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SUBJECT: Forwards addl info re hydrogen mitigation & control,in response to Varga 810715 & 0904 requests.

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October 28, 1981
AEP:NRC:00500F

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Donald C. Cook Nuclear Plant Unit Nos. 1 and 2
Docket Nos. 50-315 and 50-316
License Nos. DPR-58 and DPR-74

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

Dear Mr. Denton:

The attachments to this letter contain additional information concerning Hydrogen Mitigation and Control at the Cook Plant. Attachment No. 1 contains our responses to the requests for information contained in Mr. S. A. Varga's letter of July 15, 1981. Attachment No. 2 contains our responses to the requests for information contained in Mr. Varga's letter of September 4, 1981. In those instances where it is not possible to provide the requested information at this time, anticipated submittal dates are provided.

This document has been prepared following Corporate procedures which incorporate a reasonable set of controls to insure its accuracy and completeness prior to signature by the undersigned.

Very truly yours,

R. S. Hunter
Vice President

cc: John E. Dolan - Columbus
R. C. Callen
G. Charnoff
R. W. Jurgensen
D. V. Shaller - Bridgman
Joe Williams, Jr.
Region III Resident Inspector - Bridgman

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Attachment No. 1 to AEP:NRC:00500F
Donald C. Cook Nuclear Plant Unit Nos. 1 and 2
Additional Information on Hydrogen Mitigation and Control
Responding to Mr. S. A. Varga's Letter of July 15, 1981

Item 1 Describe the permanent hydrogen 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.

Response to Item 1

The distributed ignition system (DIS) is the permanent hydrogen control system for the Donald C. Cook Nuclear Plant. Details of the DIS design were given in Attachment No.2 of AEP:NRC:00500A (Reference 1).

As stated in Attachment No. 1 of our AEP:NRC:00500E submittal (Reference 2), the DIS design described in Reference 1 has been modified to include two additional igniters (one per train) in the instrument room in each Cook Unit. Thus, the Cook Plant DIS will employ a total of seventy (70) igniters per unit. The igniters were installed in the instrument room during the most recent Unit No. 1 refueling outage. The Unit No. 2 instrument room igniters were installed during the recent outage.

As described in Reference 1, the Cook Plant DIS is a train oriented system with each train divided into two groups; one group of seventeen (17) igniter assemblies in the lower volume and a second group of eighteen igniters in the upper volume areas which include the ice condenser and the upper plenum volume. During the design stage, igniter assembly locations were selected in order to provide coverage of those areas where hydrogen release would most reasonably be expected (i.e. the lower volume inside the crane wall; particularly near the pressurizer relief tank) and to cover those areas where the potential for hydrogen accumulation may be a concern (i.e. the steam generator and pressurizer enclosures). In locating the igniters in the specified areas, consideration was given to the proximity of the igniters to safety-related components.

The DIS is seismically mounted so as to prevent any possible interferences with safety-related equipment during or after a design basis seismic event. The normal and emergency power sources for each train of igniters meet Electrical Class 1E specifications including adequate electrical train separation criteria. The system would be actuated from the main control room through the use of two control switches per train. Annunciation is provided in the main control to indicate loss of power to the DIS and failure to operate due to hypothetical control circuit equipment malfunctions.

The above cited design features coupled with the proven ability of the igniters to initiate combustion of lean hydrogen-air mixtures under adverse conditions (in the presence of steam and sprays) provide adequate assurance of proper DIS operability in the unlikely event of an inadequate core cooling accident involving the generation of substantive amounts of hydrogen.

Proposed DIS technical specifications were forwarded to the Commission via our AEP:NRC:00500C submittal (Reference 3) to reflect installation of the two additional igniter assemblies in the instrument room of each unit.

Item 2. List the rooms within containment for which there is no direct coverage by igniters and justify exclusion of these regions.

Response to Item 2

Igniter assemblies are installed in the locations specified in Attachment No. 2 of Reference 1; with two additional locations being included in the instrument room. Igniters are provided in all areas within containment which the CLASIX code predicts to be susceptible to the accumulation of hydrogen beyond the eight volume percent (v/o) level. However, as stated above, igniters are provided in the instrument room even though CLASIX does not predict the hydrogen concentration in the room to reach 8 v/o.

