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April 20, 1982

NUCLEAR PRODUCTION DEPARTMENT

U. S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Washington, D. C. 20555

Attention: Mr. Harold R. Denton, Director

Dear Mr. Denton:

SUBJECT: Grand Gulf Nuclear Station
Units 1 and 2
Docket Nos. 50-416 and 50-417
File: 0756/0260
Ref: 1) AECM-82/26
2) AECM-81/336
3) HGN-001
Equipment Survivability
AECM-82/155

Enclosed are responses to the Chemical Engineering Branch questions which were received by Mississippi Power & Light (MP&L) from the Nuclear Regulatory Commission on April 1, 1982. The questions were originally transmitted by Mr. V. Benaroya to Mr. A. Schwencer by cover memorandum dated March 30, 1982. The questions have been renumbered 281.10 through 281.16 in accordance with a telephone conversation with your Mr. Dean Houston.

In addition to the attached responses, MP&L is also providing additional information regarding several issues raised by the NRC staff during telephone conversations on April 12th and 13th, 1982. A statement of MP&L's understanding of each concern is provided below along with MP&L's response.

1. Discuss the methodology used in defining HEATING-3 input from the CLASIX-3 temperature profiles.

   The burn peaks have been grouped into three sets. For each set, an average peak temperature was selected which exceeds the numerical average of peak temperatures in each group. Each peak was assumed to have a constant duration equivalent to roughly an average of all peak widths in the group. The exponential decay of the peak temperature is simulated by choosing several temperature-time points on a specific temperature spike and permitting HEATING-3 to linearly interpolate between those points.

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2. Discuss the criteria which will be used to activate the containment sprays. If temperature rise in containment will be used as a basis for actuating sprays, provide the location of the temperature sensors.

   Containment sprays are actuated automatically upon coincident signals of high drywell pressure and high containment pressure. The sequence begins with a low reactor water level or high drywell pressure which initiates low pressure coolant injection and starts a timer which will initiate containment spray in approximately ten minutes if the containment pressure of nine psig is present with a

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high drywell pressure signal. At this point, only operator action can prevent initiation of containment spray and the signals are not required to be present when the spray is actually initiated.

MP&L has provided four redundant temperature sensors immediately below the HCU Floor in the wetwell region. These sensors provide annunciator alarms in the control room and instrument readings are recorded on strip chart recorders. The alarm set point for these sensors is being revised to 125°F. The Grand Gulf emergency operation procedures will be revised such that the operators will initiate containment spray when the HIS has been energized due to a degraded core accident and one of these temperature alarms annunciates indicating that hydrogen combustion has commenced.

3. Is the equipment survivability analysis of essential equipment located in the drywell using wetwell temperature profiles truly conservative in light of the drywell temperature profiles for case 1 submitted in reference 2?

   The drywell break base case in reference 2 assumed that all steam and hydrogen is released into the drywell. This assumption was modified in reference 3 to reflect a more realistic assumption that the actual release is split between the drywell and the relief valves which are opened early in the transient and discharge to the suppression pool. Thus one half of the total energy released by the accident is liberated outside the drywell which decreases the peak temperatures expected inside the drywell. Hence, the drywell temperatures are not expected to exceed the equipment qualification temperature other than during the burn transients. MP&L concludes that the evaluation against the wetwell burn environment is therefore, conservative.

   The NRC staff has expressed some concern that the drywell temperatures calculated for the drywell break base cases in references two and three are excessively different.

   The energy input rate to the drywell is assumed to decrease by 50% when the SRV's are actuated for the drywell break analysis. The apparent differences in calculated drywell temperatures are caused initially through the partial high energy blowdown to the suppression pool. The 50% flow split between the suppression pool and the drywell reduces the energy addition rate sufficiently to permit the heat sinks to be more effective in desuperheating the drywell atmosphere. MP&L is continuing to evaluate this issue.

4. Confirm that the drywell spray modeled by CLASIX-3 is initiated no earlier than 7807 seconds.

   The code commences spray in the drywell at 7807 seconds.

5. Has an adequate evaluation of the survivability of the entire Automatic Depressurization System been performed?

   MP&L considers the safety relief valves to be the only components of this system which might be subject to thermally induced failures. As noted in reference 1, these relief valves have been shown to survive the worst case temperature transients which occur in the wetwell. In

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addition, MP&L does not believe that the ADS will be required to function during or after the severe environments produced by hydrogen combustion. The reactor coolant system will be depressurized by the ADS very early in the accident sequence.

6. Please verify that miscellaneous seals, gaskets, flanges and electrical boxes have been verified to survive the expected thermal transients?

