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August 7, 1985
RBG-21819
File Code G9.5

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

Dear Mr. Denton:

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

The NRC request for additional information dated July 23, 1985, asked that Gulf States Utilities (GSU) provide additional information on the hydrogen control equipment survivability report previously submitted (RBG-21,454 dated July 1, 1985). The responses to the requests for additional information are given in Attachment 1. Responses to discussion questions arising during a meeting between the Staff and GSU on July 12, 1985, are given in Attachment 2. Also, in Attachment 2 are responses to Staff questions resulting from a meeting with the Staff on July 24, 1985 (as documented in the NRC meeting summary dated July 31, 1985).

Sincerely,

J. E. Booker

J. E. Booker
Manager-Engineering,
Nuclear Fuels & Licensing
River Bend Nuclear Group

JEB/DMR/EJZ/MAM/kt

Attachments

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PDR ADOCK 05000458
A PDR

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Attachment 1

RESPONSES TO NRC'S

REQUESTS FOR ADDITIONAL INFORMATION

OF JULY 23, 1985

1. In your submittal, you state that a piece of equipment will survive if the maximum external surface temperature or the maximum internal temperature at the most limiting component reached during a hydrogen burn, is below the qualification temperature for this piece of equipment. During the qualification tests, the actual temperatures reached by the components of the tested equipment were not measured. Hence, you should demonstrate that the temperatures reached by the most limiting internal component 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:

As stated in the "River Bend Station Preliminary Equipment Survivability Report" submitted on July 1, 1985, the survivability of essential equipment is ensured if the surface temperature of the equipment remains below the qualification temperature. Only in the event that the outer surface temperature exceeds the equipment qualification temperature is it necessary to establish the temperature of the thermally limiting internal component. In our preliminary equipment survivability this additional step was only necessary to establish survivability of the Target Rock solenoid. The GSU analysis determined that the surface temperature of the solenoid when exposed to the hydrogen deflagration burn environment exceeded the qualification temperature (385°F) by 3°F. The corresponding temperature reached by the thermally sensitive component was 222°F. Since this was below the qualification temperature of the component the solenoid was judged to survive the hydrogen burns.

Validation of this approach by applying the equipment qualification temperature profiles to our equipment models has not been performed. This might be a useful procedure for the final equipment survivability analysis but was not considered necessary for a preliminary analysis. Inspection of the equipment qualification temperature profile (attached) for the Target Rock solenoid lends credence to the current methodology. The test profile for the target Rock solenoid indicates that the test temperature was in excess of 311°F for 8 hours. This extended soak time assures that the sensitive component can survive the predicted temperature of 212°F.

2. Justify the use of 12 ft/sec velocity in calculating convection of heat to the modeled equipment.

Response:

In the preliminary equipment survivability analysis, the forced convection velocity was assumed to be twice the quiescent flame speed. The total burning velocity used for equipment survivability is not related to the flame speed and should be based on expected conditions

during hydrogen deflagrations. Since the total burning velocity is less than the flame speed, use of a forced convection velocity of 12 ft/sec may be excessively conservative. Further review of the River Bend CLASIX-3 results and consideration of the River Bend containment geometry and equipment indicates that natural convection correlations may be more appropriate for characterization of the wetwell thermal environment.

During hydrogen burning, the turbulent velocity is expected to be small since there is no spray induced turbulence at River Bend. Also, since the containment unit coolers take suction from and exhaust into the intermediate volume, the wetwell turbulent velocity induced by the containment unit coolers is negligible. In addition, the wetwell pressures and deflagration pressure rise times predicted by CLASIX-3 indicate that the flame induced turbulent velocity is also small. The laminar component of the total burning velocity is also small based on the relatively small pre-burn hydrogen concentration and the steam concentrations predicted by CLASIX-3. Because the turbulent and laminar velocity components are small, the total burning velocity should also be small. Therefore, natural convection correlations are more appropriate for characterization of the wetwell thermal environment. Thus, future evaluations of equipment survivability for deflagration type hydrogen burning will apply natural convection boundary conditions to the equipment models. The evaluation of equipment survivability for diffusion type hydrogen burning will utilize scaled velocity measurements from the 1/4 scale tests.