As noted in the response to Item 1, a large number of igniters are included in the general lower volume (the most probable point of hydrogen release into containment) and the ice condenser upper plenum area (where the hydrogen concentration is expected to first exceed the lower flammability limit due to steam stripping in the ice condenser). A total of fourteen igniters are provided in the upper plenum area and a total of twenty four igniters are provided inside the crane wall in the lower volume (including the pressurizer and steam generator enclosures) so as to assure combustion of lean hydrogen-air-steam mixtures and maximize the beneficial heat removal effects of the ice condenser. The relatively large number of igniters provided in the upper plenum should minimize the amount of hydrogen entering the containment upper volume. Analyses performed using the CLASIX computer code with a separate upper plenum node also reflect a substantial decrease in peak containment pressure (compared to bulk burning in the upper volume) associated with repetitious combustion of small amounts of hydrogen in the upper plenum.

Igniters are not provided in the pipe tunnel (annulus region), in the cavity below the reactor vessel, and in the room housing the regenerative and excess letdown heat exchangers as none of these areas are considered to be susceptible to hydrogen accumulation. Both the pipe tunnel and the reactor cavity are below the design basis flood-up level.

There is no hydrogen source in the reactor cavity, discounting hypothetical breaks in the vessel itself and the hot and cold leg nozzels. The reactor cavity is below the maximum containment flood level, and may be filled with water depending on break location, ice melt time history and ECCS injection rate.

During normal operation, a portion of the discharge from the lower volume ventilation units flows from the fan accumulator room through the annulus region and into the lower reactor

cavity. The lower volume ventilation units are tripped upon low flow in the non-essential service water supply line; which is itself isolated on a phase 'B' isolation signal. Thus, the ventilation units themselves are effectively tripped on phase 'B' making both the annulus region and the lower reactor cavity relatively isolated from the remainder of the lower compartment. These areas are included in the "dead-ended volume" for CLASIX analyses and no combustion is predicted in these regions. Hence, it was concluded that no igniters were required in these areas.

The regenerative heat exchanger room is virtually isolated from the lower compartment and is not considered to be susceptible to hydrogen accumulation: hence no igniters are installed there.

<u>Item 3</u> Discuss the effects of igniter operation in lean (0-4 v/o) hydrogen mixtures for sustained duration (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.

<u>Response to Item 3</u>

The Tennessee Valley Authority (TVA) is conducting tests at their Singleton Laboratories to determine the effects of lean (0-4 v/o) hydrogen mixtures for sustained duration (24 hours) on the igniter to perform its intended function. The test plan is described in Attachment A.2 of reference 4. The results of the Singleton tests will be forwarded to the Commission subsequent to completion of testing and data evaluation.

<u>Item 4</u> 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 period in which actuation is required. Identify and justify the mode of actuation, i.e., automatic or remote manual.

<u>Response to Item 4</u>

The DIS is designed to provide additional hydrogen control capability for hypothetical accidents well beyond the design basis of the Cook Plant. The S_2D accident sequence has been used as the design basis case for evaluation of the DIS mitigation concept and as the reference point for development of DIS operating guidelines.

Conservative analyses of the S_2D case have been performed using the Westinghouse (W)/ Offshore Power Systems (OPS) CLASIX computer code. The results of these analyses are contained in Attachment No. 1 to Reference 5 and Attachment No. 2 to Reference 2. It should be noted that the version of CLASIX used in the analyses presented in Reference 5 did not have a separate node representing the ice condenser upper plenum and did not account

for passive heat sinks. The version of CLASIX used for the analyses presented indicate that timely actuation of the DIS, together with operation of the Hydrogen Skimmer/Air Recirculation System (HYS) and the containment spray system (CTS), would result in the controlled combustion of lean hydrogen-air-steam mixtures and in pressure transients well within the capability of the Cook Plant containments. These analyses show that the DIS, in conjunction with HYS and CTS operation, provides adequate control for an amount of hydrogen equivalent to that generated by approximately 80% clad oxidation during a S_2D event. The heat transfer analyses contained in Attachment No. 4 of Reference 1 indicate that the environmental conditions associated with a S_2D event with hydrogen combustion are comparable to the conditions following a main steam line break (MSLB).

