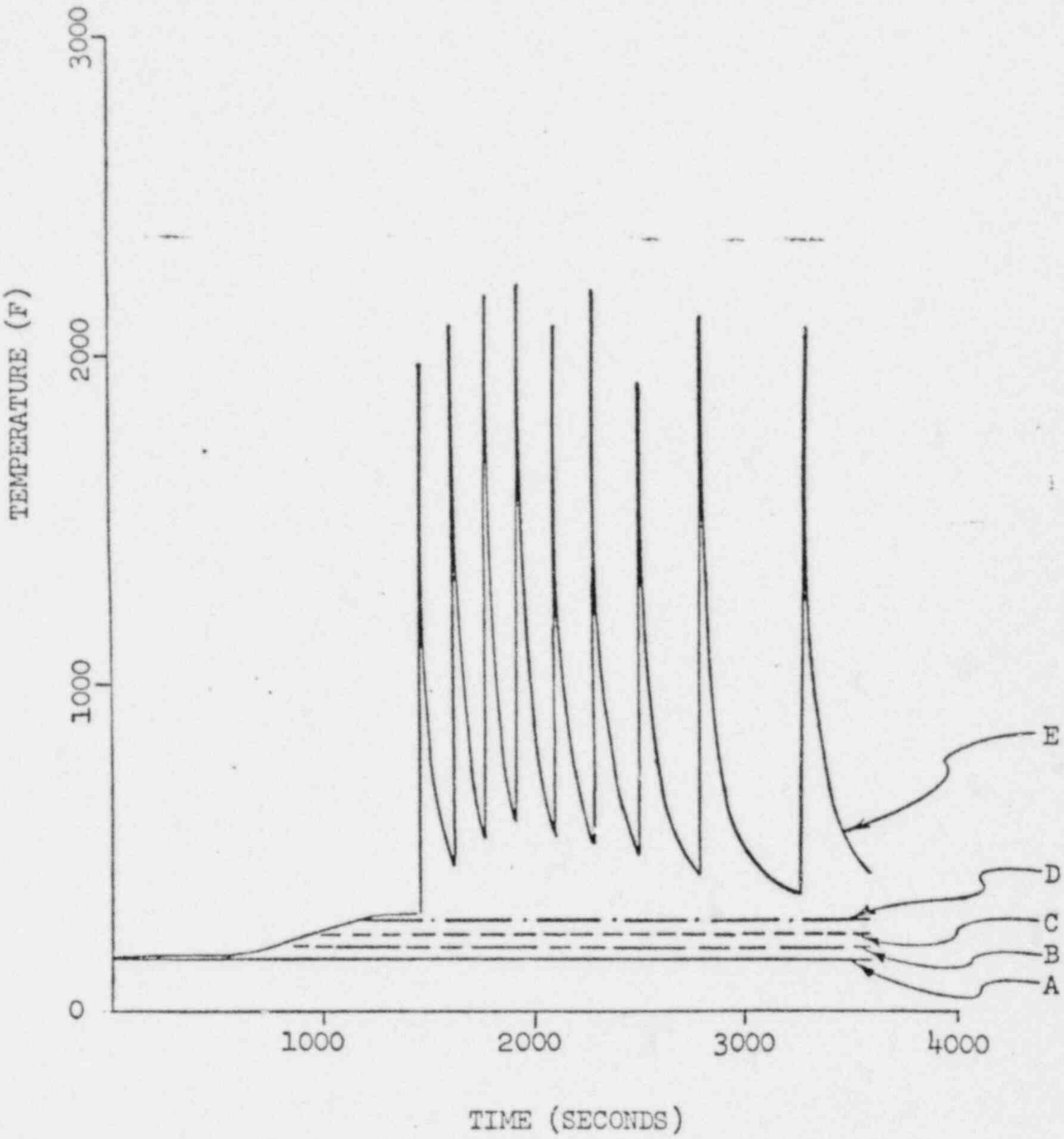
TABLE 1

MAJOR CHARACTERISTICS OF STRUCTURAL HEAT SINKS
INSIDE SEQUOYAH NUCLEAR PLANT CONTAINMENT - LOWER COMPARTMENT

Structure	Heat Transfer Area (Ft^2)	Thickness and Material (As Noted)
Operating Deck	7,507	1.1 ft. concrete
	2,971	1.6 mils coating 1.1 ft. concrete
	2,131	1.6 ft. concrete
	798	6.3 mils coating 2.1 ft. concrete
	2,646	2.1 ft. concrete
	210	6.3 mils coating 2.1 ft. concrete
Crane Wall	14,752	1.6 ft. concrete
	3,570	6.3 mils coating 1.6 ft. concrete
Containment Floor	567	1.6 ft. concrete
	7,612	6.3 mils coating 1.6 ft. concrete
Interior Concrete	3,780	1.1 ft. concrete
	567	1.1 ft. concrete
	2,992	2.1 ft. concrete
	2,384	0.26 in. stainless steel 2.1 ft. concrete
	2,373	2.1 ft. concrete
	1,480	6.3 mils coating 2.1 ft. concrete

