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DENTON,H.R. Office of Nuclear Reactor Regulation, Director

SUBJECT: Forwards responses to Questions 7 & 8 re equipment survivabilty of 820916 request for info on hydrogen combustion & control.Info completes util responses to outstanding requests dtd 820730 & 0916 & 830810.

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May 24, 1984
AEP:NRC:0500N

Donald C. Cook Nuclear Plant Unit Nos. 1 and 2
Docket Nos. 50-315 and 50-316
License Nos. DPR-58 and DPR-74
RESPONSES TO NRC QUESTIONS ON EQUIPMENT SURVIVABILITY
DURING POSTULATED HYDROGEN BURN CONDITIONS

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

Dear Mr. Denton:

This letter and its Attachment provides additional information with regard to hydrogen combustion and control during degraded core accidents for the Donald C. Cook Nuclear Plant Unit Nos. 1 and 2. More specifically, the Attachment to this letter contains responses to Questions 7 and 8 of the September 16, 1982, Request For Information transmitted to Mr. John E. Dolan of the Indiana & Michigan Electric Company (IMECo) by Mr. S. A. Varga of the NRC. These responses, which have been supplied by Westinghouse Electric Corporation/Offshore Power Systems (W/OPS), are based upon equipment survivability studies performed for the Tennessee Valley Authority's Sequoyah Nuclear Plant. Although these equipment survivability studies were not specifically performed for the Donald C. Cook Nuclear Plant, we have been advised by W/OPS that these responses are generally applicable to the Donald C. Cook Nuclear Plant.

The information presented in the Attachment to this letter completes IMECo's responses to the outstanding NRC Requests For Information on hydrogen combustion and control dated July 30, 1982, September 16, 1982, and August 10, 1983. Previous responses to these NRC requests were contained in our letter Nos. AEP:NRC:0500J, AEP:NRC:0500K, AEP:NRC:0500L, and AEP:NRC:0500M, dated October 15, 1982, October 10, 1983, December 17, 1982, and March 30, 1984, repectively.

Upon completion of your review we would like the opportunity to discuss the results with your staff.

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

Very truly yours,

M. P. Alexich
Vice President PBK 5/24/84

MPA/dam
Attachment

cc: John E. Dolan
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ATTACHMENT TO AEP:NRC:0500N

RESPONSES TO QUESTIONS 7 AND 8 OF THE NRC

REQUEST FOR INFORMATION ON HYDROGEN COMBUSTION AND CONTROL

DATED SEPTEMBER 16, 1982

DONALD C. COOK NUCLEAR PLANT UNIT NOS. 1 AND 2

Question 7:

With regard to the equipment survivability analysis, the level of conservatism implicit in the temperature forcing functions developed for the lower containment and the upper plenum is not apparent and quantifiable. Additional analyses should be conducted to provide a baseline or "best estimate" of equipment response, and to ensure that temperature curves assumed in the analyses embody all uncertainties in the accident sequence and combustion parameters. Accordingly, provide analyses of equipment temperature response to:

a) the base case transient assumed in the containment analyses;

b) the containment transients resulting from a spectrum of accident scenarios; and

c) the containment transients resulting under different assumed values for flame speed and ignition criteria for the worst case accident sequence. The range of these combustion parameters assumed for the equipment survivability analyses should include but not necessarily be limited to the values assumed in the containment sensitivity studies, i.e., 1 - 12 ft/sec flame speed and 6 - 10% hydrogen for ignition.

Response to Question 7(a):

By letter dated December 1, 1981 (L. M. Mills (TVA) to E. Adensam (NRC)), equipment survivability results for the TVA Sequoyah plant were presented for 8 v/o - 85% completeness hydrogen burns with a flame speed of 1 ft/sec. Thermal analyses also were performed using the HEATING5 computer program for a flame speed of 6 ft/sec, for all the equipment analyzed for a flame speed of 1 ft/sec. The 1 ft/sec results showed higher equipment temperatures than the 6 ft/sec analyses in every instance. The results for the Sequoyah plant are believed to be generally applicable to the Donald C. Cook Nuclear Plant due to the similar thermal sensitivity of equipment used in ice condenser containment facilities.