Since the HYS and CTS are automatically activated on a containment pressure 'high-high' signal (Phase B isolation) consideration was made as to whether a hypothetical accident sequence would result in automatic Phase B isolation. The aforementioned CLASIX analyses indicated that an S_2D event would result in Phase B isolation and automatic HYS and CTS actuation. Hence, it was logical to modify the 'Phase B' procedure to include DIS actuation.

Although no explicit analysis or accident sequence could be identified, it was felt that there may exist an accident which would not cause automatic HYS and CTS actuation but would require DIS operation. To accomodate this concern the "Inadequate Core Cooling" (ICC) procedure was modified to include manual activation of the HYS and CTS, if not already operating and DIS activation. The LOCA procedure was similarly modified. That is, the LOCA procedure has been amended to 'transfer' the operator to the ICC procedure if indication of inadequate core cooling is evident. "Caution" statements have also been added to the ICC and 'Phase B' procedures requiring analysis of containment atmosphere for hydrogen prior to CTS, HYS or DIS termination.

The CLASIX analyses presented in Reference 2 indicate that no compartment would reach a hydrogen concentration of 8 v/o until more than 4,000 seconds into a S_2D transient - well beyond the historically assumed ten minute delay in operator action from the onset of the accident. In addition, since the Phase B actuation setpoint of 3.0 psig containment pressure is exceeded early on in the S_2D sequence (approximately two minutes into the event) the modifications made to the 'Phase B' procedure would assure timely actuation of the DIS. Analyses have not, and need not, be performed for sequences other than S_2D as larger break sizes would only decrease the time prior to the Phase B setpoint and hence DIS activation for such events is adequately addressed in the 'Phase B' procedure.

Item 5. With regard to the Fenwal igniter test program provide the following information:

a) Summary of the data from the Phase 2 Fenwal tests in a format similar to that provided for the Phase 1 tests in the TVA Core Degration Program Report, Vol. 2. Include the calculated $\Delta P / \Delta P_{max}$ value.

b) Description and 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.

<u>Response to Item 5</u>

A summary of the Fenwal Phase 2 test data, including the calculated $\Delta P / \Delta P$ max value, has been submitted to the Staff via TVA letter dated October 1, 1981 (Reference 6).

<u>Item 6</u> The Staff requests submittal of a topical report on the CLASIX computer code with specific attention to a number of areas.

<u>Response to Item 6</u>

A draft topical report has been received from OPS and is presently under review by AEP, TVA and Duke Power Co. We shall forward a copy of the final topical report as soon as it is available.

<u>Item 7</u> The Staff requests submittal of information regarding the analysis of the S_2D transient using the revised CLASIX code.

<u>Response to Item 7</u>

We anticipate submittal of the requested information by approximately November 30, 1981.

<u>Item 8</u> Identify the spectrum of accidents which you have considered in your evaluation of the distributed ignition system. Discuss the rationale for selection of the various accidents. Discuss the basis for assumptions regarding termination of the accident prior to core slump if applicable. Provide the assumptions and results of CLASIX analyses performed to evaluate the containment atmosphere pressure and temperature results, similar to that provided for the S_2D transient, for the various accident sequences selected.

<u>Response to Item 8</u>

As discussed in the meeting held on July 23, 1981 in Bethesda, Md. between members of the NRC Staff and representatives of AEP, TVA and Duke Power Co., the DIS will effectively be evaluated for a "spectrum of accidents" by performing parametric studies on hydrogen release rates, utilizing the CLASIX computer code to calculate containment response and varying the MARCH S_2D output

parameters used in previously submitted analyses. As was recognized during the Bethesda meeting, such parametric studies would most likely bound a number of WASH-1400-NUREG/CR-1659 (References 7 and 8) accident sequences insofar as the hydrogen production rate is concerned. We anticipate submittal of this information by November 30, 1981.

With regard to termination of the accident prior to core slump, we would like to point out that AEP believes that consideration of core melt and (or) core slump phenomena is beyond the scope of the hydrogen control issue and will be best addressed in the degraded core cooling rulemaking. AEP has already expended significant financial and manpower resources toward the resolution of the hydrogen control issue for hypothetical accident sequences well beyond the design basis of the Cook Plant and we do not believe that the investigation of core slump and core melt phenomena should be imposed on the owners of ice condenser plants as the issues at hand are truly generic in nature.

