GULF STATES UTILITIES COMPANY

RIVER BEND STATION POST OFFICE BOX 220 ST FRANCISVILLE LOUISIANA 70775

AREA CODE 504 635-6094 346-8651

December 26, 1991
RBG- 36,165
File Nos. G9.5, G9.25.1.3

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

Gentlemen:

River Bend Station - Unit 1
Docket No. 50-458

Please find enclosed Supplement 1 to Licensee Event Report No. 91-017 for River Bend Station - Unit 1. This report is submitted pursuant to 10CFR50.73.

Sincerely,

FOR W.H. Odell
Manager - Oversight
River Bend Nuclear Group

LAE/PDG/GAB/DCH/JFM/JLB/kvm

cc: U.S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 400
Arlington, TX 76011

NRC Resident Inspector
P.O. Box 1051
St. Francisville, LA 70775

INPO Records Center
1100 Circle Parkway
Atlanta, GA 30339-3064

Mr. C.R. Oberg
Public Utility Commission of Texas
7800 Shoal Creek Blvd., Suite 400 North
Austin, TX 78757

NRC FORM 366 (6-89) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED OMB NO. 3150-0104
EXPIRES 4/30/92

ESTIMATED BURDEN PER RESPONSE TO COMPLY WITH THIS INFORMATION COLLECTION REQUEST: 50.0 HRS. FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE RECORDS AND REPORTS MANAGEMENT BRANCH (P-530), U.S. NUCLEAR REGULATORY COMMISSION, WASHINGTON, DC 20555, AND TO THE PAPERWORK REDUCTION PROJECT (3150-0104), OFFICE OF MANAGEMENT AND BUDGET, WASHINGTON, DC 20503.

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1): RIVER BEND STATION

DOCKET NUMBER (2): 0 5 0 0 0

PAGE (3): 1 OF 1 6

TITLE (4): DESIGN DISCREPANCY IN THE WIRING DIAGRAM FOR TWO HYDROGEN MIXING SYSTEM VALVES

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAMES	DOCKET NUMBER(S)
0 9	1 8	9 1	9 1	0 1 7	0 1					0 5 0 0 0
										0 5 0 0 0

OPERATING MODE (9): 1

POWER LEVEL (10): 1 0 0

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more of the following) (11)

20.402(b)	20.405(c)	50.73(a)(2)(iv)	73.71(b)
20.405(a)(1)(i)	50.36(c)(1)	50.73(a)(2)(v)	73.71(c)
20.405(a)(1)(ii)	50.36(c)(2)	50.73(a)(2)(vii)	OTHER (Specify in Abstract below and in Text, NRC Form 366A)
20.405(a)(1)(iii)	X 50.73(a)(2)(i)	50.73(a)(2)(viii)(A)	
20.405(a)(1)(iv)	50.73(a)(2)(ii)	50.73(a)(2)(viii)(B)	
20.405(a)(1)(v)	50.73(a)(2)(iii)	50.73(a)(2)(x)	

LICENSEE CONTACT FOR THIS LER (12)

NAME: L. A. England, Director - Nuclear Licensing

TELEPHONE NUMBER: AREA CODE 5 0 4 3 8 1 - 4 1 4 5

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	REPORTABLE TO NPRDS
B		2 0	L 2 0 0	Y					
B	BB	2 0	L 2 0 0	Y					

SUPPLEMENTAL REPORT EXPECTED (14)

YES (If yes, complete EXPECTED SUBMISSION DATE) — X NO

EXPECTED SUBMISSION DATE (15): MONTH DAY YEAR

ABSTRACT (Limit to 1400 spaces, i.e., approximately fifteen single-space typewritten lines) (16)

At 1500 hours on September 18, 1991, with reactor in Operational Condition 1 (Power Operation), while performing a review of Station Operating Procedure (SOP)-0040 "Hydrogen Mixing, Purge, Recombiners and Ignitors," a discrepancy in the wiring diagram of the hydrogen mixing system (*BB*) was discovered. The wiring diagram of the circuit showed that the outlet valves (*20*) 1CPM*MOV1A(B) and 3A(B) could not be manually bypassed following an isolation in response to a LOCA signal. Although the discrepancy was discovered on September 18, 1991, it is believed that the condition existed since the last modification of the circuit on July 12, 1985. Thus, the manual bypass has been inoperable since 07/12/85; therefore, this report is submitted pursuant to 10CFR50.73(a)(2)(i)(B) as operation prohibited by the Technical Specifications.

