GULF STATES UTILITIES COMPANY
POST OFFICE BOX 2951 • BEAUMONT, TEXAS 77704
AREA CODE 409 838-6631

August 5, 1985
RBG - 21771
File No. G9.5

Mr. Harold R. Denton
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

As requested by the NRC staff, Gulf States Utilities (GSU) is providing supplementary information and clarifications to assist in your evaluation of the adequacy of the Hydrogen Control System at the River Bend Station. This supplementary information consists of three attachments. Attachment 1 provides a supplement to the preliminary equipment survivability report previously submitted on July 1, 1985. Attachment 2 provides a sequence of events for the stuck-open relief valve and drywell break base cases. Attachment 3 provides a supplement to the report on hydrogen deflagration pressure effects on equipment submitted on July 5, 1985.

Sincerely,

J. E. Booker

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

EJZ/MAM/ks erg

B001
1/1

Attachment I

RIVER BEND STATION

PRELIMINARY EQUIPMENT SURVIVABILITY REPORT

SUPPLEMENT FOR DEFLAGRATION BURNING

IN THE INTERMEDIATE VOLUME

TABLE OF CONTENTS

1.0 INTRODUCTION/SUMMARY

In the previously submitted CLASIX-3 analysis of the pressure and temperature response of the River Bend Station following a hydrogen generation event (Reference 1), no hydrogen burns were predicted to occur in the containment intermediate volume (above the HCU floor) during the hydrogen release period. However, a single burn was forced to occur concurrently in the wetwell, intermediate volume, and upper containment volume in order to deplete the remaining hydrogen inventory after the hydrogen release was completed. The thermal profiles predicted by CLASIX-3 for the wetwell and intermediate volume were used to determine equipment response to deflagration burns. The thermal environment predicted for the intermediate volume was used to assess the survivability of equipment located in this volume.

The predicted intermediate volume thermal environment predicted by CLASIX-3 is consistent with the design of the hydrogen ignition system which is based on maximizing hydrogen burning at low concentration which will occur primarily below the HCU floor. However, it may be possible to postulate that a small number of burns will occur above the HCU floor. Therefore, the objective of this study is to determine the thermal response of various pieces of essential equipment located in the intermediate volume, assuming that it is exposed directly to the burn environment predicted for the wetwell region below the HCU floor.

This report considers the Target Rock solenoid and small Reliance motor previously analyzed (Reference 2) and shown to survive the intermediate volume thermal environment. In addition, two pieces of essential equipment not previously analyzed have been included. The additional models included are a Rosemount pressure transmitter and a typical power cable.

The HEATING6 thermal analysis code models of this equipment are described in Section 2.0. For each piece of equipment, the most thermally sensitive nonmetallic components and associated thermal limits were identified. The number of wetwell hydrogen burn spikes which each piece of equipment could sustain before sensitive component temperatures exceeded their limits was determined. The results of the study are summarized in Section 3.0.

2.0 MODEL DESCRIPTION

In this study, the temperature function applied to the outside of the equipment is the CLASIX-3 predicted wetwell temperature shown on Figure 1. As indicated on Figure 1, a series of burns occur in rapid succession between 3,000 and 3,500 sec after accident initiation. These burns are the direct result of the high hydrogen release rate of up to 5.125 lbm/sec used in the CLASIX-3 analysis. Hydrogen release rates of

this magnitude will not result in deflagration burning in the intermediate volume region. For this high hydrogen release rate, the hydrogen concentration in the wetwell volume will reach an ignitible concentration long before significant hydrogen accumulation occurs in the intermediate volume. This will result in a single deflagration in the wetwell volume followed by steady diffusion burning anchored at the suppression pool. All quarter scale test results to date have confirmed this sequence of events. Therefore, the series of burns corresponding to the period of high hydrogen release rate were not included in this evaluation. The thermal environment imposed on equipment in this study is the series of hydrogen burns beginning at 5,000 sec. This series results from the extended hydrogen release at the rate of 0.1 lbm/sec starting at 3,645 sec. It should be noted that the thermal environment being imposed on the equipment in the intermediate node is based upon the release of hydrogen into the small wetwell volume with burns occurring when the hydrogen concentration reaches 8 volume percent. If the release of hydrogen was directly into the larger intermediate volume, the time required for the hydrogen concentration to reach 8 volume percent would be longer, and the resulting thermal profile would consist of fewer total burns with a lower frequency of occurrence. This will allow more time for the equipment in this volume to cool between burns. In addition, the use of the wetwell thermal environment to evaluate equipment in the intermediate volume does not allow credit for cooling provided by the containment unit coolers. The CLASIX-3 analysis assumed that cooling was only provided to the intermediate volume. Therefore using the wetwell thermal environment for evaluating equipment in the intermediate volume effectively disallows credit for the containment unit coolers.

The HEATING6 thermal models of the Target Rock solenoid and the small Reliance motor used on the Limitorque valve operator have been previously submitted (Reference 2). Figures 2 through 5 (repeated from Reference 2) provide details of the equipment and corresponding HEATING6 models.

Two additional models have been developed to represent other items located in the intermediate volume. A Rosemount Model 1152 level transmitter, as shown in Figure 6, has been modeled in two parts. The thermal model of the electronic housing is shown on Figure 7. The epoxy glass laminate electronic circuit board is considered a sensitive component inside the nickel/iron alloy, cylindrical housing. The header board lead wires which contact the inside surface of the electronic housing may also be susceptible to thermal degradation but are not explicitly modeled in this study. The model of the sensing module is shown on Figure 8. The limiting component for the sensing module is the silicone oil on either side of the steel diaphragm. A 600-V, three-conductor Okonite power cable has also been modeled in this study. The critical cable component is considered to be the electrical insulation of ethylene propylene rubber which covers the copper conductor. Figures 9 and 10 show the cable construction and the associated thermal model.

The assumptions used in this study are similar to those described in Reference 2 and are summarized as follows:

1. One-dimensional (radial) modeling has been applied for the power cable. Two-dimensional modeling is assumed for the other equipment.