   The Grand Gulf Equipment Survivability Study included analyses of numerous pieces of essential equipment (such as limit switches, igniter assemblies, electrical penetrations, electrical switch gear and motors) for which seals, gaskets and flanges provide protection for internal components. In order to determine the thermal response of representative seal and gasket materials to the predicted burn environment, rubber gaskets were modeled as a part of the equipment limit/position indication switches. The results of this analysis, as shown in section 7.13 of the report submitted by reference 1, show that the surface temperature is lower than the equipment qualification temperature for the duration of the transient. The gasket surface is approximately equal (within 1 or 2 degrees F) to the surface temperature of the equipment. Based on this analysis, the peak equipment surface temperature provides a suitable basis for evaluating equipment survivability. Hence, gaskets and seals are adequately considered in determining whether an essential piece of equipment will survive the predicted hydrogen burn environment. Due to the similarities in material, and the fact that each piece of essential equipment is analyzed to the same severe wetwell burn environment, the results of the gasket thermal analysis described above are considered representative of each piece of essential equipment.

   For equipment which is not sealed, such as electrical enclosure boxes, internal components were evaluated based on direct exposure to the burn environment. This is a conservative approach since even though these boxes are not sealed the separation from the burn environment provides considerable protection.

We believe that these responses and the enclosed question responses should resolve the issues discussed and permit issuance of an interim evaluation.

Yours truly,

John D. Richardson for

L. F. Dale
Manager of Nuclear Services

RWE/SHH/JDR:rg

Attachment

cc: See next page

cc: Mr. N. L. Stampley (w/o)
Mr. R. B. McGehee (w/o)
Mr. T. B. Conner (w/o)
Mr. G. B. Taylor (w/o)

Mr. Richard C. DeYoung, Director (w/o)
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281.10 In your submittal of January 19, 1982 you state that a piece of equipment will survive if the maximum external surface temperature or the maximum internal temperature of the most limiting component reached during a hydrogen burn is below the qualification temperature for this piece of equipment. Since during the qualification tests the actual temperatures reached by the components of the tested equipment were not measured, demonstrate by analytical or experimental means that the temperatures reached by the most limiting internal components of the equipment exposed to a hydrogen burn remain below the temperatures reached by the corresponding components during the qualification tests, even though in these tests the equipment may be exposed to different temperature-time profiles.

RESPONSE

With the exception of the motor actuators, the criteria utilized to evaluate the survival of equipment in the Grand Gulf Survivability Report is based upon the equipment surface temperature response to the wetwell burn environment. Environmental qualification tests are typically conducted for extended periods of time at temperatures equal to or in excess of the qualification temperature. Thus, as a minimum, the equipment surface temperature should achieve thermal equilibrium with the test chamber during the tests.

In the case of the motor actuators, the calculated surface temperature response of the switch gear housing due to exposure to the wetwell burn environment exceeded the required 200°F qualification temperature by 8°F. However, since the interior temperature response of the switch gear itself did not exceed 200°F, the motor actuators survive this transient. The qualification temperature of 200°F for the motor actuators was based upon the containment qualification temperature. The qualification criteria for the motor actuators have since been revised to envelop the drywell LOCA conditions, i.e., 340°F[1]. Hence survival based upon the exterior surface temperature response of equipment can be considered as the only evaluation criteria utilized in the Grand Gulf Survivability Report.

[1] Grand Gulf Response to NUREG-0588, L. F. Dale (MP&L) to R. L. Tedesco (NRC), letter AECM-81/231 dated July 1, 1981.

281.11 The analyses of equipment survivability during a hydrogen burn provided in your submittal were performed for the thermal environment corresponding to the "base case". Demonstrate by providing suitable analytical and/or experimental evidence such as sensitivity studies (see 281.12 below), that using the temperature-time profiles and other thermal parameters from the "base case" as an input to the survivability analyses would yield conservative results.

Response: The containment response analysis developed for the base case stuck open relief valve represents the expected temperature profiles in the wetwell and upper containment regions of the Grand Gulf Nuclear Station during a significant hydrogen generation event. There are no other temperature profiles which have been calculated as providing more conservative representation of containment temperatures for the postulated accident sequence.

A number of conservatisms have been incorporated into the thermal analysis using the base case temperature profiles.

1) The peak temperatures assumed for each group of hydrogen burns are higher than the actual average peak temperature obtained from the CLASIX-3 temperature versus time graphs. This results in an appreciably greater area under the temperature/time curves for the survivability temperature profiles than exists in the CLASIX-3 base case temperature profile.