Based on a license-basis analysis considering regulatory requirements, a mechanistic analysis of hydrogen generation, a human reliability analysis, and a probablistic risk assessment of the hydrogen generation scenario, GSU has concluded the safety significance of this event is low.

REPORTED CONDITION

At 1500 hours on September 18, 1991, with reactor in Operational Condition 1 (Power Operation), while performing a review of Station Operating Procedure (SOP)-0040 "Hydrogen Mixing, Purge, Recombiners and Ignitors," a discrepancy in the wiring diagram of the hydrogen mixing system (*BB*) was discovered. The wiring diagram of the circuit showed that the outlet valves (*20*) 1CPM*MOV1A(B) and 3A(B) could not be manually bypassed following an isolation in response to a LOCA signal. Although the discrepancy was discovered on September 18, 1991, it is believed that the condition existed since the last modification of the circuit on July 12, 1985. Thus, the manual bypass has been inoperable since 07/12/85; therefore, this report is submitted pursuant to 10CFR50.73(a)(2)(i)(B) as operation prohibited by the Technical Specifications.

INVESTIGATION

The hydrogen mixing system (*BB*) consists of two 100 percent capacity trains, A and B. There are four motor operated valves (*20*) in each train, two inlet valves and two outlet valves. The hydrogen mixing system inlet and outlet valves (*20*) close on a LOCA signal. If the hydrogen volume reaches a preset value, the operator is directed to override the LOCA signal, open the valves, and start the system. During the review of SOP-0040 by GSU, it was discovered that the LOCA signal to outlet valves could not be bypassed to permit the valves to be opened and remain open.

Upon discovery of the problem, all associated wiring, elementary, and logic diagrams, various manuals, and records of previous modifications were reviewed. A point-to-point wiring check was also performed to confirm the actual installation. The as-built condition was found to be in conformance with the (erroneous) elementary diagram.

In response to NRC FSAR question 421.039, RBS agreed to provide a LOCA isolation signal to the hydrogen mixing system valves. As documented on the "Record of Change," this was accomplished in mid-January, 1984, on revision 6 to logic diagram (LSK) 27-24A. Within six weeks of this change (early March 1984), the LSK was again revised (revision 7). This revision provided for overriding the LOCA signal on both the inlet and outlet valves, but only the electrical elementary diagrams (ESKs) for the inlet valves were changed to implement this feature.

Other than human error as discussed herein, the reason for this mistake is unknown; however, the reason given in the "Record of Change" for the LSK revision was to override a <u>false</u> LOCA signal generated by a loss of offsite power (LOOP). Upon a LOOP, drywell cooling would be lost and the resultant heatup could cause drywell pressure to increase to the point where a false high drywell pressure LOCA signal (1.68 PSIG) would be reached. Such a false high drywell pressure signal could be eliminated by opening only the hydrogen mixing system inlet valves. This may have contributed to the error. However, it is clear that the changes to the LSK were not properly implemented in the applicable ESKs.

The original preoperational test for the hydrogen mixing system was developed from the ESK revisions that implemented the LOCA isolation signal and provided for testing the LOCA isolation function of the inlet and outlet valves. Prior to performing the test, the test engineer noticed that the control system description, which had been revised to reflect both the LOCA isolation and override signal changes to the LSKs, indicated that the LOCA signal could be overridden for the inlet valves by turning the open/close control switch for the 1CPM*MOV2A (B) valve to the open position. Since this feature had not been implemented, he initiated startup test exception 1-PT-254-TE-12. Stone & Webster (SWEC) Engineering and Design Coordination Report (E&DCR) C-60,772A was initiated to correct the circuit for the inlet valves.