3. Describe the method of enhancement of conductive heat transfer in free air spaces in order to account for the natural convection existing in these spaces.

Response:

Natural convection within the free air space of the 0.13 HP Reliance Motor, the Target Rock Solenoid, and the Crosby Pilot valve was modeled using an enhanced air heat conduction model. Natural convection within the hydrogen igniter was modeled using both enhanced conduction and a natural convection model.

The method of using enhanced conduction to model internal convection is described in Reference 1 (pgs. 255 through 260). In summary, this method uses the Grashof number to estimate the flow regime (e.g., laminar or turbulent) which is expected to occur. The value of enhanced conductivity for air is then estimated using empirical correlations, which lump together the effects of convection and conduction by supplying an enhanced air conductivity to include both heat flow mechanisms. This method yielded effective conductivities from one to ten times the standard conductivity of air, depending on the separation distance between the heat transfer surfaces and the assumed temperature difference.

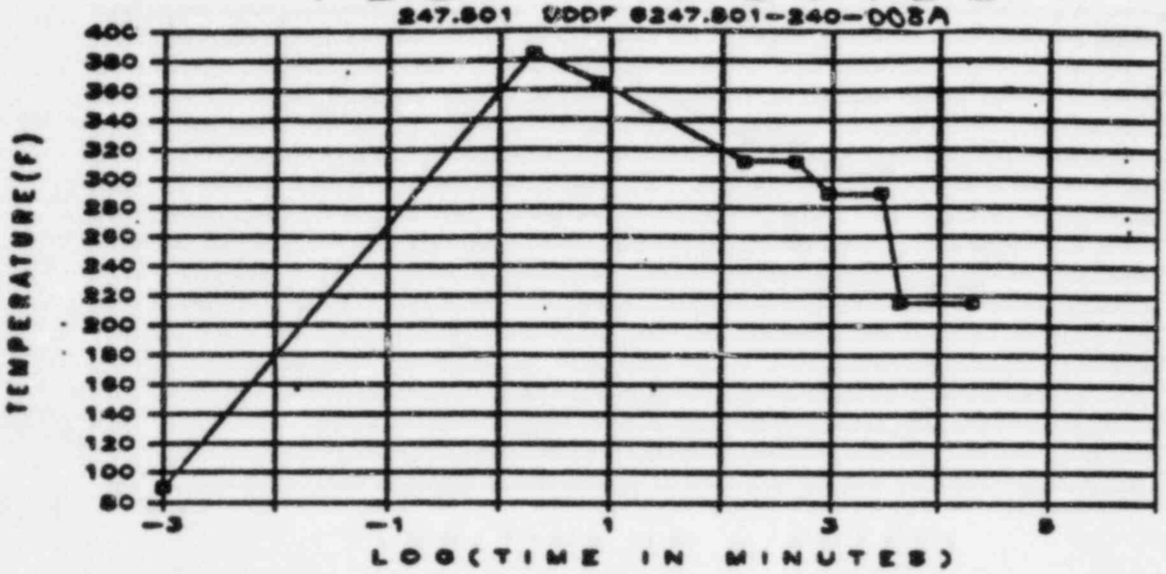
For the hydrogen igniter model, the enhanced conductivity approach was compared to results obtained using a natural convection heat transfer model. Both approaches resulted in similar results for transformer temperatures.

Both the enhanced conduction model and natural convection model require several assumptions to be made for implementation. Because the natural convection model requires fewer assumptions, future evaluations of the equipment will employ the natural convection model.

Reference 1. Heat Transfer, J.P. Holman, Fourth Edition, McGraw-Hill Book Company, New York, NY.