2. Where unit orientation with respect to vertical has not been verified, it is assumed that the unit is so oriented as to maximize convection to the most critical component.

3. Units being analyzed are assumed to be surrounded on exposed sides by hot vapor to a sufficient distance (of at least 10 ft) so as to maximize emissivity of the radiant cloud.

4. Convection of heat to the units is modeled by assuming forced convection at a velocity of 12 ft per sec.

5. Emissivity and absorptivity of the equipment component surfaces (internal and external) are set equal to conservatively high values, so as to maximize heat transfer to the equipment surface and within air spaces located inside the equipment outer surface.

6. Natural convection within free air spaces inside the equipment surface envelope is modeled by using enhanced heat conduction (Reference 3) for the Reliance motor and Target Rock solenoid. A natural convection model is used for the Rosemount level transmitter. These two methods yield comparable results for similar boundary conditions. However, the natural convection model gives a variable convection coefficient as a function of the surface-to-surface temperature difference.

7. Critical unit nonmetallic subcomponents are determined by review of vendor data and equipment qualification reports. When two subcomponents have similar projected temperature sensitivity, alternate heat transfer models are developed to maximize heat flow to each potentially critical component. Each model is then subjected to the thermal forcing function for the unit being analyzed. This procedure avoids spurious qualification on the basis of the most thermally sensitive material occurring only in a well-protected location (well insulated, attached to most massive component heat sink, etc.), while another material, with less inherent sensitivity to high temperature, may occur in a more exposed environment and thus be heated rapidly above its critical temperature.

   All units are assumed to be maximally exposed to the elevated thermal environment as indicated on the figures supplied. Exposed surfaces are allowed to radiate to the heat sinks which have surface temperatures calculated by CLASIX-3. No credit is taken for any unit being in a convective "dead zone" and thus shielded from the assumed 12-ft-per-sec gas stream. Unit internal air spaces (from

the shell or case to the heat-sensitive component which is shielded by the shell or case) are assumed to transmit heat by natural convection, by conduction, and by radiation.

3.0 RESULTS/CONCLUSIONS

The results of this study are summarized in Table 1 which shows the number of wetwell deflagration temperature spikes that each piece of equipment is capable of sustaining, without exceeding the sensitive component temperature limit. The Rosemount transmitter is predicted to survive six burns on the basis that the amplifier circuit board temperature exceeds the manufacturer's qualification temperature.

The balance of the equipment analyzed should survive 12 or more of the 39 wetwell burn spikes, which represents 31 percent of the extended series of wetwell burns. Although none of the equipment is demonstrated to survive the entire series of wetwell deflagrations, it should be recognized that the wetwell burn environment is characterized by more numerous and frequent burns due to the small wetwell volume than would be predicted by CLASIX-3 for the larger intermediate volume. Also, since the wetwell thermal profile has been applied directly to the intermediate volume equipment, no credit for cooling by the containment unit coolers is taken.

The results of this study reflect other conservatisms worthy of note. No credit has been taken in this study for reduced, radiant or convective heat transfer due to local obstructions such as walls, floors, or other equipment. Heat transfer is maximized to the sensitive internal components by assuming perfect contact between layers of materials (e.g., cable insulation and outer jacket). EPR, used as the insulation on the Okonite power cable, is rated for continuous use in seal applications for 2.0 hr at 440^{o}F. In this analysis, the cable was assumed to fail the first time that the EPR temperature reached 440^{o}F, which occurred after the seventeenth burn. The cumulative exposure of the cable to high temperature is much less than 2 hrs, and it is expected that cables would survive more than 17 burns.

Since the essential equipment is capable of surviving a minimum of six wetwell type burns, this equipment should be capable of surviving the small number of burns which might occur in the intermediate volume. For the SORV base case, all hydrogen enters the wetwell volume through the suppression pool. Since there is always sufficient oxygen to support combustion in the wetwell, even at the end of the transient, any accumulation of hydrogen in the wetwell will burn when it reaches the ignition criteria. Therefore, virtually all of the burning will occur in the wetwell volume. Buildup of the hydrogen concentration in the intermediate volume would be so slow that deflagration burns in the intermediate volume, if any, would be widely spaced. The long relaxation time between burns would also allow cooling by the containment unit coolers which would further reduce the effect of any burns in the intermediate volume.

REFERENCES

1. GSU Letter No. RBG-21,218 dated June 7, 1985, from J. E. Booker to H. R. Denton, Containment Pressure and Temperature Response to Hydrogen Combustion

2. GSU Letter No. RBG-21,423 dated July 1, 1985, from J. E. Booker to H. R. Denton, Preliminary Equipment Survivability Report