SWEC revised the ESKs for the inlet valves to implement the LOCA override capability, but as previously stated, SWEC failed to revise the ESKs for the outlet valves. E&DCR C-60,772A provided for modifying the plant as shown on the revised ESKs for the inlet valve LOCA override feature, but did not provide this feature for the controls of the outlet valves. The LOCA override feature was installed on the inlet valves and was successfully tested under test exception 1-PT-254-TE-12.

In summary, the following inappropriate actions have been identified:

a. Four ESKs were impacted by the logic change to the LSK. Two ESKs were revised to agree with the LSK, but two ESKs were not.

b. Preoperational testing prior to initial start up did not test the outlet valve LOCA signal override because the design as reflected in the ESKs did not include this feature.

ROOT CAUSE

A root cause evaluation was performed using the root cause analysis techniques of barrier, task and change analysis. Events and causal factors charting was also used to graphically depict the results of the analysis. Review of design and licensing documentation as well as interviews were used as input to this analysis. The results of the root cause analysis is given below.

The electrical elementary diagrams (ESKs) in question were not updated to reflect the changes made in revision 7 of the logic diagram (LSK). In particular, the ESKs for the outlet motor operator valve (MOV) circuits were not changed to provide for overriding the LOCA signal in order to open the valves with a valid LOCA signal present. The reason for this discrepancy is not clear, but appears to have been a human error. The record of change for the LSK shows that the changes to the logic were made for relieving high drywell pressure. It is restated on the second record of change for revision 7 that the change in logic is for "overriding a false LOCA." The mindset at this time was system operation during a loss of offsite power (LOOP). This mindset may have contributed to the ambiguous wording of the control system description. It is possible that the person making the ESK changes used the control system description rather than the LSK itself and therefore made the error in the outlet MOV's circuit. The root cause evaluation also determined the following:

- o It was SWEC practice to change ESKs immediately following changes to LSKs. The lead engineer was responsible for this work. However, in this case the ESKs were not changed until 11 months following LSK change.

- o SWEC did not follow its work practices and procedures in changing affected ESKs to match the corresponding LSK. The LSK and ESK change review process also failed to detect this error.

- o The delay of 11 months between the revision of the LSK and the update of the ESK may have been a factor in the LSK/ESK mismatch. The personnel involved in the changes to the ESK may not have been familiar with the reasons for the LSK changes.

- o Preoperational testing did not test the post-LOCA override feature for the outlet valves so it did not detect the error. The preoperational test was based on the design as reflected in the ESKs. Had the ESK properly reflected the LSK design, there is a high level of confidence that the preoperational testing would have tested the LOCA override feature. This is supported by the re-testing that was performed to clear test exception 1-PT-254-TE-12 for the inlet valves.

In conclusion, it is apparent that if SWEC had followed procedures and work practices, and had implemented the design change properly; the system would have been correctly built and tested. The primary root cause is the failure to properly implement the design change to the outlet valve circuit.

A similar event was reported in LER 91-001. In this case, a discrepancy was identified between the ESKs and LSKs for the initiation signal of the main control room ventilation (HVC) charcoal filtration system. The initiation signal configuration was to actuate at reactor water level 1

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instead of level 2. This rendered the HVC charcoal filters unable to perform their design function to mitigate the effects of a main steam line break outside the containment. GSU's analysis of plant operating history indicates that this condition did not pose a significant hazard to control room personnel.

CORRECTIVE ACTION

When the error was discovered, in accordance with the requirement of the Technical Specifications Section 3.0.3, the hydrogen mixing system was declared inoperable and the plant entered a 6 hour shutdown limiting condition for operation (LCO) action statement at 2125 on 09/18/91.