2) All of the essential equipment has been evaluated against the wetwell temperature conditions. These are the most severe thermal conditions postulated to occur as a result of hydrogen combustion. A very small amount of essential equipment is actually located in the wetwell region. Refer to the response to question 281.16.

   As indicated in the survivability report, equipment was also evaluated against conditions postulated to result from global combustion in the upper containment. The parameters for this evaluation were modified to include three global burns instead of the single burn predicted by CLASIX-3. The peak temperature used in the survivability analysis was 800° F. versus 680° F. predicted by CLASIX-3. The equipment survivability report documents that the wetwell burn environment produces more severe thermal loadings than does the global burn case.

3) As indicated in the equipment survivability report, substantial margins exist between the calculated peak temperatures resulting from hydrogen combustion and the temeperature for which the equipment is environmentally qualified.

[1] CLASIX-3 Containment Response Sensitivity Analysis for the Mississippi Power & Light Company Grand Gulf Nuclear Station, Report No. OPS-37A15 December 1982. Submitted by the Hydrogen Control Owners Group (HCOG) letter HGN-001 from J. D. Richardson to Harold R. Denton on 1-15-82. Endorsed for Grand Gulf by letter AECM-82/41 from L. F. Dale to Harold R. Denton dated 1-15-82.

281.12 In the sensitivity studies described in the submittal you varied modes of heat transfer and different thermal parameters in order to determine their effect on thermal response of the equipment. Describe in more detail these studies so that we can perform an independent review and give the ranges over which key thermal parameters are varied.

RESPONSE

To ensure that the reported thermal response of the equipment is adequately representative of the actual equipment response, several sensitivity studies were conducted. These studies evaluated the sensitivity of the results to variations in best reference material thermal properties, the effects of decreasing the calculational time step and mesh spacing selected in the HEATING-3 transient analysis, the effects of modifying the convective heat transfer relationship used and modeling assumptions used.

The sensitivity of the results due to use of best reference material thermal properties was established by varying the thermal conductivity and the surface emissivity of selected components and comparing the resulting thermal responses. The maximum thermal response of the safety relief valve and containment locks varied by less than 8°F when the thermal conductivity was reduced by a factor of ten from its best reference value. The maximum thermal response of the air actuator varied by less than 6°F when the surface emissivity was increased from its best reference value of 0.73 to 1.0.

The sensitivity of the temperature response of one piece of equipment to the modeled convective heat transfer relationship was evaluated. Temperature responses obtained with forced convection correlations, assuming velocities of one and two times the burn speed (6 and 12 feet/second), were found to predict a somewhat lower response than the natural convection correlations. Results obtained from modeling which employs laminar and turbulent natural convection differed only slightly; hence, either natural convection correlation was considered adequate.

The effects of decreasing the calculational time step and mesh spacing used in the HEATING-3 heat transfer code were established by sensitivity methods. The reported thermal responses of selected equipment (cables) were essentially identical (< 1°F) when compared with the results obtained using a ten times smaller time step. Similarly, the mesh spacing was also determined to be appropriate based upon a sensitivity study which showed that use of a mesh spacing twice as fine as that employed in the motor actuator model yielded a thermal response within 1°F of the reported response.

281.12- Continued

When developing the computer models for equipment thermal evaluation, best engineering judgement was used to determine the level of detail necessary to conservatively represent the equipment. Since all the pieces of equipment were essentially symmetric, about one or more axis, it was judged that two dimensions or even one dimension was adequate to describe the equipment. This assumed that the path of least thermal resistance from the burn environment to the limiting component is modeled. To confirm the adequacy of these criteria, a representative piece of equipment, the igniter enclosure, was modeled in detail in three dimensions. The thermal response of this model to the burn environment was compared to that from the two-dimensional model used in the survivability report.

The thermal response of limiting components using the two dimensional model was consistently higher than the thermal response resulting from the use of the three dimensional modeling. These results verify that the criteria used to simplify the equipment models into one and two dimensions are conservative.

281.13 Provide a description of the HEATING-3 computer code which you used in calculating thermal response of the equipment during a hydrogen burn.

RESPONSE

HEATING-3 is a standard multi-dimensional heat conduction program developed at Oak Ridge National Laboratory. The users manual (Reference ORNL-TM-3208, Turner, W. D., and M. Siman-tov, February 1971), which is based on an Oak Ridge National Laboratory report contains the following abstract describing the code.