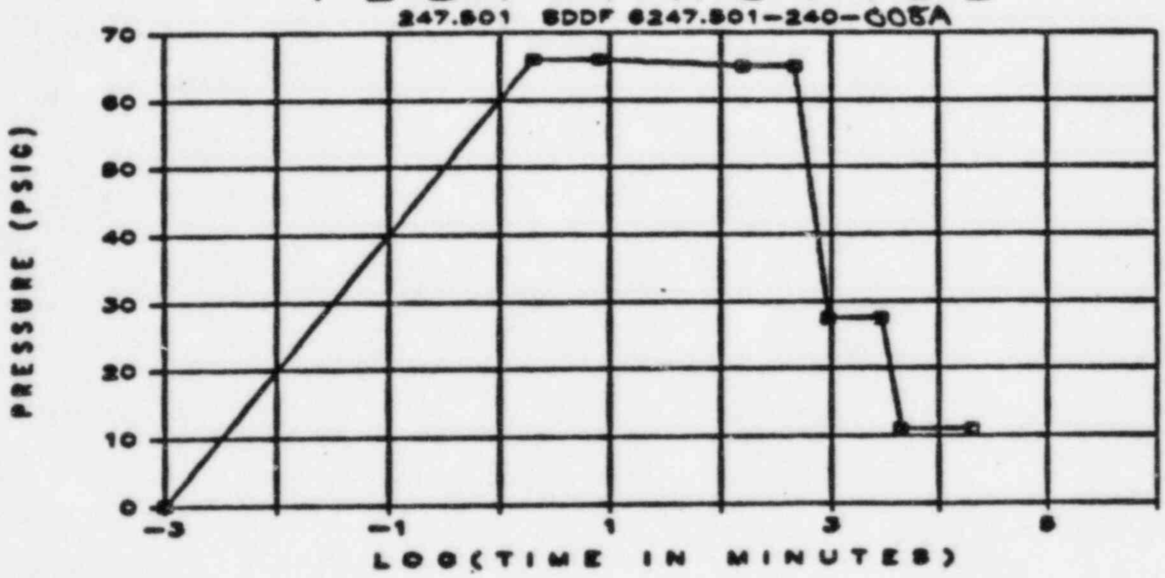
TEST PROFILE

247.801 UDDF 6247.801-240-008A



TEST PROFILE

247.801 SDDF 6247.801-240-008A



TEST PROFILE DATA FOR 247.501 SDDF 6247.501-240-002B

TIME	0	2min	8min	2hr40min	8hr	16hr	2days	3days	14days
LOG(MINUTES)	-3.00	0.[illegible]	0.90	2.20	2.68	2.98	3.46	3.64	4.30
TEMP(F)	90	385	365	312	312	290	290	215	215
PRES(PSIG)	0	66	66	65	65	27.5	27.5	11	11

Attachment 2

RESPONSES TO INFORMAL

STAFF QUESTIONS

NRC/GSU MEETING JULY 12, 1985

CSB Comments

1. Q. What actuates HMS fans?
   R. Manual initiation after opening inlet and outlet valves (see FSAR Section 6.2.5.2.1)

2. Q. Does EPG address shutoff of recombiners?
   R. Yes, the draft EPG recombiners are to be shut off at the maximum hydrogen concentration for recombiner operation (6%) or the lowest hydrogen concentration which can support a deflagration whichever is lower.

3. Q. Does EPG address startup of HMS?
   R. Operation of hydrogen mixing system is included in the draft EPG

4. Q. Does EPG consider burn environment?
   R. Temperature and pressure resulting from hydrogen combustion is considered in the development of the draft EPG.

5. Q. RPV pressure instruments are not listed in "essential equipment". Does EPG utilize RPV pressure instrumentation?
   R. There are no operator actions in the hydrogen control draft EPG which are based on RPV pressure.

6. Q. Does the hydrogen control EPG utilize containment pressure instrumentation?
   R. The draft EPG uses containment and drywell pressure instrumentation to direct operator actions. Pressure instrumentation is not included on our "essential equipment" list since this instrumentation is outside the containment.

7. Q. Why are only 4 containment isolation SOVs in the containment atmosphere monitoring system listed?
   R. The hydrogen monitoring system is required to provide the containment and drywell hydrogen concentration for a hydrogen generation event (HGE). Since the draft EPG is based on global deflagrations and therefore uniform hydrogen concentrations, it is only necessary to provide a single containment and drywell measurement. As a result, only four valves (2 per division) are required to survive a hydrogen burn environment (1CMS*33E&F and 1CMS*34A&B). However, if these valves are shown to survive the large volumetric burns predicted by CLASIX-3, the other HMS valves will also survive.

