Attachment 1

EQUIPMENT SURVIVABILITY ENHANCEMENT

August, 1985

Gulf States Utilities
River Bend Station - Unit 1

Survivability Enhancement Report

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1.0 Introduction

1.1 Purpose

The purpose of this report is to describe and provide preliminary evaluations of the effectiveness of various techniques to enhance the survivability of essential equipment. Enhancements considered include the application of external insulation, the use of thermal radiation shields and the physical relocation of equipment or sensitive components.

Survivability enhancements are being considered in order to demonstrate that essential equipment located in the intermediate volume can survive exposure to a significant number of serial burns predicted to occur in the RBS wetwell by the CLASIX-3 analysis previously submitted (Ref. 1). It is recognized that the thermal environment predicted for the wetwell is more severe than what would be expected to occur in the intermediate volume. If burning were to occur in the intermediate volume, the burns would be less severe, fewer in number and less frequent that the wetwell burns predicted by CLASIX-3. Evaluating the survivability of equipment located in the intermediate volume using the wetwell thermal profiles is very conservative. Therefore, if the equipment can be shown to survive a significant number of these serial wetwell burns, it can be reasonably assumed to survive the degraded core accident.

Equipment located in the wetwell volume, hydrogen igniters and their power cables, must be shown to survive the entire wetwell thermal environment. The previously submitted equipment survivability report (Ref. 2) did not demonstrate survivability of the hydrogen igniters. Various physical modifications which would enhance the hydrogen igniter survivability are evaluated here.

1.2 Criteria

The goal of this report is to evaluate the effectiveness of various survivability enhancement schemes in order to determine the most appropriate methods of ensuring equipment survivability.

A series of criteria have been developed in order to evaluate various options. Acceptable enhancement schemes must meet the following:

1. There should be minimal effect on existing equipment qualification.

2. The enhancement must be physically feasible and not interfere with normal operation and maintenance.

3. All physical modifications, if necessary, must be completed before startup following the first refueling outage.

4. Technically acceptable options should be compared on a cost basis.

2.0 Rosemount Transmitters

2.1 Local Installation Details

Local installation details have been examined for the Rosemount RPV level transmitters. The transmitters are mounted in two horizontal rows on open racks. The racks are mounted on 1 1/4" thick solid steel pool swell shields welded directly to the HCU floor support steel (el. 114'0"). The pool swell shields provide direct thermal radiation shielding from the wetwell volume. The transmitters are mounted such that the sensing module is toward the rear of the panel and the electronic housing is toward the front but within the confines of the open racks. The distance of the various racks from other equipment and walls varies and, therefore, no credit is taken for local shielding by equipment and walls.

2.2 Insulation

Consideration has been given to the addition of insulation on individual Rosemount transmitters. An insulation system consisting of a one inch thick layer of SILTEMP #CH188 insulation fitted over the entire electronic housing, surrounded by a sixteenth inch thickness of stainless steel, has been analyzed. The results indicate that with this insulation system the Rosemount transmitters are capable of withstanding 23 serial wetwell burns. The use of a second insulation system consisting of a layer of KAOWOOL insulation between two layers of SILTEMP is being considered. The heat conduction properties of this system indicate that this system would be more effective in protecting the equipment.

Evaluation of this insulation scheme indicates that there may be some impact upon the existing qualification of the units. Since these transmitters are supplied by GE, the effect on the seismic and IE qualifications would require GE review and approval. However, at this time the effects appear to be negligible, as the proposed insulation is lightweight and the transmitters generate very little heat with temperature inside the electronics housing typically only 5° - $10^{\circ}F$ above ambient. Conceptual design indicates that the concept of insulating individual transmitters is feasible and could be implemented in an acceptable timeframe and at a reasonable cost. In addition, the insulating materials are readily available at the site and can be fabricated into easily removable sections to facilitate periodic transmitter calibration.

2.3 Thermal Shields

Various concepts of providing thermal radiation shields have been considered. The simplest concept consists of the application of thin sheet metal shields enclosing all four sides of the instrument racks. These sheet metal shields would provide for a reduction of the incident thermal radiation by a factor of approximately two. However, the shields would be responsive to the temperature due to convective heat transfer and would lose their effectiveness as the shield temperature approaches the gas temperature.