The short-term corrective action was to revise SOP-0040 to provide operators with a method to bypass the LOCA signal to the outlet valves. This would permit opening of the valves post-LOCA. This method would only be used when required by Emergency Operating Procedure (EOP)-002, "Primary Containment Control." Following the incorporation of this method into the procedures, the LCO was cleared at 0120 hours on 09/19/91.

The long-term corrective action was to modify the wiring to permit the opening of the outlet valves post-LOCA. This was completed during the mid-cycle 4 outage which began in September, 1991. Modification Request (MR) 91-0101 implemented this change. Subsequent testing confirmed that the outlet valves now conform to the design requirements.

Plant modifications are no longer performed under the control of SWEC procedures, but are performed by Design Engineering personnel under procedure ENG-3-006. This procedure requires that all affected documents be revised simultaneously and design changes are verified to be consistent from one drawing type to another.

After the root cause had been determined, GSU immediately began a review of seven systems which were identified to have LOCA override features. The LSKs of these systems were reviewed against the corresponding ESKs to ensure proper design implementation of the LSK. In addition, in order to determine the scope of the problem, GSU performed a design consistency verification of a sample of LSKs versus ESKs. The sample consisted of Division I systems which shared the prominent characteristics of the hydrogen mixing system (i.e. systems infrequently operated or called into service under accident conditions). The results of the design consistency verification did not identify any LSK versus ESK mismatch that might have an operational impact. However, several minor inconsistencies were discovered. Even though only minor inconsistencies were found, a 100% design consistency verification of ESKs and LSKs for safety related systems will be conducted. These design consistency verifications will be completed by June 30, 1992. If errors which could affect system function are found in elementary drawings, GSU will also evaluate the preoperational tests for the system.

Periodic retesting of the hydrogen mixing system including valve manipulation and starting of the fans will be performed as part of the integrated ECCS test to ensure that the hydrogen mixing system will function with a LOCA signal present.

SAFETY ASSESSMENT

The impact on plant safety of the wiring problem on both trains of the hydrogen mixing system drywell exhaust motor-operated valves (*20*) (MOVs) was initially assessed from a licensing-basis perspective. To ensure a thorough safety assessment, additional analyses were completed to evaluate this situation using mechanistic and probabilistic methods.

LICENSE-BASIS ANALYSIS

Licensing-Basis Hydrogen Production
for a Loss-of-Coolant Accident (LOCA)

USAR Section 6.2.5.1 (Ref. 1) states:

"The combustible gas control system (*BB*) is designed in accordance with the following criteria:

1. Sizing of the combustible gas control subsystems (except the igniter system) is based on limiting the drywell and containment hydrogen concentrations after a LOCA to 4 volume percent, considering hydrogen generation and accumulation from active core cladding metal water reaction, radiolysis, and metal corrosion in accordance with the assumptions specified by Regulatory Guide 1.7, Rev. 2."

For the metal - water reaction, the Reg. Guide allows the amount of zirconium cladding assumed to react to be equal to the outer 0.00023-inch of the cladding thickness, calculated on a core-wide basis. The metal - water reaction is assumed to occur for the first two minutes of the LOCA (Ref. 2).

Based on this regulatory guidance, the hydrogen production at River Bend following a LOCA was calculated in Reference 3. Figure 1 is a plot of the resulting drywell hydrogen concentration (percent) versus time after the LOCA. For this calculation, hydrogen mixing (*BB*) was assumed to be inoperable.

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As stated in the USAR (Ref. 1), 4% drywell hydrogen is the design basis for hydrogen mixing. This level is reached at about 4.5 hours after the LOCA. Hydrogen mixing (*BB*) would be necessary at or before this time to meet the design basis.

Reg. Guide 1.7 discusses hydrogen burning between 4% and 6%, and states that "... a limit of 6 volume percent would not result in effects that would be adverse to containment systems." If 6% is considered limiting, then hydrogen mixing (*BB*) operation would be needed within about 17 hours of the LOCA.