8. Q. In RBG-21218 dated June 7, 1985, the applicant states that the assumption of a volume fraction for ignition of 0.08 and a fraction of hydrogen burned equal to 0.85 is conservative compared to test results from NTS. It is not clear which is worse - 8/85 or 6/65.

R. "Equipment survivability analyses to date demonstrate that the dominant effect is radiant heat transfer during combustion. Since the 8/85 criterion results in much higher peak temperatures during combustion than 6/65, the 8/85 criterion will pose the greater threat to equipment survivability and is therefore conservative. GSU has used the 8/85 assumption to be consistent with previous applicants assumptions and staff direction. This assumption is also conservative with respect to containment pressures.

9. Q. GSU has used MAAP and BWR Core Heatup Code (BWRCHUC) for the DWB case and the flow split from the MAAP code. Why are the release rates for the DWB case different from the SORV case?

R. Since the BWRCHUC code is not a system code, flow splits cannot be calculated with this code. Mechanistic flow splits were therefore obtained from the MAAP code. Minor differences in the BWRCHUC and MAAP produce slight differences in releases. The impact of these variations are small compared to the effect of using scaled RBS release rates. The hydrogen and steam releases for the RBS analysis were based on the Grand Gulf core size and coolant mass. Therefore, these release rates could be reduced to represent the actual releases for RBS. The hydrogen releases could be reduced by the ratio of .78 to account for core size and the steam release rate by 0.75 to account for mass of coolant. Since they were not reduced, the values used in the GSU analysis are conservative. In addition, most of the thermal loading to equipment is due to the non-mechanistic constant release which is unaffected by the initial blowdown history.

10. Q. Is the drawdown used in the July 5 submittal different from the drawdown used in the June 7 submittal?

R. The July 5 submittal used a drawdown initiated at 2300 sec. into the transient. The June 7 submittal did not include drawdown. Not modeling the drawdown would have minimal impact on the analytical results. The only change would be to slightly increase the steady-state drywell pressure by approximately 1.0 psi.

11. Q. In the July 5 submittal, the quantity of water removed was 4526 cubic feet. What is the basis for this removal since the drywell cavity is approximately 20,000 cubic feet?

R. Reflood was assumed to only reflood the core and keep the core fully covered. This assumption is consistent with the non-mechanistic HCOG 75% Mwr release history which is based on an unpressurized core. The only impact on the analytical results from not assuming the drywell holdup volume is filled would be a small increase in drywell pressure of approximately 1 psi.

12. Q. The reflood initiation is delayed from the suppression pool drawdown by approximately 1100 seconds. Why?

R. One of the difficulties in attempting to achieve consistency between the BWRCHC code and MAAP is timing of events. The time of drawdown of the suppression pool has a negligible impact on containment response as discussed above.

13. Q. The steam and hydrogen are not superheated coming from the core. Seems to be unmechanistically quenched.

R. Since the non-mechanistic model is based on a completely covered core, the steam and hydrogen are at the saturation temperature for the prevailing RPV pressure.

14. Q. The analysis assumes that 85% of the blowdown is to the suppression pool. The steam and hydrogen to the break appears to be low compared to what is going to the pool.

R. The flow split is based on a mechanistic analysis for a realistic blowdown. Assuming a higher fraction went through the break would not change the results significantly since the additional input to the drywell would still enter the suppression pool through the LOCA vents.

<u>EQB Comments</u>

1. Q. Previous equipment survivability analysis used the wetwell thermal profiles. GSU has used the intermediate volume thermal profiles. Additional justification is required.

R. The CLASIX-3 analysis submitted by previous applicants employed a three compartment model (i.e., drywell, wetwell and containment). In this representation, the volume which GSU has termed the intermediate volume was included in their containment volume. Representation of the intermediate volume in the GSU analysis was required for three reasons. The first reason was the restricted flow area between the intermediate volume and the upper containment in River Bend that does not exist in other plants. The second reason is that the containment fan coolers are physically located in the intermediate volume. To represent this heat sink in either the wetwell or containment volume in a three volume model would not be consistent with good engineering practice. The third reason was to allow proper representation of the effect of bypass leakage. Bypass leakage from the drywell will only enter the intermediate volume. Not including an intermediate volume would mask the effect of hydrogen addition due to bypass leakage. Therefore, an intermediate volume was included in the CLASIX-3 model of River Bend. Exclusion of an intermediate volume by prior applicants required a choice between the thermal profiles in the

