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U.S. Nuclear Regulatory Commission
Mail Station P1-37
Washington, D.C. 20555

Attention: Document Control Desk

Subject: Grand Gulf Nuclear Station
Docket No. 50-416
License No. NPF-29
Grand Gulf Nuclear Station Plant-Specific Hydrogen Control Analysis

GNRO-94/00013

Gentlemen:

In October of 1980, the Nuclear Regulatory Commission (NRC) published a proposed hydrogen control rule. The NRC published the final version of this rule by amending the hydrogen control requirements of 10CFR50.44 on January 25, 1985. The final hydrogen control rule requires that each BWR licensee with a Mark III containment submit an analysis to the NRC that demonstrates compliance. The Rule requires that the analysis provide an evaluation of the consequences of releasing large amounts of hydrogen into the primary containment during a postulated degraded core accident. The analysis must address recovery from the degraded condition, use scenarios that are accepted by the NRC, support the design of the hydrogen control system, demonstrate that the containment structural integrity will be maintained, and that systems and equipment necessary to establish and maintain safe shutdown will be capable of performing their function if exposed to the environmental conditions created by the burning of hydrogen.

Since the hydrogen control program inception, Grand Gulf Nuclear Station (GGNS) and the Hydrogen Control Owners Group (HCOG) have completed a significant amount of testing and analysis to demonstrate compliance with the Hydrogen Control Rule (10CFR50.44). In addition to significant analyses, the HCOG hydrogen control program led to design and construction of a large (1/4-scale) test facility and the performance of plant-specific modeling and testing to define the hydrogen combustion phenomena and the attendant effects in a Mark III containment during a postulated degraded core accident.

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Specific details of the Hydrogen Control Program, both plant-specific and generic, are contained in the GGNS Hydrogen Control Final Analysis Report. This final analysis has provided, by reference or inclusion, an evaluation of the consequences of hydrogen released from a recoverable degraded core accident, including the recovery period, using a postulated accident accepted by the NRC. The analysis supports the design of the hydrogen control system installed at GGNS, shows that containment structural integrity is maintained, and demonstrates survivability of systems and components necessary to establish and maintain safe shutdown and containment integrity. This final GGNS-specific hydrogen control system analysis meets or exceeds the requirements specified in 10CFR50.44.

The GGNS final analysis was conducted in accordance with the NRC approved topical report. Pursuant to the staff's August 5, 1993 letter (reference: GNRI-93/00135), our final analysis reports will not be submitted for staff review. However, for your convenience, we have summarized in the attached, significant findings and conclusions of our plant-specific hydrogen control final analysis. This document constitutes the final GGNS Quarterly Status Report and satisfies the requirements of Operating License Condition 2.C.(33)d in its entirety.

Should you have any questions or concerns regarding the attached, please contact Ms. Jewel Summers at (601) 437-2149.

Yours truly,

C. R. Hutchinson

CRH/JS/mtc
attachment: GGNS Plant-Specific Final Hydrogen Control Analysis
cc: (See Next Page)

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GRAND GULF NUCLEAR STATION

PLANT-SPECIFIC

HYDROGEN CONTROL ANALYSIS

I. Introduction

A. Background

The Grand Gulf Nuclear Station initiated its hydrogen control program in early 1980, following the accident at Three Mile Island Unit 2 in March of 1979. In May of 1981, GGNS joined with other utility owners of General Electric BWR/6 nuclear steam supply systems with Mark III containments and formed the Hydrogen Control Owners Group (HCOG). The primary purpose of the HCOG was to collectively address the technical and licensing issues associated with hydrogen control.

In July 1981, the HCOG began an integrated program which provided guidance for member utility's hydrogen control programs while completing generic work that could be shared by the entire group. In order to define the various hydrogen control issues, the HCOG developed a program plan document which outlined specific tasks and actions required to resolve them. The Hydrogen Control Program Plan Document was submitted to the staff on behalf of the HCOG. Work activities associated with these tasks have since been completed.

B. Licensing Topical Report

In February of 1987, the HCOG issued a Topical Report to the staff which summarized the tasks of the Hydrogen Control Program and documented the closure mechanism and attendant references for the many subtasks delineated by the Hydrogen Control Program Plan. In September of 1993, the HCOG issued Accepted Topical Report HGN-112-NP-A to meet a Generic SER requirement and to update the previously submitted Topical Report for all tasks in the generic program. Issuance of the Supplemental Safety Evaluation Report (SSER) by the staff initiated commitments to submit within six-months, plant-specific analysis reports.