3. J. P. Holman, Heat Transfer, New York (McGraw-Hill, 1976), pp 225 to 259

TABLE 1

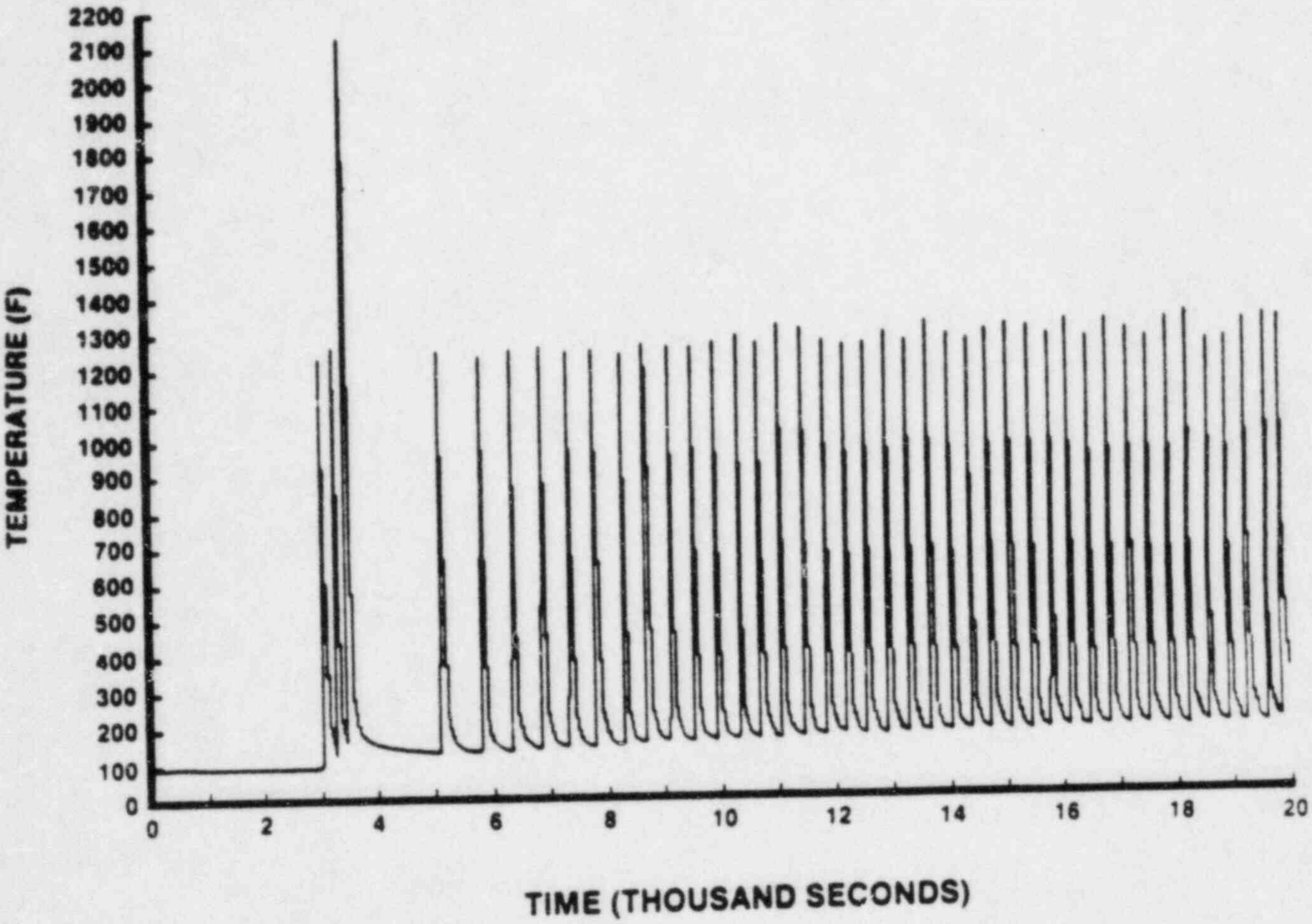
SUMMARY OF RESULTS

Equipment	Sensitive Component(s)	Temperature Limit	Number of Burns Prior to Exceeding Temperature Limit
Reliance motor (0.13 hp)	Stator coil insulation	$340^{\circ}F^{1}$	12
Target Rock solenoid	Rectifier	$385^{\circ}F^{1}$	17
Rosemount transmitter	Amplifier/ electronics	$303^{\circ}F^{1}$	6
	Silicone oil	$400^{\circ}F^{2}$	29
Okonite power cable	EPR insulation	$440^{\circ}F^{3}$	17

NOTES:

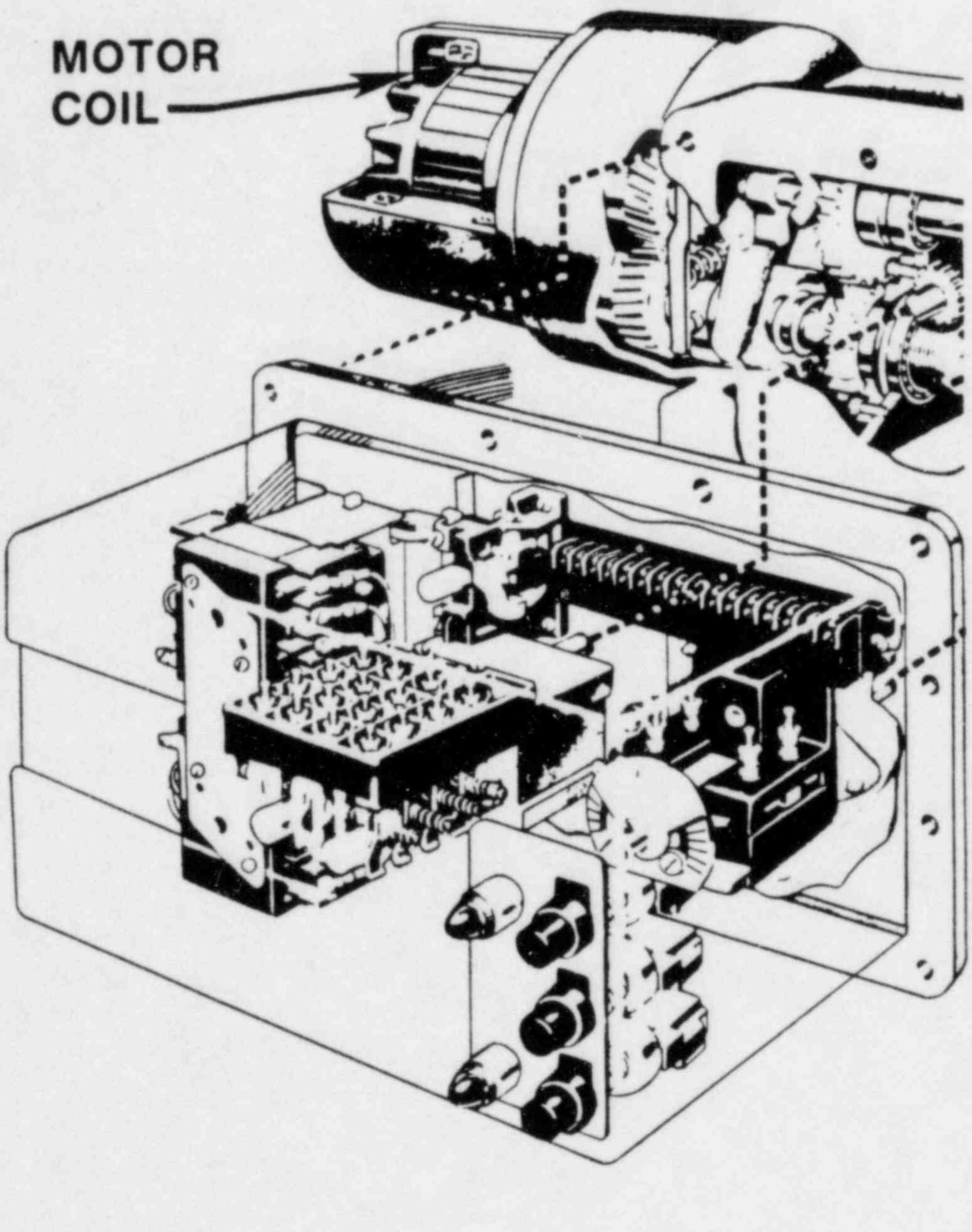
1 Qualification temperature
2 Maximum continuous service temperature
3 Maximum continuous service temperature for exposure time of 2.0 hr