containment and the wetwell. Clearly, the selection of the containment profile would have been non-conservative so that they had no alternative but to select the wetwell thermal profile. Since the intermediate volume thermal profile is available, GSU selected this profile to evaluate equipment response. However, GSU has evaluated intermediate volume equipment response to wetwell deflagrations. The results of this analysis was provided in GSU letter RBG-21,771 dated August 5, 1985. This analysis showed that all equipment analyzed would survive a significant number of wetwell hydrogen deflagrations.

2. Q. No DWB thermal profile is provided.

   R. The GSU equipment survivability report used the DWB thermal profiles for equipment in the drywell. These profiles have been provided in RBG-21218 dated June 7, 1985. The results of this analysis are:

Unit	HGE	EQ Temperature	Predicted Temperature Casing	Predicted Temperature Sensitive Component
Hydrogen Igniter	DWB	340°F (470°F)*	320°F	305°F
Crosby (ADS) pilot valve				
O-ring	DWB	340°F**	336°F	336°F
coil	DWB	340°F**	336°F	312°F

*470°F predicted for sensitive component for 25 watts operating power and 340°F soak temperature

**LOCA qualification completed (RBG-21,331 dated June 19, 1985)

3. Q. Criteria 1 on page 4 of RBG-21423 does not say that subsequent failure does not affect the event.

   R. Revision 2 of the HCOG program Task II was revised to include a fifth criteria. This criteria is "components whose failure could preclude the ability of the above systems to fulfill their intended function". This criteria will be included in the final GSU equipment survivability report along with the inclusion of any equipment which satisfies this criteria.

4. Q. Exclusion criteria 3 on page 4 of the equipment survivability report does not meet "single failure" criterion.

   R. Exclusion of these isolation valves is appropriate since their postulated failure would not affect plant safety.

These isolation valves are open during normal operation, cooldown and post-LOCA and would fail in the as-is position. Therefore, failure of these valves would have no effect on plant operation or safety. In addition, there are motor-operated isolation valves outside containment for functional backup. An example of valves which would fall under this exclusion criteria are the RCIC isolation valves. This exclusion criteria is identical to the criteria used by previous applicants (see MP&L Letter AECM-83/0671).

5. Q. Exclusion criteria 4 on page 5 of the equipment survivability report excludes check valves. If there are any non-metallic components in these check valves, they cannot be excluded.
   R. Exclusion of these check valves is appropriate since they will perform their required function during and after a HGE. These valves are qualified for reactor system pressure and temperature and are subject to an environment which is virtually insensitive to the hydrogen burn thermal environment. In addition, they have no safety-related instrumentation or electrical function and are passive mechanical devices. Examples of check valves which are excluded by this criteria are the LPCS and HPCS check valves. This exception criteria is identical to the criteria used by previous applicants (see MP&L Letter AECM-83/0671).

6. Q. No information included for upper volumes.
   R. The only essential equipment located in the upper containment are the hydrogen recombiners and igniters. The recombiners were not evaluated in this report; therefore, no thermal profiles for the upper containment were provided in this report. However, the thermal profiles were submitted as part of our CLASIX-3 report (Figures 5 and 34 of the June 7, 1985 report and Figure 5 of the July 5, 1985 report). Inspection of these thermal profiles reveals that the maximum temperature (excluding the forced burn) is approximately 220°F. A temperature of this magnitude is not a threat to survivability of the hydrogen recombiners particularly since the draft hydrogen control EPG will require isolation of the recombiners before 6 v/o hydrogen is reached. (Igniters were evaluated against the wetwell thermal environment profile.)

7. Q. How is heat removal considered?
   R. Heat removal from equipment is by both radiation and conduction. The exposed equipment surfaces are allowed to radiate to heat sink surfaces with surface temperatures calculated by the CLASIX-3 computer code. In addition, heat is conducted from the equipment into heat sinks where

appropriate. Appropriate values of thermal contact resistance are employed so as not to overestimate the temperature reduction due to conduction. Reradiation from equipment is considered to be uniform but conduction only involves the surfaces which are in physical contact.