C. Generic Safety Evaluation Report/Supplemental Safety Evaluation Report (SSER)

On August 10, 1990, the staff issued its Generic Safety Evaluation Report (SER), which documented the staff's review of the HCOG generic program relating to the Mark III Containment Hydrogen Control Program. The evaluation focused on the assessment of completed testing and analyses performed by the HCOG in support of the plant unique analysis. The HCOG submitted two additional documents in April of 1991 to address several generic SER concerns. The staff's evaluation

of those concerns concluded that they were consistent and compatible with 10CFR50.44. A supplemental SER was issued in June of 1993 providing final closure of all outstanding NRC issues.

II. Significant Hydrogen Control Program Findings

A. Selection, Design, and Installation of Hydrogen Control System

Several hydrogen control concepts were evaluated by the HCOG. It was concluded that from a performance, functional, safety, and testing perspective, the distributed hydrogen ignition system (HIS) provided the optimum design. The system consists of thermal glow plug igniter assemblies at multiple locations in containment and drywell. There are 90 igniter assemblies in the GGNS system which is designed such that no single active or passive failure will prevent acceptable system performance. The system is powered from redundant, separate Class 1E power sources. The vulnerability to interruption of power to the hydrogen igniters has been further evaluated for the GGNS as part of its IPE effort, as required by the generic SER and by Generic Letter 88-20 and its supplements.

Two exceptions exist at GGNS with respect to the generic spacing criteria. One exception is in the upper containment where due to lack of adequate physical support, no igniters were located between elevation 207'9" and elevation 262'0". This configuration does not adversely affect the functioning of the HIS because this open region of the upper containment above the refueling floor does not contain obstruction which would promote formation of hydrogen accumulations. The highly turbulent conditions produced by localized combustion and the operation of containment sprays will preclude stagnation of hydrogen in this region and will promote hydrogen transport to regions furnished with igniters. The second exception is in the lower region of the drywell below elevation 146'. Six igniters were originally to be located in this region of the drywell but were subsequently deleted from the design based on the fact that this region of the drywell can become submerged from a drywell break or Weir Wall overflow. Long term submergence of igniters could produce an unacceptable short circuit condition resulting in potential loss of both divisions of igniters in the drywell and a portion of the igniters in the containment. Short term submergence qualification of the igniter assemblies has been performed with satisfactory results.

B. Definition of Accident Scenarios Appropriate for Recoverable Degraded Core Accidents

The selection of accident scenarios addressed by the HCOG program was initially delineated in HGN-006 and subsequently clarified in HGN-052. NUREG-1150 indicates that the short term station blackout sequences, i.e., TBU, represent the dominant contributors to the GGNS core damage frequency. The HCOG reviewed the TBU sequences and based on information in NUREG/CR-4550 and 4551, roughly 80% of the TBU sequences lead to severe accident conditions and are inappropriate scenarios for hydrogen control evaluations under 10CFR50.44. To render a TBU sequence recoverable, timely power restoration and timely core reflood must occur. With these stipulations, the TBU sequences are encompassed by the HCOG Hydrogen Generation Event (HGE) scenarios and the attendant analysis developed during the Hydrogen Control Program. This is consistent with the staff position in the SSER that the reflood timing assumption should be adjusted to produce a conservative estimate of hydrogen production and establish a conservative hydrogen generation profile.

C. Completion of the 1/4 Scale Test Program

The 1/4 Scale Test Facility was a large scale test vessel which provided detailed data on the thermal environment that would result from diffusive combustion in Mark III containments. The use by HCOG of GGNS for the base design of the 1/4 scale facility enhanced the applicability of the measured data to the full scale plant. In addition, the significant number of instrumentation devices provided a comprehensive data set for mapping temperatures at full scale. The results of the GGNS production tests were detailed in HGN-130. The keynote conclusion of the 1/4 scale testing was that the Mark III containment distributed system of glow plug igniters is a very effective means of controlling hydrogen combustion. The data compiled for GGNS provided an excellent representation of the environmental conditions that would exist during an event which meets the intent of 10CFR50.44.

D. Equipment Survivability Analysis

The generic SER requires each licensee to provide plant-specific information concerning plant unique design features that are relevant to the essential equipment selection. The GGNS Equipment Survivability List adheres very closely to the generic selection

iteria, with only minor differences. Containment vacuum breakers were determined not to be required at GGNS, and are not included on the list. Terminal blocks and junction boxes are not specifically listed but these components have been considered in the electrical cable survivability analysis. The thermal response of a variety of equipment has been evaluated using the HEATING-6 computer code in conjunction with the 1/4 scale test data. The GGNS Equipment Survivability Analysis Report describes the evaluations in detail.