TABLE 1

Structure	Heat Transfer Area (Ft^2)	Thickness and Material (As noted)
Miscellaneous Steel	12,915	7.8 mils coating 5.3 in. carbon steel
	7,560	7.8 mils coating 0.78 in. carbon steel
	5,250	7.8 mils coating 1.1 in. carbon steel
	2,625	7.8 mils coating 1.45 in. carbon steel
	1,575	7.8 mils coating 1.7 in. carbon steel



A - Calculated Atmospheric Temperature Without Burn
- LOTIC S_2D case
- assumed as initial temperature for heat sink calcuations (160°F)

B - Measured Atmospheric Temperature With Burn
- TMI - 2 (210°F)

C - Experimental Heat Sink Temperature With Burn
- Fenwal Phase 2, Part2, Test 2 (multiple burn)
- maximum igniter box internal temperature (238°F)

D - Calcuated Heat Sink Temperature With Burn
- TVA analysis
- maximum heat sink temperature (275°F)

E - Calculated Atmospheric Temperature With Burn
- CLASIX S_2D case
- no structural heat sinks

FIGURE B.1

EVALUATION OF EQUIPMENT SURVIVABILITY IN FENWAL TESTS AND AT SEQUOYAH NUCLEAR PLANT

Lists of both the components that were tested at Fenwal for equipment survivability and the equipment in the test vessel required to support the combustion tests were presented in Tables 6 and 7, of Appendix B to the TVA Quarterly Progress Report on Hydrogen Combustion and Control. These lists included a description of the visible effects of their exposure to the hydrogen burns. Those components that showed any significant effects are reproduced here in Table 1 along with comments on the severity or implications of those effects. In addition, a discussion is presented of the applicability of these test results to similar key equipment currently installed in the Sequoyah containment. The list of key equipment at Sequoyah was taken from Tables 8 and 9 of Appendix B to the TVA Quarterly Report.

This list of key equipment is also reproduced here as Table 2 along with a discussion of location and protection. As noted, with only three exceptions, the key components required to achieve and maintain cold shutdown following a degraded core, small-break LOCA event are protected from the environmental effects associated with such an event. The three exceptions are: item 4, hot leg RTD cable; item 11, cold leg RTD cable; and item 10, core exit thermocouple cable. The hot leg RTD cable is currently encased in conduit inside the containment to within a few inches of the well in the hot leg piping. The cold leg RTD cable is currently encased in conduit to within 20 feet of the cold leg piping. The core exit thermocouple cable is exposed for several feet above the reactor vessel in order to allow removal of the vessel head. The insulation material for each of these cables is of superior quality construction designed for high temperature applications as detailed in Table 2. TVA will, in its hydrogen research program, continue to evaluate these short lengths of cable for both short term and long term transient heatup due to hydrogen burning. The cabling will be encased in metal conduit or equivalent protection will be provided if shown to be necessary.

