ENTERGY

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February 10, 1994

U. S. Nuclear Regulatory Commission
Document Control Desk
Washington, D. C. 20555

Subject: River Bend Station
Docket No. 50-~~456~~ 458
License No. NPF-47
River Bend Station Plant Specific Hydrogen Control Analysis

Reference: NRC Letter from E. T. Baker to P. D. Graham
"Plant Specific Hydrogen Control Analysis
(TAC No. M59714)"

File No.: G13.18.14.5

RBG-40041

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 10 CFR 50.44 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 must provide an evaluation of the consequences of releasing a large amount of hydrogen into the primary containment during a postulated recoverable 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 the systems and equipment necessary to establish and maintain safe shutdown will be capable of performing their function if exposed to the environmental conditions crated by the burning of hydrogen.

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Since the hydrogen control program inception, River Bend Station and the Hydrogen Control Owners Group (HCOG) have completed a significant amount of testing and analysis to demonstrate compliance with the Hydrogen Control Rule. The HCOG selected a distributed system of glow plug igniters as the optimum design for hydrogen control, and a system of this design was installed at River Bend Station.

The HCOG hydrogen control program culminated in the design and construction of a large (1/4 scale) test facility and the performance of plant-specific testing to define the hydrogen combustion phenomena and the attendant effects a Mark III containment during a postulated recoverable degraded core accident leading to a hydrogen release equivalent to a 75% metal-water reaction of the active fuel rod cladding.

Specific details of the Hydrogen Control Program, both plant-specific and generic, are contained in the River Bend Station Hydrogen Control Summary Report, i.e. the Final Analysis Report. The final analysis has provided an evaluation of the consequences of hydrogen released from a recoverable degraded core accident, including the recovery period, using a postulated accident sequence accepted by the NRC. The analysis supports the design of the hydrogen control system installed at River Bend Station, shows that containment structural integrity is maintained, and demonstrates survivability of systems and components necessary to establish and maintain safe shutdown and containment integrity. The River Bend Station final hydrogen control analysis meets or exceeds the requirements specified in 10 CFR 50.44.

The final analysis was also conducted in accordance with the requirements in the NRC Mark III Containment Generic Hydrogen Control Safety Evaluation Report. Pursuant to the staff's August 5, 1993 letter (see reference), our final analysis report will not be submitted for staff review. In the attached, significant findings and conclusions of the plant-specific hydrogen control final analysis are summarized.

Should you have any questions regarding the attached, please contact Mr. J. L. Burton at (504) 381-4710.

Sincerely,

James J. Fisicaro

James J. Fisicaro
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Quality Verification

JJF/dab
attachment
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SUMMARY OF RIVER BEND STATION PLANT-SPECIFIC HYDROGEN CONTROL FINAL ANALYSIS

I. Introduction

A. Background

The River Bend Station (RBS) 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, RBS 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 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 utilities' 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 program plan documents which outlined specific tasks and actions required to resolve them. The Hydrogen Control Program Plan Documents were submitted to the staff by the HCOG. All work associated with these tasks has since been completed.

B. Licensing Topical Report and Safety Evaluations

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 mechanisms and attendant references for the many subtasks delineated by the Hydrogen Control Program Plan. On August 6, 1990, the staff issued its Generic Safety Evaluation Report (SER), which documented the staff's review of the HCOG generic program regarding the Mark III Containment Hydrogen Control Program. The evaluation focused on the assessment of the completed generic 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 indicated that the HCOG's intended disposition was consistent and compatible with 10 CFR 50.44. A Supplemental SER was issued in June of 1993 providing final closure of all outstanding NRC issues. Issuance of the Supplemental Safety Evaluation Report by the staff initiated commitments to submit plant-specific final analysis reports within six-months.

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. The RBS hydrogen control program has addressed all pertinent plant specific activities outlined in HGN-112-NP-A.

II. Significant Hydrogen Control Program Findings

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

Several hydrogen control concerns were evaluated by the HCOG. It was concluded that from a performance, functional, safety, and testing perspective, the distributed hydrogen ignition system provided the optimum design. The system consists of thermal glow plug igniter assemblies at multiple locations in the containment and drywell. There are 90 igniter assemblies in the RBS 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 RBS as part of its Individual Plant Examination (IPE) effort, as required by the generic HCOG SER and by Generic Letter 88-20 Supplement 3.

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. The latest versions of NUREG-1150 indicate the short term station blackout sequences, i.e., TBU, represent the dominant contributors to the Mark III containment 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 10 CFR 50.44. 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. Furthermore, the reflood timing and the reflood flow rates have been selected via comprehensive sensitivity analyses to produce a conservative calculation of the total hydrogen production and establish a conservative hydrogen generation profile, consistent with staff comments in the generic SER regarding the BWR Core Heatup Code (BWRCHUC). HCOG's position with regard to the HGE was accepted in the Supplemental SER.