A second concept of thermal shielding, using a thermally thick shield, consisting of a layer of two inch thick KAOWOOL insulation encapsulated in SILTEMP fabric has been considered. This shield would be mounted on the four sides of the instrument rack to protect all exposed sides of the Rosemount transmitters. Open areas would be provided above and below the shields to allow natural air circulation around the instruments.

An evaluation of this shielding scheme has shown that the instruments could survive at least 19 serial wetwell burns. The analysis of this shielding scheme was stopped at 13,250 seconds since this was sufficient to show the viability of this enhancement method. The temperature at this point was 325°F

which is well below the equipment qualification temperature. Therefore, functionally this scheme is effective. Leaving space for natural circulation around the transmitters would not affect their qualification for normal and LOCA service. The shield would be designed to be removable to allow for maintenance activities. No significant problems are foreseen with respect to the design, construction, installation and cost of this option. Therefore, preliminary analysis indicates that this thermally thick shield concept is an acceptable method to achieve survivability for the Rosemount transmitters.

2.4 Relocation

Relocation of the Rosemount transmitters would require extensive rerouting of cables and tubing. In addition to the expense and schedule impact which could be prohibitive, the transmitter function is very sensitive to location parameters such as elevation and instrument line length. Therefore, this option is to be unfeasible for the reactor level transmitters.

3.0 Wetwell Hydrogen Igniters

3.1 Local Installation Details

Two methods are utilized for mounting the igniters to the structures in the wetwell region. Six igniters are bolted to

the webs of the structural beams supporting the HCU floor. The remaining six wetwell igniters are bolted directly to the outside of the drywell wall.

The igniters attached to the beams are provided significant shielding by the beams and by a pool swell shield plate (5/8" x 29" x 13") welded to the bottom of the beam flange. Those mounted directly to the drywell wall have a pool swell shield located below them (within 2 feet of the igniter) which provides some thermal shielding. The thermal model used in this evaluation is of a typical igniter located on the drywell wall. The igniters located on the beams have not been evaluated in detail.

3.2 Insulation

Close wrap insulation of the hydrogen igniters would potentially invalidate the hydrogen igniter environmental qualification. This effect is primarily due to the large internal heat generation from the internal transformer. Therefore, no further consideration has been given to this option at this time.

3.3 Thermal Shields

A thermal shield concept has been evaluated for the hydrogen igniters. This concept consists of a thermal shield consisting of one inch thickness of KAOWOOL encapsulated in SILTEMP fabric insulation. A layer of stainless steel would be added to the outside surface for support. These thermal shields would be mounted vertically on both sides of the igniter, above the igniter, and beneath the igniter above the pool swell shield. The thermal shields would be placed as close as possible to the igniter and the top surface of the igniter. The thermal response analysis using this protection concept indicated that the thermal limiting component, the ignition transformer, would reach a temperature of 345^{o}F after 38 wetwell burns. Further refinement of the protection concept and a better estimation of the qualification temperature should demonstrate that this concept will provide a sufficient protection for the entire series of wetwell burns.

3.4 Relocation

Relocation or replacement of the wetwell igniter transformers (the critical component with respect to thermal survivability) has been considered. In this case, a series of low voltage (12 to 24 volt) transformers would be mounted above the HCU floor. Each transformer would supply power to several igniters.

Preliminary evaluation of this concept indicates that there would be some effect on existing equipment qualification, although physical modifications to the igniters would be limited. The availability of qualified transformers for this application is also uncertain. In order to implement this design, replacement transformers would be required to be placed within an enclosure which would protect the transformer from the harsh environment while allowing for cooling of the transformer. As an alternative, consideration is being given to the placement of transformers outside containment. Further evaluation, including cost and schedule impact is underway.

4.0 Wetwell Cables

4.1 Local Installation Details

The only cables located in the wetwell that are considered as essential equipment are those supplying power to the wetwell igniters. The igniter power cables are run in aluminum conduit and are in direct contact with walls and structural steel members. In the vicinity of the igniters flexible conduit is used and is typically not attached to walls. These cables are Oakonite cables, using ethylene propylene rubber (EPR) insulation surrounded by two layers, the conductor jacket and outer jacket, of hypalon.