Operator Actions to Initiate Hydrogen Mixing

If a LOCA were to occur, the operators in the main control room would respond to the event using the existing Emergency Operating Procedures (EOPs). These procedures incorporate Revision 4 of the BWR Owners Group (BWROG) Emergency Procedure Guidelines (EPGs), as well as the Hydrogen Control Owners Group (HCOG) EPGs.

In particular, operators would use EOP-2 (Ref. 4) to respond to high drywell hydrogen indications. The hydrogen control section of this procedure is entered when drywell or containment hydrogen concentrations exceed 0.5%, or reactor water level is below -162 inches or cannot be determined.

Per EOP-2 step 65, hydrogen mixing (*BB*) is initiated when drywell hydrogen exceeds 2% and reactor pressure is below 30 psig. From the LOCA calculation (Ref. 3), these conditions will exist at about 5 minutes into the event. Therefore, the conditions requiring the operators to attempt to initiate hydrogen mixing (*BB*) occur early in the LOCA.

Due to the number of other activities requiring immediate operator attention following a LOCA, it is reasonable to assume that no attempt to start hydrogen mixing (*BB*) will be made for some period of time. The River Bend SER (Ref. 5) states that "... operators are not required to take any action before 20 minutes following a LOCA to maintain the safety of the plant." Using this philosophy, it is assumed that operators will not perform step 65 of EOP-2 until 30 minutes into the LOCA. This would be the time of discovery of the failure of the LOCA override function for the drywell exhaust MOVs (*20*).

Recovery Actions

Using the assumptions and results from Reference 3, and the above assumption for operator action, a sequence of events for the LOCA can be constructed (see Table 1). From the table, it is clear that plant staff personnel would have a minimum of 4 hours to solve the hydrogen mixing MOV isolation problem described in this LER. An event this serious would result in the activation of the Emergency Response Organization, including the Technical Support Center (TSC). Using the engineering resources available in the TSC, it is reasonable to assume that hydrogen mixing (*BB*) would be restored to operability within this time.

Emergency Operating Procedure (EOP)-2 step 56, directs operators to operate all hydrogen igniters (*BB*) if containment hydrogen concentration is in the safe zone of the hydrogen deflagration overpressure limit (HDOL) curve and drywell hydrogen concentration is less than 9%. This direction would minimize hydrogen pocketing by locally burning hydrogen concentrations between 4% and 6%. Since this action would control localized hydrogen concentration, response time for the TSC staff to correct the hydrogen mixing problems would be increased.

Conclusions

From the licensing-basis analysis, the following conclusions were reached:

1) Based on Reg. Guide 1.7, drywell hydrogen will reach a level of concern between 4.5 hours and 17 hours after the LOCA assuming no mixing or igniter operation.

2) Within 5 minutes of the LOCA, operators will meet EOP-2 requirements for hydrogen mixing (*BB*) initiation.

3) Operators will discover that the hydrogen mixing drywell exhaust MOVs (*20*) do not operate properly within 30 minutes of the LOCA.

4) At least 4 hours will be available after discovery to troubleshoot and correct the MOV problem.

5) Corrective action time can be increased by operating hydrogen igniters (*BB*) as directed by EOP-2.

SUPPLEMENTAL ANALYSES

To ensure that hydrogen mixing system performance for conditions beyond the licensing basis is adequately addressed, several additional analyses were undertaken. These were:

1. Develop a mechanistic scenario for hydrogen generation

2. Perform a human reliability analysis (HRA) of operator actions, and

3. Perform a probabilistic risk assessment (PRA) of the hydrogen generation scenario

Mechanistic Analysis

Reg. Guide 1.7 discusses hydrogen generation for events with both operable and degraded ECCS. The license-basis assumes degraded ECCS to maximize hydrogen production. This assumption was verified using MAAP3.0B, Rev. 7.0. This thermal/hydraulic analysis computer code predicts that for a large break LOCA at River Bend, no hydrogen will be generated if the ECCS operates as designed.