8. Q. Table 5.0-1 only covers some components. What about other components listed in the analysis?

   R. Representative examples of essential equipment were included in the equipment survivability analysis to demonstrate interim compliance with the final hydrogen control rule. The equipment included in our preliminary analysis is commensurate with the equipment selected by other applicants for their preliminary analysis. All essential equipment will be included in the final equipment survivability analysis as necessary.

9. Q. What is meant by significant exceedance of valve design pressure?

   R. The design pressure for the RBS containment is 15 psig and all internal components are design to withstand this design pressure. In addition, the working pressure associated with the valves is much greater than the containment design pressure. Since the CLASIX-3 analysis predicts pressures well below the design pressure, the survivability of these valves is assured.

10. Q. Hydrogen Mixing System fan and electrical motor exclusion must be considered.

    R. The operation of the Hydrogen Mixing System has been considered. Since these fans will not be operated with a delta pressure across them, they will be unaffected by pressure.

11. Q. The pressures given in Table 1 considered DWB pressures, but not forced burn pressures.

    R. As stated in our CLASIX-3 submittals and in the report on pressure effects on equipment, the forced burn is artificial in that the burn is forced to occur regardless of the hydrogen concentration. However, this has been addressed in GSU's August 5, 1985, submittal (Attachment III of RBG-21,771). All equipment listed therein, with the exception of containment unit coolers and hydrogen mixing system fans, is qualified for pressures greater than or equal to 35 psig. The unit coolers and hydrogen mixing system fans, although not qualified for 35 psig, have no components that are susceptible to high pressures.

12. Q. Shortly after the release period, pressure rises from 12 to 35 psi. Why was the 35 psi pressure spike ignored?

R. The 35 psi pressure spike is due to a forced burn and as explained above is not considered applicable to this evaluation. However, as explained above and in Attachment III of RBG-21,771 dated August 5, 1985, essential equipment will survive this pressure spike.

13. Q. Provide listing of qualified pressures similar to temperature survivability analysis.

R. Since the pressures predicted by the CLASIX-3 analysis are below the design pressure, further evaluation of pressure capability is not required. All equipment is qualified to operate at a pressure of 15 psig in the containment and 25 psig in the drywell. The qualified pressures which essential equipment can withstand is provided in Attachment III of RBG-21,771 dated August 5, 1985.

14. Q. Address the pressure differential across the drywell valves and fans.

R. The Hydrogen Mixing System is provided for long term removal of hydrogen from the drywell. The hydrogen mixing fans are interlocked with the inlet and outlet valves such that they cannot be operated until both the inlet and outlet valves have been opened. As a result, the drywell and containment pressures will have equilibrated before the mixing fans are operated.

<u>Additional Information
Requested July 24 1985</u>

1. Q. Resolve the difference in energy released to the drywell and suppression pool for the revised drywell break case.

R. The energy rate (Btu/sec) to the suppression pool starting at 3645 seconds was given as 39918 in Table 1 of the revised drywell break base case analysis (RBG-21454 dated July 5, 1985). The value used in the CLASIX-3 analysis should have been 35918 instead of 39918. The net effect of using a higher value in the CLASIX-3 analysis was to add more heat to the suppression pool which, in turn, resulted in a 8.2^{o}F increase in the suppression pool temperature.

2. Q. What is the effect of not including superheat in the DWB base case?

R. The mechanism proposed by the NRC to produce superheated steam during the constant (0.1 lbm/sec) hydrogen release is to allow a periodic reflood. This cyclical reflood implies that the degree of superheat is not constant with time. Since the pressure would increase in conjunction with the production of superheated steam, most of the superheated steam release would be through the ADS valves. Therefore, the impact on the drywell thermal environment would be

minimal. In addition, a cyclical reflood during this portion of the transient is unrealistic based on guidance provided to the operators or expected plant conditions.

3. Q. GSU should specify which scenarios would be considered in their final analysis.

   R. The final equipment survivability report will consider the limiting thermal environment applicable to the equipment analyzed. The hydrogen release scenarios to be considered will be the stuck open relief valve (SORV) and the drywell break (DWB) cases.