FIGURE 1



WETWELL TEMPERATURES
SORV CASE - RELEASE B
RIVER BEND STATION

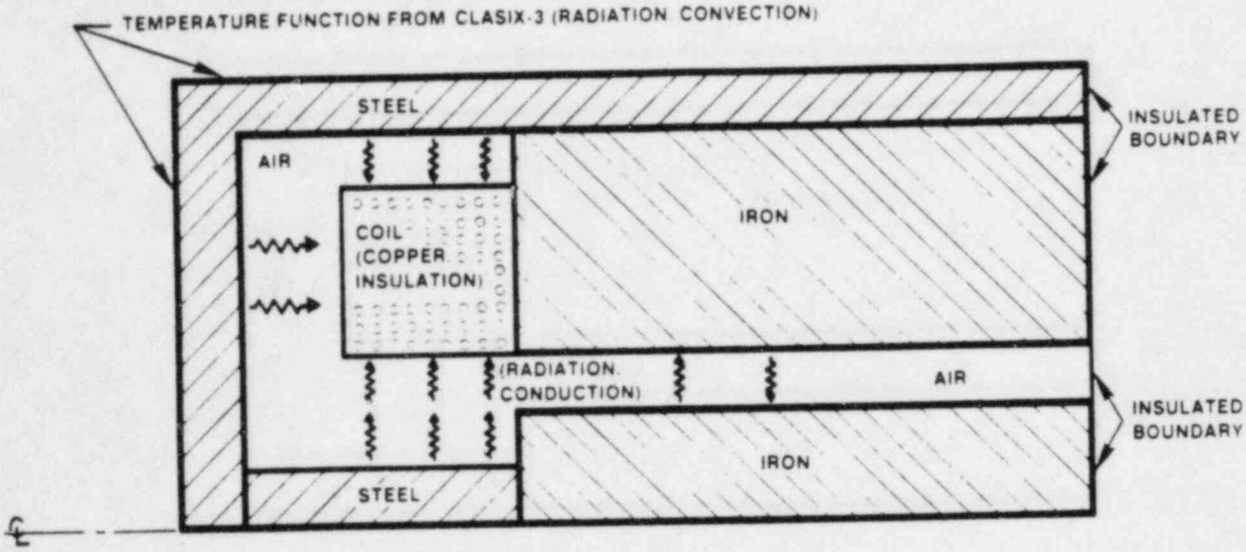
FIGURE 2



LIMITORQUE VALVE OPERATOR MOTOR
RIVER BEND STATION

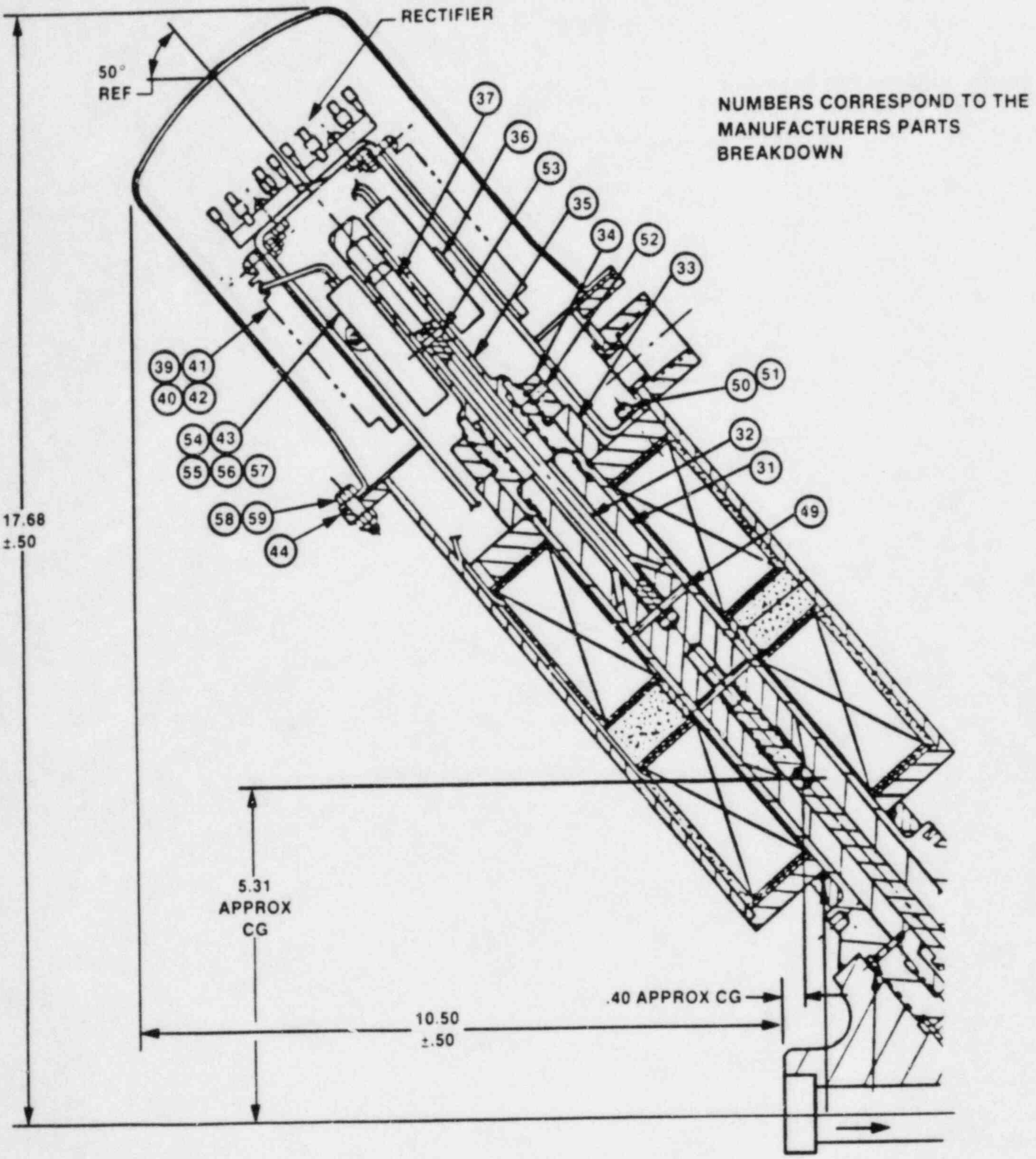
FIGURE 3

LIMITORQUE VALVE OPERATOR
0.13-HP RELIANCE MOTOR



The above shows a two-dimensional model (cylindrical coordinates) of the stator coil (mixture of copper and insulation), which is taken as the critical component. An insulated boundary is used to separate the model from other elements assumed to follow the same temperature transient (typical).