Item Nos. 9 through 14 The response to these questions will be provided to the NRC in followup reports to this submittal. We anticipate submittal of the requested information to the NRC prior to November 30, 1981.

<u>References for Attachment No. 1 to AEP:NRC:00500F</u>

1) Letter No. AEP:NRC:00500A dated April 24, 1981

2) Letter No. AEP:NRC:00500E dated July 2, 1981

3) Letter No. AEP:NRC:00500C dated May 29, 1981

4) Letter dated September 22, 1981: L. M. Mills (TVA) to E. Adensam (NRC)

5) Letter No. AEP:NRC:00500 dated January 12, 1981

6) Letter dated October 1, 1981: L. M. Mills (TVA) to E. Adensam (NRC)

7) Reactor Safety Study-An Assessment of Accident Risks in U. S. Commercial Nuclear Power Plants; WASH-1400 (NUREG-75/014), USNRC, October 1975

8) Reactor Safety Study Methodology Applications Programs: Sequoyah No. 1 PWR Power NUREG/CR-1659/1 of 4, Sandia National Laboratories, February 1981.

Attachment No. 2 to AEP:NRC:00500F
Donald C. Cook Nuclear Plant Unit Nos. 1 and 2
Additional Information on Hydrogen Mitigation and Control
Responding to Mr. S. A. Varga's Letter of September 4, 1981

A. EQUIPMENT SURVIVABILITY

DCC Items A.1.a and A.1.b - In our submittal of July 2, 1981 (Reference 1), reference is made (in Section 2.0 of Attachment No. 1) to an analysis performed by TVA (Section 2.3 of Reference 2) for the Sequoyah Plant of the heat up rate of equipment only in the ice condenser upper plenum. The equipment of concern is the igniter assemblies, igniter power cable routed in conduit, and the ice condenser insulation panels and intermediate deck doors. The latter two are of concern only to the extent that the calculated metal temperature (inside surface) is used in evaluating insulation pyrolysis during hypothetical periods of prolonged combustion in the upper plenum. Since the equipment being evaluated, the location of the affected equipment (the ice condenser upper plenum), and the temperature profile from CLASIX for the upper plenum are very similar for Cook and Sequoyah we believe that the conservative analyses performed by TVA are conservatively applicable to the Cook Plant.

Details of the igniter assembly and igniter locations are contained in Attachment No. 2 of Reference 3. Details of the Ice Condenser design are contained in the Cook Plant Final Safety Analysis Report.

DCC Item A.2 - As stated in our response to A.1.a and A.1.b in only one instance has a TVA analysis been directly applied to the evaluation of Cook Plant equipment and the application of the analysis shown to be conservative for the Cook Plant. Our response is given below. (Note: Items asked on the Cook Dockets are identified as 'DCC' items; those addressed to TVA as 'SNP' items).

SNP Item A.1.a - The basis for considering the effects of hydrogen combustion on selected (or needed for inadequate core cooling (ICC) mitigation) equipment is provided in Attachment No. 3 of Reference 3. The evaluation contained therein clearly shows that survival of the ICC equipment assures that the ability to achieve and maintain the reactor coolant system in a safe shutdown condition and to maintain adequate hydrogen control are not impaired by a S_2D event involving hydrogen combustion. It must be recognized that inherent in the definition of the S_2D event is the arbitrary and non-mechanistic assumption that redundant trains of numerous safety-related systems are not available for accident mitigation.

SNP Item A.1.b - The most recent Cook-specific analyses performed with the modified CLASIX code (See Attachment No. 2 of Reference 1) do not predict combustion in the dead-ended volume, the fan/accumulator rooms, and the containment upper volume. Survivability of ICC equipment in those regions is not affected by hydrogen combustion in other regions. The peak temperatures for the dead-ended, fan/accumulator, and upper volume regions are 216 F, 205 F and 169 F respectively; well below the peak temperature used for MSLB qualification.

SNP Items A.1.c and A.1.d - We anticipate submittal of the requested information by November 30, 1981.