Sensitivity cases were run using MAAP3.0B with various ECCS pumps out-of-service or degraded, in an effort to produce a hydrogen generation curve which approximates the curve in Figure 1. Table 2 provides a listing of the cooling pumps operable for each MAAP3.0B case and the resulting hydrogen generation. It required severe degradation of ECCS to produce hydrogen using MAAP3.0B. Also, the amount of hydrogen produced is significantly greater than the amount assumed for Reg Guide 1.7.

An exact match between Reg Guide 1.7 hydrogen generation and the mechanistic analysis was not possible. However, this analysis did indicate that the design basis accident (DBA) ECCS configuration (HPCS operable, LPCS operable and 1-train of LPCI operable) provides a conservative bounding case for degraded ECCS. The DBA ECCS configuration is provided in Reference 5.

Human Reliability Analysis (HRA)

A human reliability analysis was performed to identify the probability of failure to successfully start hydrogen mixing following a LOCA. The method used in the HRA considered the following:

1. the symptoms of the event,
2. the indicators, alarms, and annunciators available to the operators,
3. operator actions and procedural guidance available
4. operator decisions needed, consequences of failure, and opportunities to recover from operator errors;
5. the timing of decisions, and
6. the stress factors associated with the occurrence of a LOCA.

This information was used to develop the HRA event trees for failure to operate hydrogen mixing at 4.5 hours and at 17 hours after the LOCA.

Probabilities were assigned to the HRA fault trees using NUREG/CR-4772 (Ref. 7). Solving the fault trees gave probabilities for failure to restore hydrogen mixing of 1.25 E-2 at 4.5 hours after the LOCA and 5.6E-4 at 17 hours after the LOCA.

Probabilistic Risk Assessment (PRA)

The River Bend PRA model was developed to respond to NRC Generic Letter (GL)88-20 (Ref. 8). The PRA model was used to determine the probability of a LOCA with failure of the hydrogen mixing system.

From the above mechanistic analysis, it was determined that the design basis ECCS case represented a conservative degraded ECCS configuration for hydrogen generation. Table 3 provides conditional probabilities for various ECCS cases. The design basis ECCS case has a conditional probability of 5.81E-3. No higher probability events will result in hydrogen generation.

From NUREG/CR-4550 (Ref. 9), the frequency for a large break LOCA is 1E-4 per year. Therefore, the highest frequency for a LOCA with hydrogen generation due to degraded ECCS is:

1E-4 per year * 5.81 E-3 = 5.81 E-7 per year

The frequency that hydrogen mixing will not be restored within 4.5 following such an event is:

5.81 E-7 per year * 1.25 E-2 = 7.3 E-9 per year

The frequency that the system will not be restored in 17 hours is:

5.81 E-7 per year * 5.6 E-4 = 3.3 E-10 per year

CONCLUSIONS

From these mechanistic and probabilistic analyses, the following conclusions were reached:

1. The generation of hydrogen following a LOCA required ECCS degradation beyond design basis assumptions. Therefore, use of design basis ECCS configuration as the hydrogen generation case is conservative.

2. HRA techniques demonstrate a high probability for success (98.75%) in restoring hydrogen mixing before drywell hydrogen concentrations exceed 4% (4.5 hours after LOCA).

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3. The overall frequency of a LOCA with hydrogen generation and failure to restore hydrogen mixing before drywell hydrogen exceeds 4%, is extremely low.

SAFETY SIGNIFICANCE

The license-basis evaluation above demonstrates that although the hydrogen mixing system would not have performed its intended function following a LOCA, adequate time existed for discovery and corrective action to restore the system to operation. Therefore, based on this evaluation the safety significance of this problem is low.