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 environments that would result from diffusive combustion in Mark III containments. Plant-specific testing in the RBS configuration ensured that the 1/4 scale results are directly applicable to and

accurately model RBS. In addition, a significant amount of instrumentation was provided to generate a comprehensive data set for mapping temperatures at full scale. The results of the RBS production tests were detailed in HGN-130. A 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 RBS provided an excellent representation of the environmental conditions that would exist during a conservatively developed postulated hydrogen generation event which meets the intent of 10 CFR 50.44.

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 RBS Equipment Survivability List adheres closely to the generic selection criteria, with only minor differences (e.g. drywell and containment vacuum breakers were not used at RBS). 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 RBS Equipment Survivability Analysis Report describes the evaluations in detail.

RBS equipment locations have been evaluated to ascertain the local thermal environments. Equipment located in limiting thermal environments, as determined from 1/4-scale data, was evaluated using the HEATING-6 code. Massive equipment such as motor-operated valve components exhibited calculated peak critical component temperatures which were considerably less than the equipment qualification temperature. Less massive equipment such as pressure transmitters exhibited higher peak calculated temperatures but still less than the qualification temperatures. A few small cables had peak calculated temperatures which exceeded the qualification temperature. The results of various industry cable tests were examined in this context. These tests indicated the cables could survive high temperatures for short durations. Based on the information available, it was judged that short term excursions above the qualification temperature (i.e., 10 to 15 minutes) would not be expected to cause cable failures. Based on the extensive program of testing by the HCOG and on the plant-specific results, it is concluded that all essential equipment for hydrogen control in the RBS containment and drywell would survive the postulated hydrogen generation event. The analysis thus indicated that no plant modifications are necessary to ensure equipment survivability.

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

The RBS plant-specific implementation of the HCOG Generic Combustible Gas Control Emergency Procedure Guideline (CGC EPG) is contained in the Hydrogen Control Section of EOP-2. Procedure EOP-2 has been developed in a consistent manner with the generic guidance while taking into account the plant-specific design features of RBS. The RBS Plant Specific Technical Guidelines (PSTGs) discuss the plant design features and document any differences which occur between EOP-2 and the CGC EPG as a result. For example, since RBS uses unit coolers instead of containment sprays, all steps regarding sprays have been eliminated, simplifying EOP-2.

In accordance with the CGC EPG, the RBS hydrogen igniters are actuated if reactor water level drops below the Top of Active Fuel or cannot be determined and both the primary containment and drywell hydrogen concentrations are below the Hydrogen Deflagration Overpressure Limit (HDOL). The igniters are also actuated if primary containment or drywell hydrogen concentration exceeds the minimum detectable concentration (~0.7% at RBS) 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.

III. Conclusions Regarding Conformance to 10 CFR 50.44

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

Section (iv) (A) of 10 CFR 50.44 requires that: "Each licensee...with a Mark III type of containment...shall provide its nuclear power reactor with a hydrogen control system justified by suitable program of experiment and analysis." Relative to conformance at River Bend Station, Entergy Operations, Inc. concludes the following:

1) The Hydrogen Ignition System (HIS) installed at RBS meets the requirements of 10 CFR 50.44. Plant-specific testing in the 1/4-Scale Test Facility has demonstrated the viability and effectiveness of the HIS itself and of the concepts of deliberate ignition and controlled combustion.

2) Hydrogen generation events for 10 CFR 50.44 evaluations have been adequately addressed during the HCOG generic hydrogen control program and that attendant RBS plant-specific efforts. ATWS and SBO scenarios have received considerable attention in this regard. The HCOG HGE scenario has resulted in a conservative hydrogen release history for hydrogen combustion testing and analysis. The HCOG scenario encompasses a recoverable TBU short-term station blackout sequence.

3) The ultimate capacity of the RBS containment is 53 psig. Based on the RBS 1/4-scale test results and peak pressures calculated in the HCOG generic CLASIX-3 analysis program, the RBS containment would maintain its structural integrity during a degraded core HGE. The RBS drywell structure is stronger than the containment and would also maintain structural integrity.

4) Based on the analyses reported in the RBS 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. No plant or equipment modifications are required to ensure that the essential systems function as required.

Overall, Entergy Operations, Inc. considers that River Bend Station conforms to the requirements of 10 CFR 50.44. 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.

In conclusion, the requirements of 10 CFR 50.44 and all requirements in the Generic SER have been addressed by the RBS hydrogen control final analysis. This analysis has provided, by reference or inclusion, an evaluation of the consequences of hydrogen released from a recoverable degraded core accident leading to 75% metal-water reaction, including the recovery period, using a postulated accident accepted by the NRC.