HEATING-3, a modified version of the HEATING program,[1] is designed to solve steady-state and/or transient heat conduction problems in one-, two-, or three dimensional Cartesian or cylindrical coordinates. Thermal conductivity, density, and specific heat may be dependent on temperature. Heat generation rates may be dependent on position and time, and the boundary temperatures may be time dependent. The boundary conditions may be fixed temperatures or any combination of constant heat flux, forced convection, natural convection, and radiation. The boundary conditions can be from-surface-to-boundary, from-surface-to-surface, or from-surface-to-surface plus conduction. The mesh spacing can be variable along each axis. There can be as many as 1,750 lattice points, 100 regions, 50 materials, and 50 boundary conditions.

The "extrapolated Liebmann method" and a modification of the "Aitken & 2 extrapolation process" are used to solve the finite difference equations which approximate the partial differential equations for a steady-state problem. The difference equations for a transient problem involve the first forward time difference, and thus, the solution is expressed explicitly in terms of the temperatures at the previous time level.

For transient calculations, a modified explicit method is incorporated into the program as an option which allows the use of an arbitrary time increment while maintaining stability.

[1]Turner, W. D., and J. S. Crowell, Notes on HEATING--An IBM 360 Heat Conduction Program, Union Carbide Corporation, Nuclear Division.

281.14 In your submittal you claim that the survivability analyses performed for cables apply also to terminal blocks because thermal properties of the terminal blocks are similar to those of the cables. Justify this claim by listing the key thermal parameters and providing suitable descriptions.

RESPONSE

The following represents a comparison of the thermal properties of typical terminal block and cable insulation materials.

	ρC_p	K
	(BTU/in^3°F)	BTU/sec in °F
Terminal block (phenolic)	.017	3.1×10^{-6}
Cable Insulation	.016	4.8×10^{-6}

In order to further verify the similarity in thermal properties, an analysis of the terminal blocks was conducted. In the analysis, a 0.25-inch thick piece of terminal block material was assumed to be exposed directly to the "base case" burn environment.

No credit was taken for the enclosure found around all terminal blocks. The resulting maximum calculated surface temperature was 262°F, well below the 300°F maximum calculated for the cable.

281.15 In analyzing thermal response of the Drywell Purge Compressors and in discussing secondary fires in the containment during a hydrogen burn, you stated that the oil in the sump of the compressor or in any other locations in the containment will not burn because the surface of all the pools of oil will remain below the autoignition amounts of combustible vapor when it reaches the flash point temperature. This vapor may ignite by some external sources of ignition present in the containment (e.g., sparks from electric motors). The flash point temperature is usually considerably below the autoignition point for a given material. In light of these considerations, show that at the surface temperatures predicted by your analysis generation of combustible vapors will not pose any significant problems.

RESPONSE

The flash point temperature for the lubricating oil in the Drywell Purge Compressor is 425°F. This temperature is well above the calculated maximum oil surface temperature of 228°F. Consequently, the generation of combustible vapors will not pose any problems.

281.16 It can be postulated that under certain circumstances elevated temperatures may be developed in the wetwell area, directly above the suppression pool. These temperatures may prevail for an extended period of time due to continuous burn of the high concentration of hydrogen released from the suppression pool. Show that any safety related equipment which may be located in this area will survive this high temperature environment.

RESPONSE

The potential for a continuous burn above the suppression pool as well as its related effects is being evaluated by MP&L.[1] The temperature effects from a continuous burn are the dominant concern, since pressurization is expected to be much less severe than the cases already evaluated.

A minimal amount of safety-related equipment is located in the wetwell region (below elevation 135'4" in the containment).[2] This includes suppression pool and containment temperature sensors, the igniters, associated igniter power supplies, a drywell airlock, and a containment personnel air lock. The igniters and containment temperature sensors in this region are well protected due to location in the webbing of I-beam or the addition of structural material to protect this equipment from pool swell.

This configuration will provide considerable protection from the effects of a continuous burn. The igniter power supply cables are well protected since they are located in steel conduit, which is routed through structural I-beams in the vicinity of the igniters.

The personnel locks located in the wetwell region have an interior (containment side) and exterior door. Each door has two inflatable seals separated by an air gap. The seals are well protected since the surface area of the seal exposed to the burn will be much less than the area in contact with a large heat sink, i.e., the door. Even if both seals were to fail, the door would not fail catastrophically, and the exterior door would remain completely isolated from the burn environment.

[1] Report on the Study of Hydrogen Control in GGNS, Lewis and Karlovits, Combex, November, 1981, transmitted to the Nuclear Regulatory Commission by letter AECM-82/25, March 2, 1982.

[2] Volume 9A of the Grand Gulf FSAR.