The supplemental analyses also demonstrates that the safety significance of this condition is low. The PRA result for LOCA with hydrogen generation and failure to restore hydrogen mixing within 4.5 hours is 7.3 E-9 per year. This frequency is a factor of 730 lower than the NRC safety goal for large releases of 1.0 E-6 per year. The NRC safety goal assumes containment failure following a core damage event. The above LOCA scenario does not necessarily lead to core damage or containment failure. Both the frequency and severity of the analyzed event are less than the event postulated for the NRC Safety Goal. Therefore, GSU has concluded that the safety significance of inoperable hydrogen mixing valves is low.

References

1. RBS USAR Section 6.2.5.1, "Combustible Gas Control in Containment - Design Bases"

2. USNRC Regulatory Guide 1.7, Rev. 2, "Control of Combustible Gas Concentrations in Containment Following a Loss-of-Coolant Accident"

3. GSU Calculation No. G13.18.14.1*06-0, "Evaluation of Failure of the Hydrogen Mixing System to Operate"

4. EOP-2, Rev. 8, "Containment Control"

5. RBS SER, NUREG-0989, Section 6.3.3.3, "Emergency Core Cooling System - Functional Design"

6. USNRC Generic Letter (GL) 88-20, "Individual Plant Examination for Severe Accident Vulnerabilities"

7. USNRC NUREG/CR-4772, "Accident Sequence Evaluation Program Human Reliability Analysis Procedure"

8. USNRC Generic Letter (GL) 88-20, "Individual Plan Examinati[illegible]or Severe Accident Vulnerabilities"

9. USNRC NUREG/CR-4550, "Analysis of Core Damage Frequency: Internal Events Methodology"

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"FIGURE 1"