SNP Item A.2 - The list of ICC/Hydrogen Control Equipment inside containment contained in Table 3-1 of Attachment No. 3 to Reference 3

includes a number of transmitters. The function performed by these transmitters, their location inside containment, and a summary of their susceptibility to exposure to a hydrogen combustion environment are given below. A detailed discussion of the susceptibility of these transmiters to exposure to a hydrogen burn environment is contained in Attachment Nos. 3 and 4 to Reference 3.

FUNCTION	LOCATION OF TRANSMITTERS
Monitor Steam Generator Narrow Range Level	Lower Volume
Monitor Pressurizer Pressure	Instrument Room
Monitor Pressurizer Level	Instrument Room
Monitor Wide Range RCS Pressure	Lower Volume

The transmitters used to monitor wide-range RCS pressure are located in the lower volume, well below the flood-up level anticipated at the onset of hydrogen combustion and hence, are not subjected to the effects of hydrogen combustion. Similarly, two-of-the three transmitters provided on each steam generator are below the anticipated flood-up level at the time of hydrogen combustion. Based on the analyses presented in Attachment No. 4 to Reference 3, the one 'exposed' transmitter per steam generator is also expected to survive a hydrogen combustion event.

Transmitters used to monitor pressurizer pressure and level are located in the instrument room - an area in which CLASIX does not predict hydrogen combustion.

The transmitters used for the above functions have successfully completed LOCA/MSLB environmental qualification and exposure to the environmental conditions predicted by CLASIX would not adversely affect the ability of the transmitters to continuously perform their respective functions.

SNP Items A.3 Through A.8 - We anticipate submittal of the requested information by November 30, 1981.

DCC Item B.1 - In evaluating the potential deleterious affects of hydrogen combustion on exposed cable, the following major considerations were made:

(1) In what regions of the containment does CLASIX predict combustion?

(2) Is there any exposed safety cable in the region(s) identified in (1)?, and

(3) What is the duration and spacing of the burns in the affected regions?

CLASIX predicts combustion only in the lower volume and the ice condenser upper plenum. As there are no exposed safety cables in the upper plenum (igniter power cable is routed in conduit) our evaluation focused on the lower volume.

In comparing the CLASIX results with the Sandia Fire Test (Reference 4), the major considerations made were the duration of the cable exposure to the fire source and the type of cable involved. A secondary consideration was the wetting of cable by containment spray (which would serve to enhance the fire retardance of the cable).

The Sandia testing was performed on dry cross-linked polyethylene cable, which Sandia believes to be the least fire retardant cable qualified to IEEE-383. In the Sandia test, the cable was continuously held in the flame front until failure (minimum time to failure was five minutes). The most recent CLASIX analysis contained in Attachment No. 2 to Reference 3, indicates that a total of seven burns will occur in the lower volume over a time period in excess of one thousand seconds. The time period between burns is approximately two minutes (see Figures 1 and 2).

The duration of combustion in the Lower Compartment for CLASIX analyses is nine seconds per burn. As shown in Figure 1, the time from the onset of combustion until the bulk lower compartment temperature falls below the MSLB temperature is on the order of fifteen seconds. Conservatively assuming the seven burns to be consecutive (no time between burns) and taking no credit for cooling between burns the total time above MSLB temperature would be 105 seconds; approximately one-third of the time shown in the Sandia test before cable failure. Of course the actual time a given cable is exposed to a flame is dependent of the flame speed and the cable routing and would be significantly less than the previously cited 105 seconds. If the cable were wet due to spray operation the effects of the burn environment would be even less severe than the Sandia test environment. However, it is not essential that the cables be wetted for them to withstand the S_2D sequence.

For reasons stated above, we believe that exposed cable would not constitute a potential secondary fire source during a S_2D-hydrogen combustion event and would, in fact, perform its safety function during such an event.

DCC Item B.2 - The total energy content of the polyethylene encapsulating the fiberglass insulation in the ice bed region is on the order of 20 x 10^6 Btu. As stated in Reference 1, the calculated temperature of the metal adjacent to the insulation (370 F) is insufficient to result in significant degradation of the polyethylene. It should be noted that the Duke analysis used to determine the metal temperature conservatively assumed a 'stationary' flame in the ice bed for approximately forty five minutes. No realistic mechanism has been identified which would result in combustion of polyethylene in the insulation panels. We believe the Duke analysis to be conservatively applicable to Cook Plant and do not believe degradation or combustion of polyethylene to be a significant concern.