4.2 Analysis Results

The cables that are located in the flexible conduit are completely exposed to the high temperature environment. In order to provide supplemental protection to this portion of the cables a wrap insulation has been considered. The insulation considered consists of four layers of SILTEMP CH188 fabric providing a total thickness of 0.216 inches. Analysis shows that the cable in flexible conduit remains below 250^{O}F, which is significantly below the qualification temperature of the cable and therefore survives the entire transient.

Analysis of the cable located within conduit mounted onto walls has not been completed. The intended analytical approach is to determine the thermal response of the cable and to then calculate the life of the insulation using a Arrhenius technique. As shown above, if this method fails to demonstrate survivability of the cable, application of thermal insulation could then be used to enhance survivability.

5.0 Conclusions

The evaluation of equipment survivability enhancements for the Rosemount transmitters indicated that relocation is not a feasible alternative. Of the remaining two options, insulation and shielding, both meet the acceptance criteria although some question

remains regarding the impact on environmental qualification for the insulation option. Since the shielding option has no impact on environmental qualification and meets all acceptance criteria this would be the most feasible survivability enhancement.

For the hydrogen igniters located in the wetwell volume, the option of using close wrap insulation is not feasible due to the potential impact on environmental qualification. Likewise, relocation may not be desirable due to environmental qualification concerns and the extensive redesign and rework required. Therefore, the most feasible option for providing survivability enhancements for the wetwell igniters would be thermal shielding.

The evaluation of survivability enhancements for cable located in the wetwell indicates that the addition of external insulation significantly improves the ability of this cable to survive a hydrogen generation event.

In summary, this evaluation has demonstrated that there are acceptable methods of enhancing the ability of equipment to survive a hydrogen generation event. For each of the components evaluated, a preferable method has been identified. If the results of the GSU final analysis and HCOG testing program indicate a need to enhance the survivability of equipment required to survive a hydrogen generation event this evaluation will be used to define the appropriate protection measures. Since the appropriate protection

measures, if required, must consider both deflagration and diffusion thermal environments, it is not prudent to provide equipment protection at this time.

REFERENCES

1. RBG-21,218 dated June 7, 1985, from Gulf States Utilities (J. E. Booker) to Nuclear Regulatory Commission (H. R. Denton).

2. RBG-21,423 dated July 1, 1985, from Gulf States Utilities (J. E. Booker) to Nuclear Regulatory Commission (H. R. Denton).

Attachment 2

RESPONSES TO NRC

STAFF QUESTIONS

GSU/NRC Meeting August 12, 1985

Questions and Comments from 8/12/85 GSU/NRC Meeting

1. Provide additional information on the equipment hatch and personnel air locks. Specifically, provide the type and number of seals.

   Response: The equipment hatch located at El. 103' 9", Azimuth 225^{o} and radius 60'0" is provided with double O-ring seals. The personnel air locks are located at elevation 117' 10" and elevation 175'0." Each airlock has an inner and outer door each of which is provided with a double inflatable seal. Each inflatable seal has its own air tank with makeup being provided by the Instrument Air System (IAS). In addition, the air supply to each seal is provided with a check valve such that loss of one seal does not effect the other seal. Therefore, if the performance of the innermost seal of the inner door is degraded, there will still be three seals to protect containment integrity.

2. The NRC staff suggests adding the Reactor Pressure Vessel pressure instrumentation to the list of equipment required to survive a hydrogen burn event. In addition, the applicant should consider adding the non-ADS safety relief valves and the remaining containment monitoring system valves to this list.

   Response: Gulf States Utilities agrees to add these to our list of equipment required to survive a hydrogen generation event. The specific equipment to be added to this list is given in Table 1.

This equipment will be incorporated into our final list of equipment to be presented in our final equipment survivability report.

3. Provide additional information to justify exclusion of check valves from the list of equipment required to survive a hydrogen generation event.