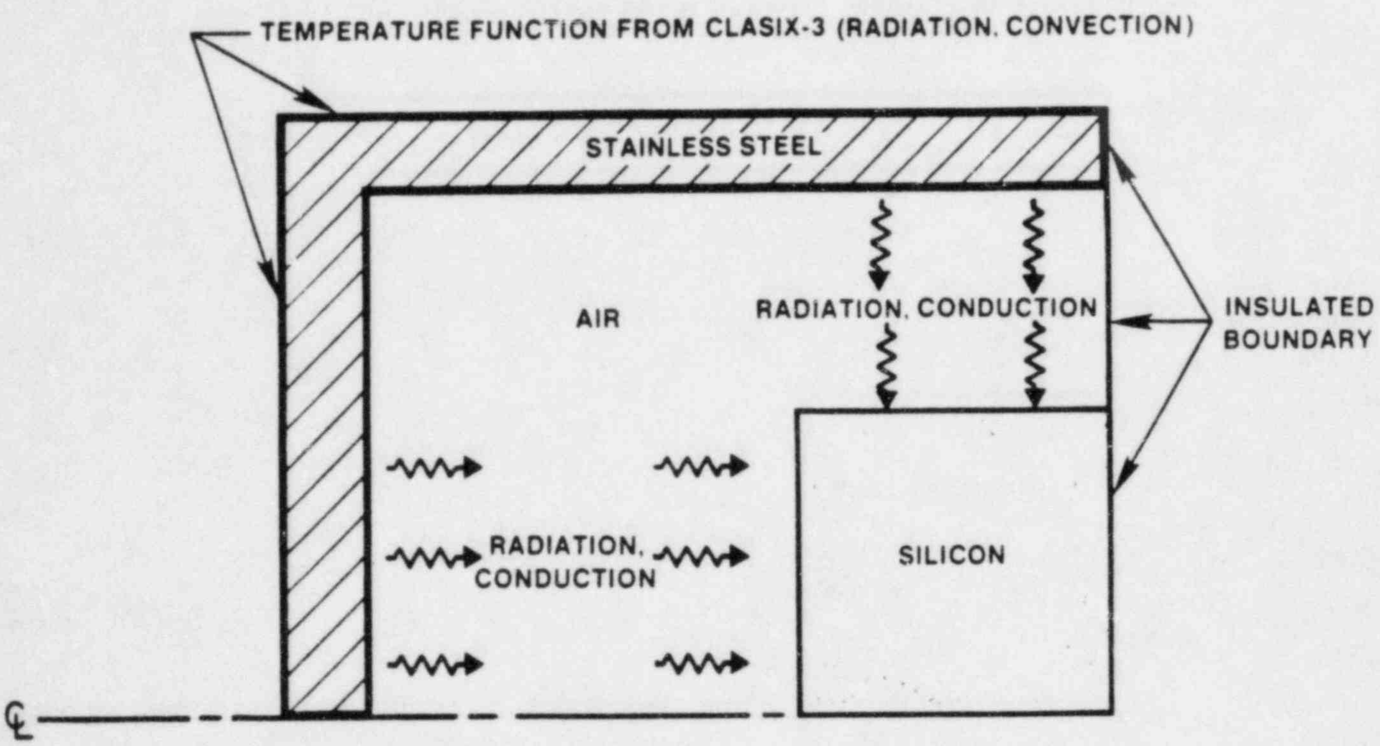
FIGURE 4



TARGET ROCK SOLENOID VALVE
RIVER BEND STATION

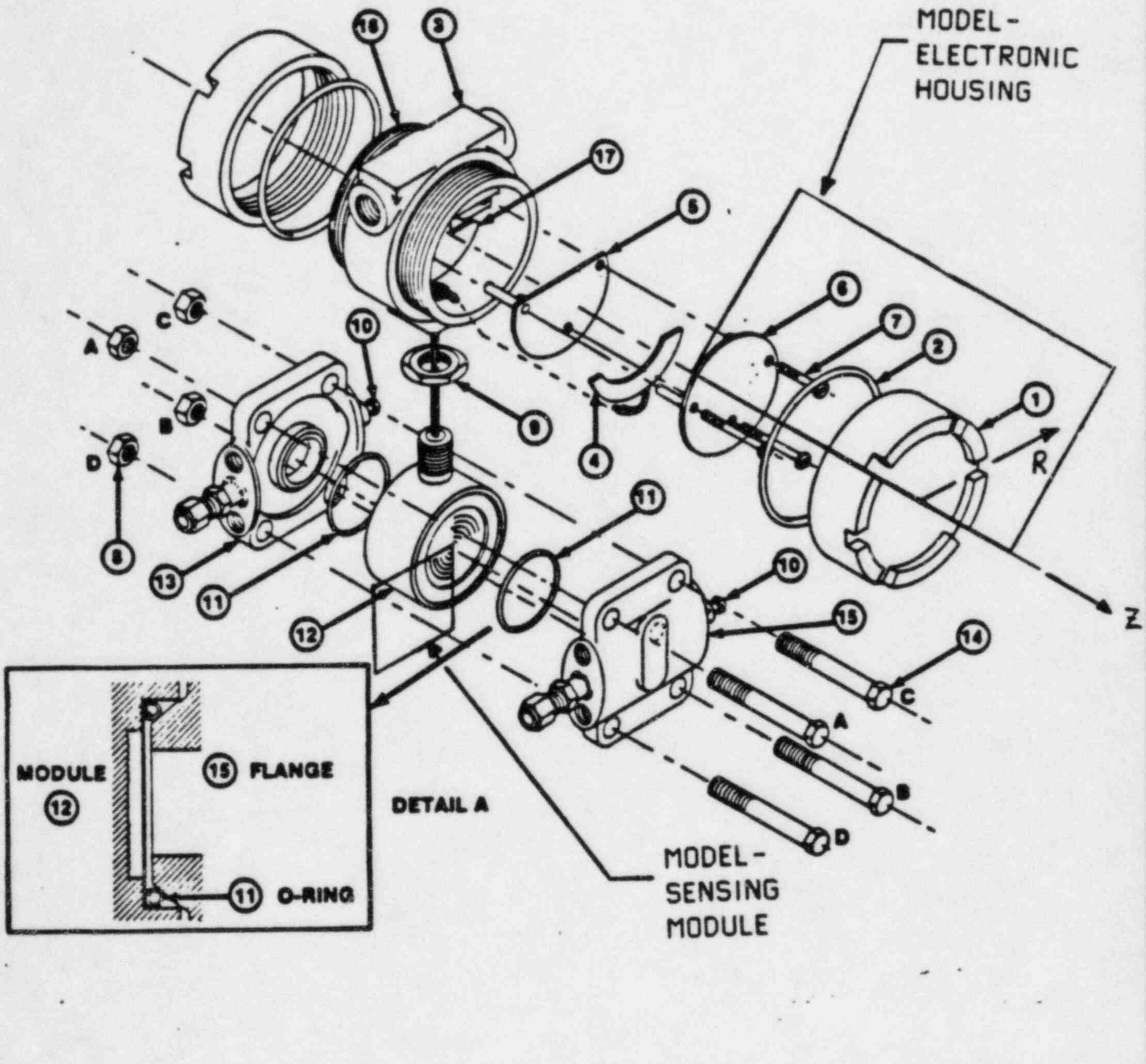
FIGURE 5

TARGET ROCK SOLENOID VALVE



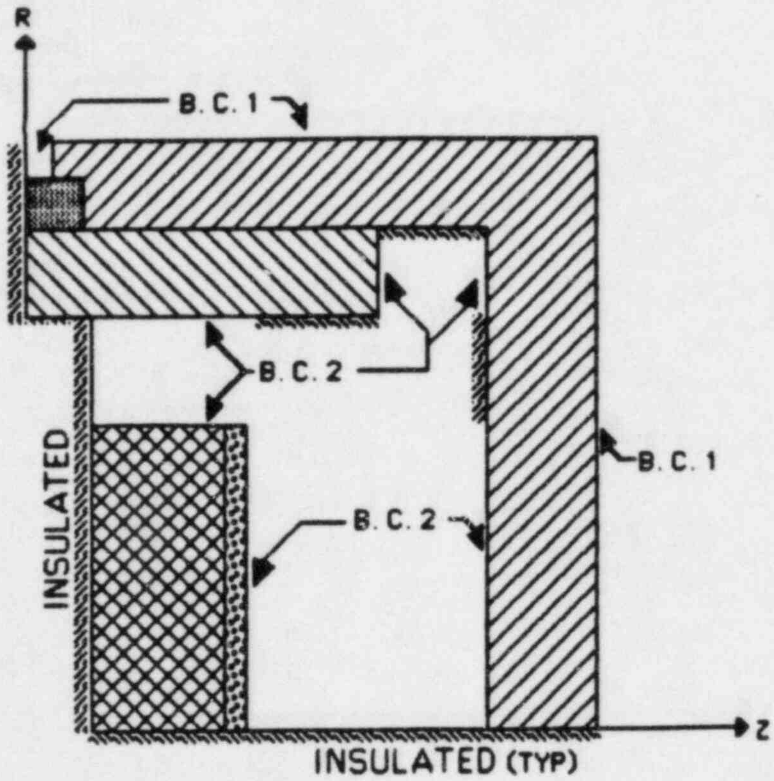
The above shows a two-dimensional model (cylindrical coordinates) of the rectifier block, which is considered to be the critical component. The body of the valve is not considered as a heat sink as it is also subjected to the thermal transient.