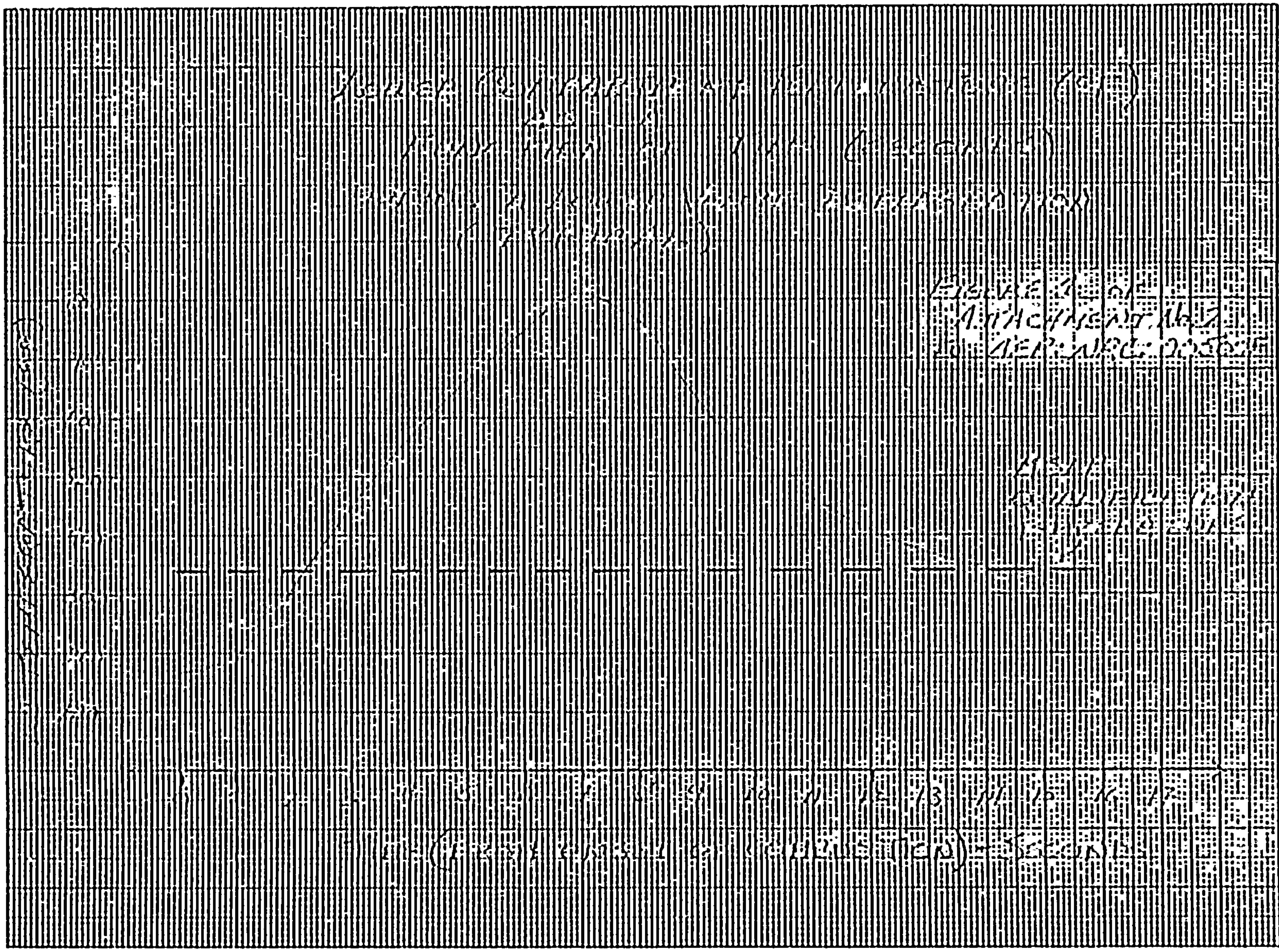
References for Attachment No. 2 to AEP:NRC:00500F