Table 1

Equipment	No. of Test Exposures	Effect of Tests	Comments	Relation to Sequoyah Key Equipment (Table 2)
Black plastic coated	1	Two scorch spots (2" by 1/2")	Surface effects only	Used inside containment. All cables are wrapped or routed in conduit inside containment
TVA igniter assembly	30	Assembly still functions well. Transformer coating scorched. Transformer wires scorched. Wrap on transformer windings scorched. Glow plug connector scorched. Transformer laminations corroded. Cover gasket scorched and hardened. Assembly exterior lightly corroded.	Scorching on transformer and cover gasket indicates that a hydrogen burn occurred inside the igniter box. Box was intentionally not sealed to see if this would occur. Closer examination revealed that scorching was superficial and not functionally degrading.	Used inside containment as component of interim mitigation system. However, igniter boxes inside containment are complete sealed at all openings and penetrations with high temperature RTV insulation.
Duke igniter assembly	6	Cover seal burned, but no other obvious degradation.	Igniter did not experience any internal burning.	"
Wood block (4"x4"x5-1/2")	20	Thin browning over much of wood surface.	-	Wood is not used inside containment.
Thermocouple lead wires (first set)	30	Teflon insulation burned off most of wires.	Melting temperature of teflon is 620°F. The diameter of the thermocouple wire and teflon sheath were 0.032 and 0.058" respectively. Since the lead wires were directly exposed to hydrogen burn atmosphere, the insulation could be expected to fail after multiple burns.	Most thermocouples contained inside containment have multiple sheathes and are enclosed in conduit (see item 10 in table 2 for exception).
Fan motor (1st)(1/150 hp shaded pole motor)	20	Light oxidation over surface; soldered connections failed on last test.	Silver solder has a melting temperature in the range of 900 to 1400°F. These solder connections were exposed to atmospheric temperatures for some tests (i.e., 12% H_2) as high as 2000°F (calculated).	There are no exposed solder connections inside containment
Fan motor (3rd)(1/150 hp shaded pole motor)	1	Failed after high temperature transient burn test; soldered connections detached.		

TABLE 2

EVALUATION OF SURVIVABILITY OF SEQUOYAH KEY EQUIPMENT

Key Equipment	Location and Protection
1. Steam Generator, Pressurizer, and Sump Level Transmitters	Located outside the crane wall. Transmitter cases are 1/4 inch thick steel or cast iron. All cabling from the transmitters is run in conduit. The cases and conduit are sealed.
2. Air Return Fan Motors	Totally enclosed massive motor (1300 pounds). No exposed solder connection. All control and power cables to the motor are enclosed in conduit and sealed.
3. Hydrogen Analyzers	All components located in the annulus. Components are not exposed to a burn.
4. Hot Leg RTD's	All cables are enclosed in conduit except at the RTD well in the hot leg. Cable construction same as item 11.
5. Gasket and Seals for Flanges, Electrical Boxes, Air Locks, and the Equipment Hatch	The seals are not exposed directly to the atmosphere. The boxes or penetration assemblies will protect the gaskets from thermal radiation from hydrogen burns.
6. Hydrogen Igniters	The igniter boxes are steel and have been sealed (igniter assembly used at Fenwal was not sealed). Cables to the box are enclosed in conduit and sealed.
7. Electrical Penetrations	Consists of a metal canister welded to the containment. Header plates are welded over the ends of the canisters.
8. Containment Isolation Valves Including Hydrogen Sample Valves FCV-43-201, 202, 207, and 208	The containment isolation valves will be in the required position prior to any hydrogen burn. All air supplies will be isolated and all relays and controls are outside containment with only power feeds to the valves (i.e., the valves cannot change position). The power feeds are routed in conduit.
9. Wrapped Cable	All cables at the electrical penetrations are wrapped with 1/16-inch thick lead. These runs are short (approximately 12 inches) and are all located at the containment wall outside the crane wall.

10. Exposed Cable - Core Exit Thermocouples	Runs of cable several feet long not in conduit in order to allow removal of the reactor vessel head. Cable construction: two wires 0.032 inch in diameter coated with 0.0005 inch polymide tested at 650°F for 1000 hours. Each wire is wrapped with 0.06 inch silicon-impregnated fiberglass braid. The two-wire assembly is wrapped with a 0.02-inch copper braid and a final coating of the silicon-fiberglass braid. The fiberglass braid has been qualified for 900° F.
11. Exposed Cable Cold Leg RTD's	Twenty feet of exposed cable. Construction of cable: 4 conductors, 22 GA, nickel-plated, silicon rubber-insulated, nickel clad copper shield, silicon-impregnated fiberglass wrap, stainless steel armor braid. Diameter of outer sheath is 3/8 inch.
12. Junction Boxes	GA fourteen gauge steel. No solder connections are used in any boxes.

SHORT-TERM EFFECTS OF A HYDROGEN BURN

During a hydrogen burn a short duration energy release occurs. This energy release affects equipment in two ways. First, there is radiative heat transfer from the flame front as it approaches and recedes from an object. Secondly, there is conduction and radiation as the flame passes around an object.