Concentration, percent

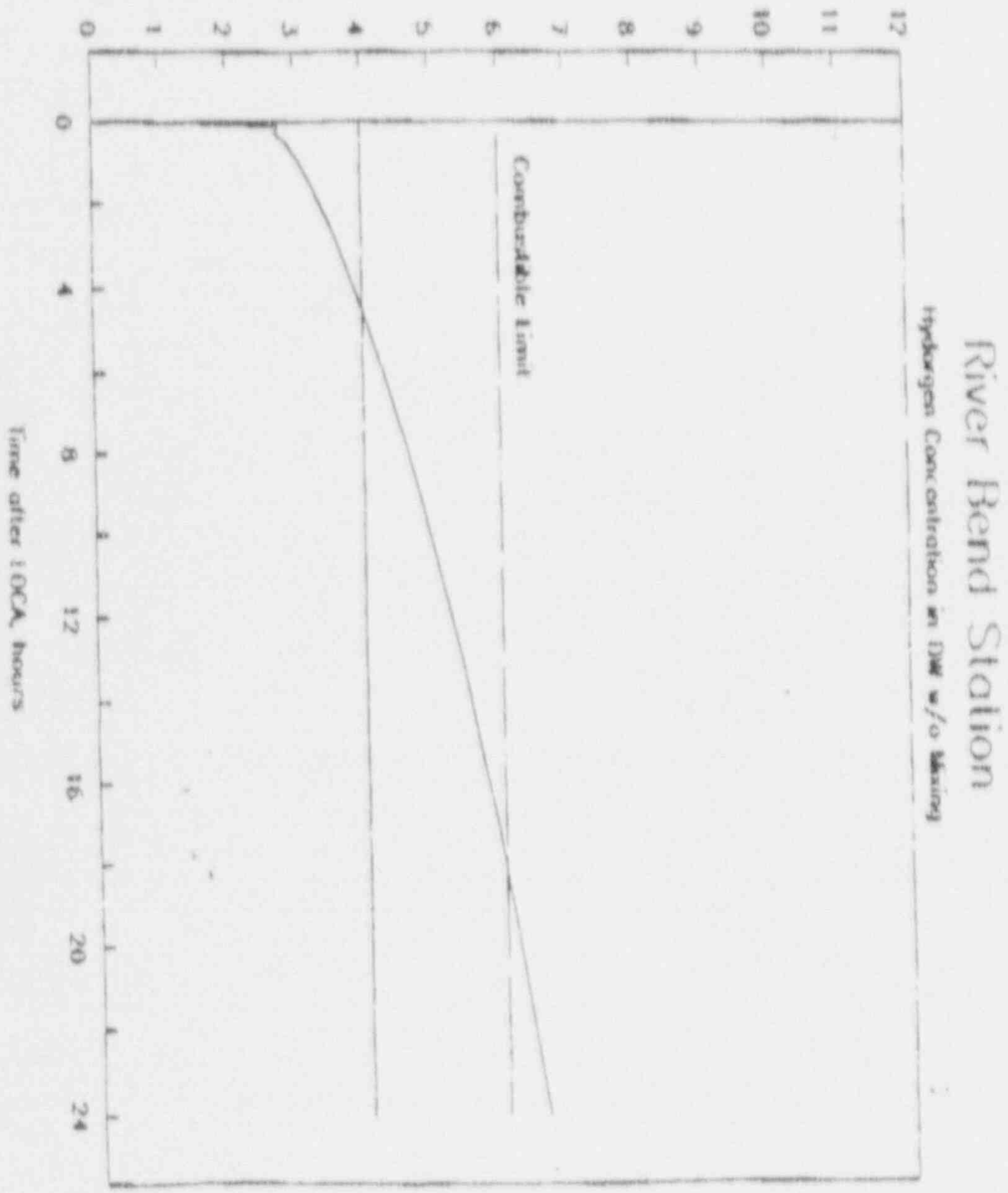

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Table 1
Post-LOCA Hydrogen Mixing
Sequence of Events

Time (minutes)	Event
0	LOCA
1	EOP-2 Entry Condition (> 0.5% H_2)
2	E d of metal-water reaction (Radiolytic uecomposition and corrcsion continue)
5	Drywell hydrogen > 2% and Reactor pressure < 30 psig
30	Operator unsuccessfully attempts to start hydrogen mixing
270 (4.5 hours)	Drywell hydrogen > 4% (possible ignition of pockets of hydrogen - No explosions)
1020 (17 hours)	Drywell hydrogen > 6% (possible global combustion - No explosions)

TABLE 2

Cooling Mechanism	Mass of Hydrogen Generated from metal water reaction (lbs)*
Design Basis:	
HPCS + LPCS + LPCI (1)	0
Beyond Design Basis:	
LPCS + LPCI (1)	0
LPCS + LPCI (2)	0
LPCS (50%) + LPCI (1)	246
LPCS	273
LPCI (2)	650
CRD + LPCI (3)	654
HPCS	660

* Reg Guide 1.7 hydrogen due to MWR = 20.8 lbs

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TABLE 3

ECCS Combinations	Conditional Probability
1 HPCS Pump, 2 LPCI Pumps, and 1 LPCS Pump Operating	1.09E-01
3 LPCI Pumps and 1 LPCS Pump Operating	5.29E-02
1 HPCS Pump and 3 LPCI Pumps Operating	4.90E-02
1 HPCS Pump and 2 LPCI Pumps Operating	6.06E-03
2 LPCI Pumps and 1 LPCS Pump Operating	5.93E-03
1 HPCS Pump, 1 LPCI Pump and 1 LPCS Pump Operating *	5.81E-03
3 LPCI Pumps Operating	2.69E-03
1 HPCS Pump and 1 LPCS Pump Operating	1.12E-03
1 HPCS Pump Operating	5.79E-04
2 LPCI Pumps Operating	3.19E-04
1 LPCI Pump and 1 LPCS Pump Operating	2.97E-04
1 HPCS Pump and 1 LPCI Pump Operating	2.75E-04
1 LPCS Pump Operating	4.97E-05
1 LPCI Pump Operating	4.53E-06

* ECCS DBA Configuration