GGNS equipment locations have been evaluated to ascertain the local thermal environment. Only those items for which further detailed thermal response analysis was required were actually evaluated using the HEATING-6 code. Equipment such as motor-operated valve components exhibited calculated peak critical temperatures which were considerably less than the equipment qualification temperature. Less massive equipment such as thermocouples and pressure transmitters exhibited higher peak calculated temperatures but still less than the qualification temperatures. Several small cables had peak calculated temperatures which exceeded the qualification temperature. The results of various industry cable tests were examined in this context including other Sandia tests which indicated the cables could survive very high temperatures for short durations. Based on the information available, it was judged that the short term excursions above the qualification temperature (i.e., 10 to 15 minutes) would not be expected to cause cable failures.

Relative to containment spray availability, the GGNS IPE did not identify any significant vulnerabilities due to the loss of decay heat removal systems, including containment sprays. Therefore, from a probabilistic perspective, the effects of not having containment sprays available during a hydrogen generation event is not a containment performance concern. Based on the extensive program of testing by the HCOG and on the plant-specific results, it is concluded that the essential equipment in the GGNS containment and drywell would survive the postulated hydrogen generation event.

E. Generic and Plant-Specific Emergency Procedures for Hydrogen Control

In accordance with the HCOG Generic Combustible Gas Control Emergency Procedure Guidelines (CGC EPG), igniters are actuated if reactor water level drops below the Top of Active Fuel and both the primary containment and drywell hydrogen concentration is below the Hydrogen Deflagration Overpressure Limit (HDOL). The igniters are also activated if primary containment or drywell hydrogen concentration exceeds the minimum detectable concentration provided the primary containment or drywell HDOL is not exceeded. It is intended that once turned on, the igniters be continuously operated thereafter. They would be secured only if the hydrogen concentration exceeded the HDOL and it could not be determined that they had been continuously energized.

The plant-specific Emergency Operating Procedures (EOPs) instruct the operator to unconditionally secure the igniters if primary containment or drywell HDOL is exceeded. This deviation is required because no reliable method is available at Grand Gulf that allows the operator to determine if the igniters have been continuously energized. The direction to secure igniters avoids the possibility of a deflagration which could challenge the containment structural integrity.

It should be noted that GGNS Emergency Procedure EP-3 gives instructions to use containment sprays to control primary containment pressure in accordance with the BWROG Emergency Procedure Guidelines. The use of sprays will cool and depressurize the containment helping to keep it within the HDOL, potentially precluding the need to secure the igniters and vent the containment. This would be beneficial since continued operation of the igniters would further reduce the hydrogen concentration ensuring that the HDOL is not exceeded.

III. Conclusions Regarding Conformance to 10CFR50.44

Section 8 of the Generic SER requires that each licensee document its overall conclusions with respect to the Hydrogen Control Rule. The GGNS Final Analysis Report summarizes the major aspects of both the HCOG generic and the GGNS plant-specific hydrogen control programs. The intent of these programs has been to achieve compliance with the Hydrogen Control Rule.

Section (iv)(A) of 10CFR50.44 requires that: Each licensee... with a Mark III type of containment...shall provide its nuclear power reactor with a hydroge[illegible]rol

system justified by suitable program of experiment and analysis." Relative to conformance at the GGNS, Entergy Operations, Inc. concludes the following:

1) The Hydrogen Ignition System (HIS) installed at the GGNS meets the requirements of 10CFR50.44. Plant-specific testing in the 1/4-Scale Test Facility has demonstrated the viability and effectiveness of the HIS itself and of the concept of deliberate ignition for hydrogen control.

2) Appropriate hydrogen generation events for 10CFR50.44 evaluations are considered to have been adequately addressed during the HCOG generic hydrogen control program and the attendant GGNS plant-specific efforts. The HCOG HGE scenario has resulted in a conservative hydrogen release history for hydrogen combustion testing and analysis. The HCOG scenario is considered to encompass a recoverable TBU sequerce.

3) Based on the GGNS 1/4-scale test results and peak pressures calculated in the CLASIX-3 analysis program, the GGNS containment would maintain its structural integrity during a degraded core HGE. The GGNS drywell structure would also maintain its structural integrity.

4) Based on the equipment survivability analyses reported in the GGNS Equipment Survivability Analysis Report and on the HCOG generic work on this subject, the drywell and containment equipment essential for hydrogen control would be expected to survive a recoverable degraded core HGE. Hence, safe plant shutdown and maintenance of containment integrity would be expected.

Overall, Entergy Operations, Inc. considers that GGNS conforms to the requirement of 10CFR50.44. Emergency procedures are in effect for hydrogen control, and the design of the key mitigative hydrogen control systems is supported by extensive analysis and testing.

The requirements of 10CFR50.44 and line items in the Generic SER have been addressed. The final analysis has provided, by reference or inclusion, an evaluation of the consequences of hydrogen released from a recoverable degraded core accident, including the recovery period, using a postulated accident accepted by the NRC.