Response: Exclusion criteria number four of the equipment survivability report (RBG-21,423 dated July 1, 1985) stated that check valves which are qualified for reactor pressure and temperature and which have no safety-related instrumentation or electrical function are assumed to survive a hydrogen burn mechanically. The HPCS check valve (E22*AOVF005), the RHR check valves (E12*AOVF041A, B and C) and the LPCS check valve (E21*AOVF006) have been evaluated under our mechanical equipment qualification program. All of these valves are 10 inch Atwood & Morrill Co. testable check valves. The only non-metallic subcomponents associated with the check valve itself are the valve packing and gasket. Two types of packing are used for these valves; Grafoil 235 and non-asbestos J. Crane 1630FG. The maximum service temperature for these materials is 1000°F. The gasket material is Parker Style 911 (Grafoil & S/S) Spirotallic which has a maximum service temperature of 1000°F. Since all non-metallic subcomponents of these check valves have a high service temperature and are effectively shielded from a hydrogen

burn environment, their ability to survive a hydrogen burn is assured. In addition, the presence of water on at least one side of the check valve will further enhance the ability of these valves to survive a hydrogen generation event.

4. Provide the basis for the number of burns the Rosemont pressure transmitter, and other equipment listed in the August 5, 1985, submittal, can withstand.

Response: The evaluation of the number of wetwell burns the equipment located in the intermediate volume can withstand considered a small motor, a Target Rock solenoid, a Rosemont transmitter and power cable. The Okonite power cable was evaluated against the maximum continuous service temperature of 440°F for an exposure time of 2 hours. The cable was conservatively assumed to fail the first time that the EPR reached this temperature. As stated in the August 5, 1985, submittal, this approach is conservative since the cumulative exposure time at this temperature is much less than 2 hours. The Rosemont transmitter was evaluated against a temperature of 303°F. As illustrated in our August 7, 1985, submittal this is conservative since the transmitters have been qualified at temperatures in excess of 311°F for a minimum time of 8 hours. These values are based on a Rosemont Model 1152 transmitter. Since the pressure transmitters associated with RPV water level and pressure have been replaced by Rosemont Model 1154

transmitters, it is more appropriate to use the qualification temperatures for these transmitters. The Rosemont Model 1154 transmitters have a qualification temperature of 420°F and were tested at temperatures above 320°F for 8 hours. Therefore future evaluations of equipment survivability for these transmitters will use 320°F as the qualification temperature for the thermally limiting internal sub-component. The Target Rock solenoid was evaluated against a qualificaion temperature of 385°F. To establish a more realistic qualification temperature for the most thermally limiting component would require an evaluation of the thermal response using the actual equipment qualification thermal profile. If this evaluation is necessary to demonstrate equipment survivability, the results will be incorporated into the final equipment survivability report. The Reliance motors were evaluated against a qualification temperature of 340°F. Review of the qualification thermal profile indicates that the motors were tested at 346°F for three hours. Therefore, use of 340°F is conservative.

5. Provide additional justification on the ability of the containment unit cooler motor and hydrogen mixing system fan motor to withstand a static pressure of 35 psig.

Response: The peak pressure resulting from a forced, simultaneous wetwell, intermediate volume and upper containment burn was 35 psig. Since the hydrogen mixing system will not be operating at

this time, the only component of this system susceptible to a high static pressure would be the hydrogen mixing system fan motor. Although this motor has not been specifically tested to pressures above 15 psig, other motors of similar construction have been demonstrated to survive elevated pressures. The hydrogen mixing system fan motor is a totally enclosed fan cooled, 1.5 hp, NEMA class 4 motor (Westinghouse TEFC 145T). Review of the environmental qualification test data for a Reliance motor indicates that this motor has been qualified to a pressure of 105 psig. Based on this comparison, it can be concluded that even though the hydrogen mixing system fan motor has not been qualified to pressures above 15 psig the fact that similar motors have been qualified to high pressures indicates that this motor will survive pressures produced by hydrogen deflagrations. The containment unit cooler fan motor, like the hydrogen mixing system fan motor, is also of open construction. This motor is a 150 hp Westinghouse model 445TCZ motor. Since it is similar in construction to other motors which have been qualified to high static pressures we have reasonable assurance that this motor will survive the pressures produced by hydrogen deflagrations.