A transmitter was chosen as a representative sample to evaluate the short term heatup effects of a hydrogen burn at Sequoyah. The transmitter was picked because of the relatively high thermal conductivity of the steel housing. The HEATING 5 computer code was used to model a housing seven inches in diameter, six inches long, and 1/4-inch thick. A temperature profile representing the flame front approaching, passing around, and receding from the transmitter was imposed as the forcing function on the transmitter. The model was set up so that the temperature in the transmitter wall was calculated at 0.05 inch intervals to obtain a complete temperature distribution. The results of the analysis showed the maximum internal steel temperature is 265°F. The analysis also showed the maximum outside temperature of the housing is 407°F.

TEMPERATURE PROFILE USED TO EVALUATE

SHORT TEMPERATURE EFFECTS

ON EQUIPMENT

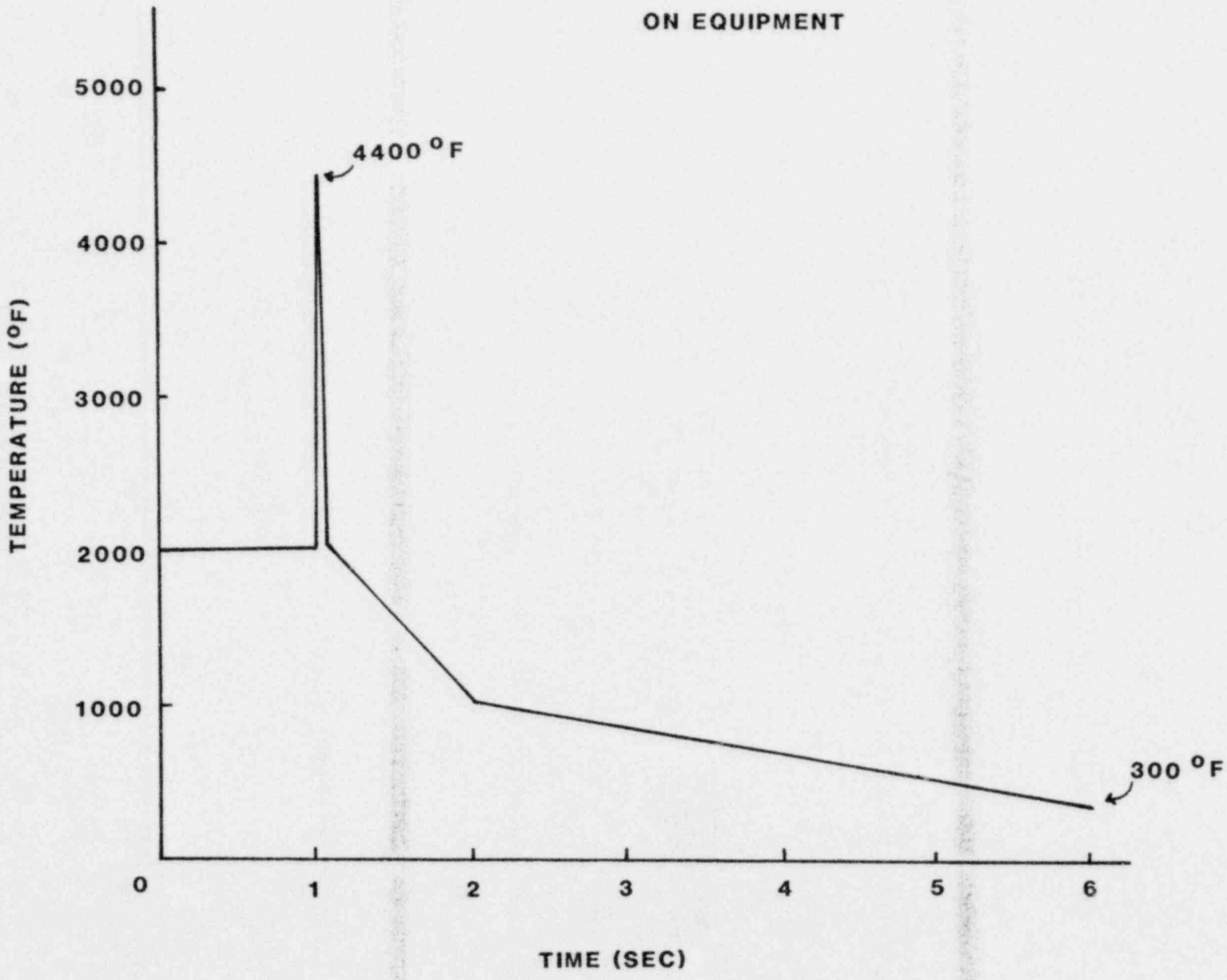


FIGURE 1