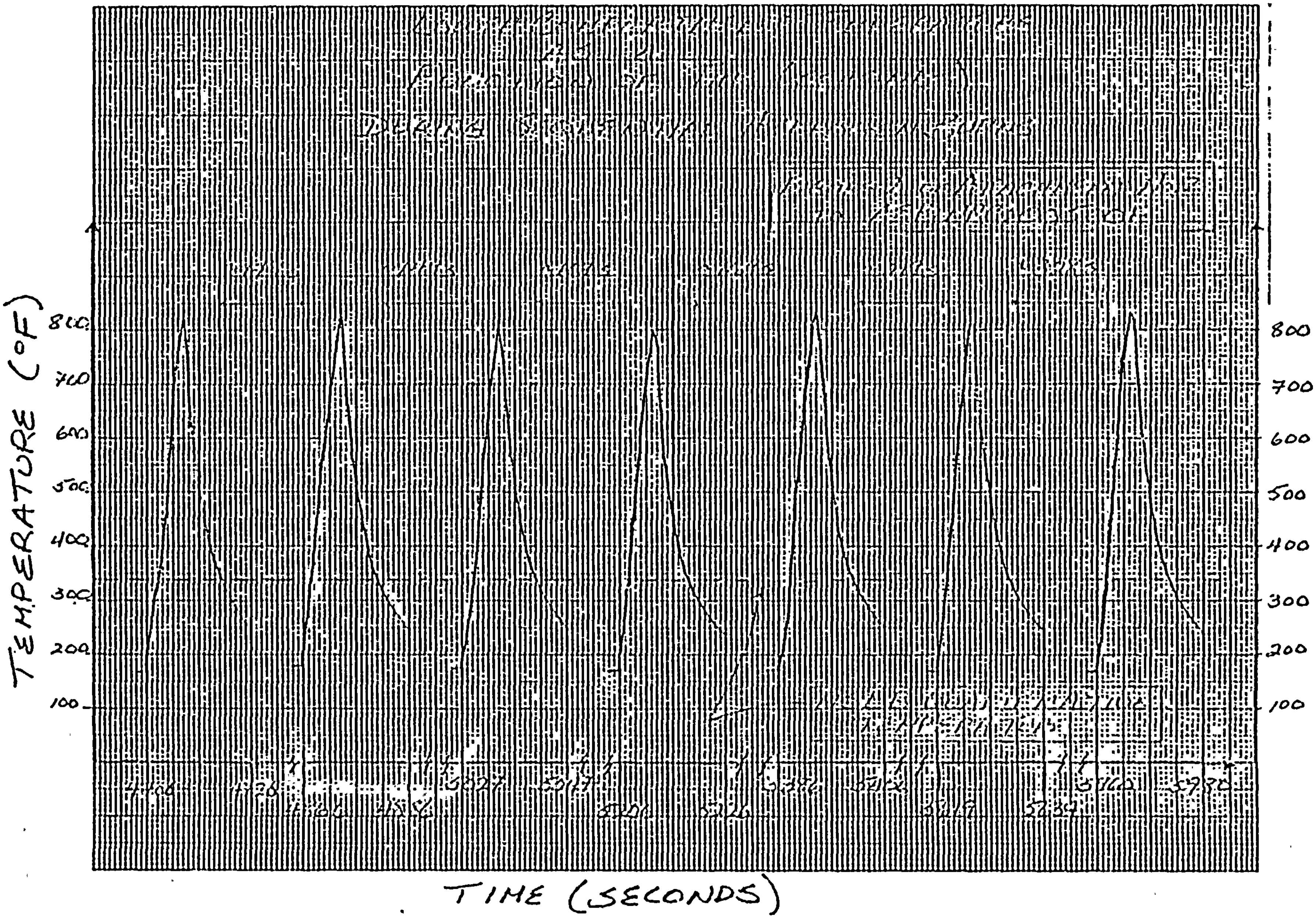
(1) AEP:NRC:00500E dated July 2, 1981

(2) TVA report; "Resolution of Equipment Survivability Issues for the Sequoyah Nuclear Plant", May 29, 1981.

(3) AEP:NRC:00500A dated April 24, 1981

(4) Klamerus, L. J., "Fire Protection Research", Quarterly Progess Report, October - December 1977 NUREG/CR-0366.

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