Table 1

Equipment Identification	Function	Equipment Description Make/ Manufacturer Vendor Model/ Catalog No.	EDC Zone Location	Elevation	Location Azimuth Degrees	Radius	Peak Accident EDC Temperature	Peak Accident Qualified Temperature
Containment CMS Containment Atmosphere Monitoring								
1CMS*SOV33A	Containment Atmosphere Sampling	Solenoid Valve, Target Rock TRCP 77KK-003	CT-G	190'9"	61.55	59'9"	165°	385°
1CMS*SOV33AA		TRCP 77KK-003	CT-G	128'4"	20.61	61'1'	165°	385°
1CMS*SOV33B		TRCP 77KK-003	CT-G	190'2"	298.75	58'7"	165°	385°
1CMS*SOV33BB		TRCP 77KK-003	CT-G	118'6"	338.47	58'11"	165°	385°
1CMS*SOV33D		TRCP 77KK-003	CT-G	190'9"	245	59'6"	165°	385°
1CMS*SOV33G		TRCP 77KK-003	CT-G	165'4"	300.35	166'4"	165°	385°
1CMS*SOV33H		TRCP 77KK-003	CT-G	182'3"	263.3[illegible]	48'11"	165°	385°
1CMS*SOV33J		TRCP 77KK-003	CT-G	181'4"	115.30	33'9"	165°	385°
1CMS*SOV33K		TRCP 77KK-003	CT-G	184'0"	53.56	29'2"	165°	385°
1CMS*SOV33S		TRCP 77KK-003	CT-G	157'3"	278.95	54'8"	165°	385°
1CMS*SOV33T		TRCP 77KK-003	CT-G	157'3"	250.79	54'5"	165°	385°
1CMS*SOV33U		TRCP 77KK-003	CT-G	190'9"	26.08	57'5"	165°	385°
1CMS*SOV33V		TRCP 77KK-003	CT-G	190'9"	335.83	57'0"	165°	385°
1CMS*SOV33W		TRCP 77KK-003	CT-G	145'6"	23.56	56'1"	165°	385°
1CMS*SOV33X		TRCP 77KK-003	CT-G	145'6"	332.58	58'7"	165°	385°
1CMS*SOV33Y		TRCP 77KK-003	CT-G	143'5"	145.00	39'10"	165°	385°
1CMS*SOV33Z		TRCP 77KK-003	CT-G	145'9"	223.20	39'9"	165°	385°

Equipment Identification	Function	Equipment Description Make/ Manufacturer Vendor Model/ Catalog No.	EDC Zone Location	Elevation	Location Azimuth Degrees	Radius	Peak Accident EDC Temperature	Peak Accident Qualified Temperature
Drywell Safety Relief Valves								
1B21*RVF41A	Depressurize Reactor Vessel	Crosby 8xRx10, Style HB-65-DF	DW-1	132'4"	50.91	19'0"	330	340°F
1B21*RVF41G		Style HB-65-DF	DW-1	132'5"	76.21	24'3"	330	340°F
1B21*RVF41L		Style HB-65-DF	DW-1	132'4"	63.07	25'5"	330	340°F
1B21*RVF47B		Style HB-65-DF	DW-1	132'5"	271.90	23'7"	330	340°F
1B21*RVF47D		Style HB-65-DF	DW-1	132'3"	316.34	19'7"	330	340°F
1B21*RVF47F		Style HB-65-DF	DW-1	132'4"	302.58	25'3"	330	340°F
1B21*RVF51B		Style HB-65-DF	DW-1	132'5"	283.79	24'3"	330	340°F
1B21*RVF51C		Style HB-65-DF	DW-1	132'5"	82.07	23'9"	330	340°F
1B21*RVF51D		Style HB-65-DF	DW-1	132'3"	325.99	19'11"	330	340°F

Equipment Identification	Function	Equipment Description Make/ Manufacturer Vendor Model/ Catalog No.	EDC Zone Location	Elevation	Location Azimuth Degrees	Radius	Peak Accident EDC Temperature	Peak Accident Qualified Temperature
Containment Reactor Instrumentation								
1B21*PTN62A	Measure RPV Pressure	Rosemont Pressure Transmitter Model 1154	CT-G	117'6"	46.54	111'8"	165^{o}F	420^{o}F
1B21*PTN62B		Rosemont Pressure Transmitter Model 1154	CT-G	117'6"	197.06	109'10"	165^{C}F	420^{o}F