Response to Question 7(b):

The S_2D scenario represents a reasonable upper bound scenario for the Donald C. Cook Nuclear Plant. The maximum hydrogen release rate and the total amount of hydrogen released prior to core slump, as predicted by the MARCH computer code for the Sequoyah plant, bounds the other accident scenarios believed to be high contributors to the risk at the Donald C. Cook Nuclear Plant. In the TVA letter dated December 1, 1981 (L. M. Mills (TVA) to E. Adensam (NRC)), the maximum hydrogen release rates were provided for several scenarios. The S_2D scenario had a maximum hydrogen release rate of 1.1 lb/sec. The S_1D scenario had the highest peak hydrogen release rate, 1.3 lb/sec. The S_2D event resulted in 75% of the core being oxidized while for the next most likely scenario, approximately 35% of the core was calculated to be oxidized. Although the S_1D scenario resulted in a slightly higher hydrogen release rate than the S_2D scenario, it was not high enough to result in oxygen

inerting during burns, prevent a rapid reduction in hydrogen concentration in the burn compartment during a burn, nor produce higher atmospheric and flame temperatures for a set of given ignition criteria than the S_2D scenario. The much larger amount of hydrogen released in the S_2D case results in more burns and higher equipment temperatures. The S_2D scenario used for the equipment survivability evaluations produces higher equipment temperatures than would be produced by the other scenarios reviewed. Therefore, the results for the equipment survivability evaluations based upon the S_2D scenario conservatively bound the other scenarios.

Response to Question 7(c):

In the response to Question 7(a) above, it was stated that flame speeds of 1 ft/sec produced higher equipment temperatures than flame speeds of 6 ft/sec. The comparison of these cases given in TVA's December 1, 1981 letter referenced above showed that the longer burn duration seen at the lower flame speed results in greater energy input to the equipment. This effect was more important in determining the maximum equipment temperature than changes in peak burn temperature. Equipment survivability analyses using flame speeds higher than those already studied will not result in higher equipment temperatures.

Other equipment survivability analyses performed for the Sequoyah plant used a burn criteria of 6 v/o - 60% completeness of burn. These analyses resulted in peak equipment temperatures that were essentially the same as reported in the other analyses. The margin between calculated maximum temperatures and the survivability temperatures are quite large.

It is noted that some of the equipment survivability results reported for the Sequoyah plant are conservative when applied to the Donald C. Cook Nuclear Plant, due to the additional heat sink provided by the lower compartment spray system at the Donald C. Cook Nuclear Plant.

Question 8:

For the survivability analysis, it is our understanding that the current thermal model assumes radiation from the flame to the object only during a burn, with convection occurring at all times outside the burn period. In an actual burn, radiation from the cloud of hot gases following the flame front can account for a substantial portion of the total heat transfer to the object. An additional heat flux term or a combined radiation-convection heat transfer coefficient should be used to account for this radiant heat source. In this regard, clarify the treatment of heat transfer following the burn and justify the approach taken.

Response to Question 8:

The equipment survivability analysis referenced above for the Sequoyah plant utilized thermal models which assumed radiative heat transfer only during a burn. The radiative heat transfer during the

burn included the radiation from the cloud of hot gases following the flame front. Radiative heat transfer from the hot cloud for all thermal models considered in the referenced study was evaluated at the adiabatic flame temperature. Additional analyses performed since the TVA work referenced above have shown that radiative heat transfer from the atmosphere to the equipment after burn termination produced changes in the equipment surface temperature response of about $10^{o}F$. CLASIX temperature profiles were used as the temperature forcing function for the radiative heat transfer after burn completion. Gas and surface emissivities of 1.0 (i.e., black body) and view factors of 1.0 were used in the post-burn period for conservatism.

The temperature forcing functions used in the equipment survivability analysis for the TVA Sequoyah plant provide a conservative estimate of the temperature forcing functions for the Donald C. Cook Nuclear Plant. Unlike the Sequoyah plant, the Donald C. Cook Nuclear Plant has sprays in the lower compartment which result in lower temperatures in that compartment and greater heat removal from the containment atmosphere.