FIGURE 6



PRESSURE/LEVEL TRANSMITTER

FIGURE 7



MATERIAL

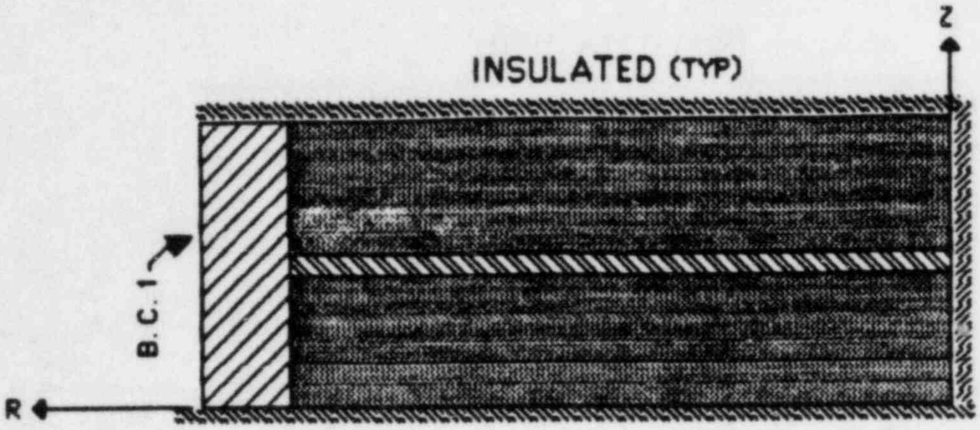
1. LOW COPPER ALUMINUM
2. NICKEL/IRON ALLOY
3. SOLDERING MATERIAL
4. ETHYLENE PROPYLENE RUBBER (EPR)
5. EPOXY GLASS LAMINATE

BOUNDARY CONDITIONS

1. FORCED CONVECTION & RADIATION
2. FREE CONVECTION & RADIATION

THERMAL MODEL OF PRESSURE/LEVEL TRANSMITTER (ELECTRONIC HOUSING) (ES-002-0)

FIGURE 8



MATERIALS

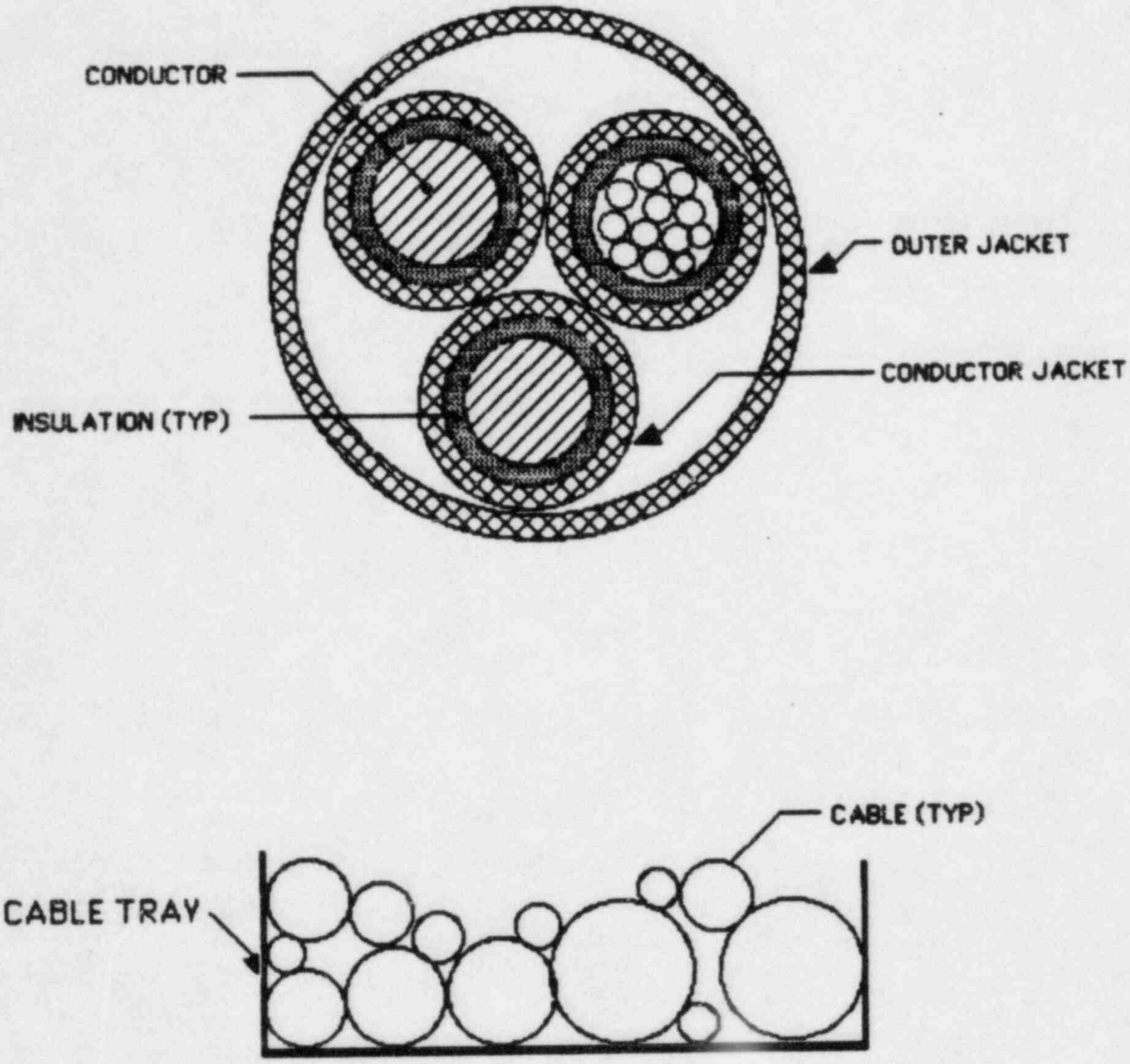
1. 316 STAINLESS STEEL
2. SPRING STEEL
3. SILICONE OIL

BOUNDARY CONDITIONS

1. FORCED CONVECTION & RADIATION

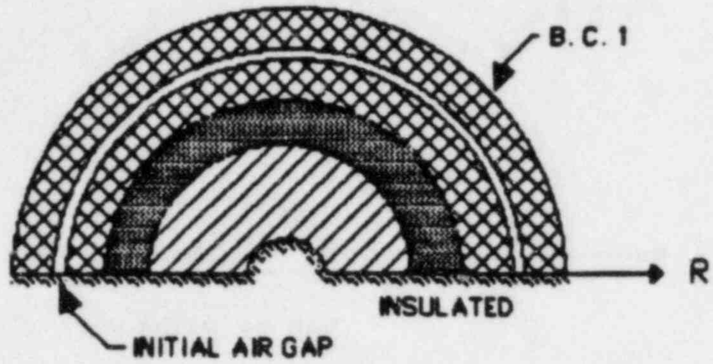
THERMAL MODEL OF PRESSURE/LEVEL TRANSMITTER
(SENSING MODULE) (ES-002-0)

FIGURE 9



CONSTRUCTION OF POWER CABLE

FIGURE 10



MATERIAL

1. COPPER

2. CHLOROSULFONATED POLYEHYLENE (TRADE NAME HYPALON)

3. ETHYLENE PROPYLENE RUBBER (EPR)

BOUNDARY CONDITIONS

1. FORCED CONVECTION & RADIATION

POWER CABLE THERMAL MODEL

(ES-001-0)

Attachment II

SEQUENCE OF EVENTS

FOR SORV AND DWB

BASE CASES

SEQUENCE OF EVENTS
FOR
SORV BASE CASE

Time (sec)	Event
0.0	Relief valve stuck open coincident with loss of all ECCS
240	ADS manually open at top of active fuel
409	Core uncovery
2000	Core 3/4 uncovered
3400	Reflood initiated (5000 gpm)
3645	Reflood complete
19832	Hydrogen production ceases

Sequence of Events
For
DWB Base Case

Time (sec)	Event
0.0	Drywell break (break area equal to 1 SRV) coincident with loss of all ECCS
1077	Auto ADS open
1283	Core uncovered
2300	Reflood initiated (5000 gpm) Suppression pool drawdown (for revised DWB)
3645	Reflood complete
21569	Hydrogen production ceases

INTRODUCTION

In the previously submitted report on equipment pressure survivability, "Hydrogen Deflagration Pressure Effects on Equipment" dated July 5, 1985, the essential equipment was shown to survive the pressures produced by hydrogen burns during hydrogen release. During a meeting with the NRC staff held on July 24, 1985, Gulf States Utilities was requested to evaluate the effect of the burn which was forced to occur after the hydrogen release was terminated.

RESULT

The pressure peak resulting from the forced, simultaneous wetwell, intermediate and containment burn was 35 psig. All essential equipment has been evaluated to establish its capability to withstand a 35 psig static pressure, which may result from a hydrogen deflagration burn. Pressures for which the equipment has been qualified are given in Table 1. As shown on this table, all equipment listed, with the exception of the containment unit coolers and the 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. The unit coolers are of open construction, and all components such as valves and motors are of sturdy construction and are capable of withstanding 35 psig. The unit cooler piping and coils are constructed to ASME Section III, Class 3 and will withstand 150 psig. The hydrogen mixing system fans are also of sturdy construction and are not susceptible to high pressures. In addition, the hydrogen mixing system fans will not be operating during the period when hydrogen deflagrations are occurring.

Table 1

Function	Equipment Description Make/Manufacturer Vendor Model/Catalog No.	Qualified Pressure (psig)
DRYWELL		
Automatic Depressurization System (ADS)		
Main steam safety/relief valves (ADS)	Crosby 8 x R x 10, Style HB-65-DF	35
Hydrogen igniter ignite hydrogen/air-combustible mixture during degraded core event	Power Systems Model 6043	70
Resistance thermal detectors	Pyco, Inc.	65
CONTAINMENT		
CMS Containment Atmosphere Monitoring		
Containment and drywell atmosphere sampling	Solenoid valve, Target Rock TRCP 77KK-003	66
CPM Containment Hydrogen Mixing		
Mixing fan (typ)	Fan motor, Buffalo Force West, TBFC 145T	15
Exhaust valve (typ)	Motor-operated valve, Posi-Seal, LMTQ SMB-000-2	105
Supply valve (typ)	Motor-operated valve, Posi-Seal, LMTQ SMB-000-2	105
E12 Residual Heat Removal		
LPCI Injection	Motor-operated valve, Velan LMTQ SB-2-60	70
HCS Hydrogen Recombiner		
Hydrogen recombiner	Hydrogen recombiner, Westinghouse Model 4B	70.0
Hydrogen Igniter System		
Hydrogen igniter Ignite hydrogen/air combustible mixture during degraded core event	Power Systems Model 6043	70.0

Function	Equipment Description Make/Manufacturer Vendor Model/Catalog No.	Qualified Pressure
HVR Ventilation - Reactor Plant		
Unit cooler Mitigate temperature increase during event and return temperature to normal following event	Unit cooler motor, Buffalo Forge West 445TCZ	15.0
JRB Superstructure - Reactor Building		
Cont. personnel airlock	Door access, Graver Woolley	118.0[1]
Drywell personnel airlock	Door access, Graver Woolley	118.0[1]
Drywell equipment hatch	Door access, Graver Woolley	118.0[2]
Cont. equipment hatch	Door access, Graver Woolley	118.0[2]
Instrumentation		
Reactor pressure vessel level transmitter RHR/LPCI permissive instrumentation	Rosemount Model 1152	73.0
Resistance thermal detector	Pyco, Inc.	65.0
Containment Electric Penetrations		
Electrical Penetration Assembly	Conay Corp/Unique	70.0

1. 72.0 psig based on ultimate capacity analysis
2. 56.0 psig based on ultimate capacity analysis

Attachment III

HYDROGEN DEFLAGRATION PRESSURE EFFECTS

SUPPLEMENT TO EVALUATE

RESPONSE TO FORCED BURN