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November 20, 1990
ST-HL-AE-3608
File No.: G25 & G04.02

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

South Texas Project Electric Generating Station
Units 1 & 2
Docket Nos. STN 50-498, STN 50-499
Responses to the NRC Request for Additional Information on the External Events Analysis in the Probabilistic Safety Assessment
South Texas Project Electric Generating Station (STPEGS)

Reference: (1) Meeting Minutes by the NRC (Mr. George F. Dick, Jr.) dated July 27, 1990 (ST-AE-HL-92530).

In the Reference meeting minutes, the NRC identified six questions regarding the external events analysis (i.e., seismic events and events other than fire) which contribute to the STPEGS Probabilistic Safety Assessment (PSA) results. A meeting with NRC personnel was held in Rockville, Maryland, on September 20, 1990 to discuss HL&P responses to these questions. HL&P's written responses are provided as an attachment to this letter.

If you should have any questions on this matter, or the attachment, please contact Mr. A. W. Harrison at (512) 972-7298 or myself at (512) 972-8530.

M. A. McBurnett
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Attachment: (1) Responses to STP PSA External Events Questions

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Revised 10/08/90

Attachment 1
Responses to STP PSA External Events Questions

Q1: Provide a discussion on the potential seismic interactions of the overhead crane in the diesel generator building with other equipment located in the vicinity.

Response:

The diesel building cranes are not specifically analyzed in the PSA seismic analysis since they were not identified in the seismic walkdown as a limiting component.

The Diesel Generator Building (DGB) overhead crane in each Class 1E Standby Diesel Generator (SDG) cubicle (Reference 1) is designed, manufactured and tested in accordance with the requirements of top-running single-girder, hand-chain overhead traveling cranes as stated in the Crane Manufacturers Association of America (CMAA) Specification 74. The rated capacity of each crane is 6000 pounds. The DGB cranes have been purchased by Quality Class 8 Specification with Seismic Qualification and Quality Assurance requirements, therefore meeting the intent of Quality Class 7 (Seismic Class II/I, Reference 2). The structural integrity of these cranes is required to preclude the damage to safety-related equipment.

The design load conditions for the DGB overhead (OH) crane with associated allowable stresses include the following (see Reference 3):

1. Dead Load + Live Load + OBE
2. Dead Load + Live Load + SSE.

The stresses are examined with the trolley at mid-span, 1/4-span and at the end of the span and hook at highest and lowest position. For load combination 1, the allowable stresses for structural steel are in accordance with part I of AISC-1969 Specifications, and for load combination 2, the allowable stresses do not exceed 90 percent of the AISC yield strength.

There is no procedure governing the parking or restraint of the subject crane since the crane is designed to withstand SSE accelerations under a combination of dead load plus live load. However, operators are instructed that cranes are to be parked clear of all obstructions and plant equipment.

A photograph in Attachment 1 shows a DGB cubicle with the crane parked at the north end. Photos are also provided which show a close-up view of each end of the crane structure. The crane design and construction, the crane wheel design and span, the location and construction of the runway rails, and the wall-to-wall span and the close proximity of the crane wheel structure to the walls of the seismic class I building make it unlikely that the crane will fail before the other equipment in the DGB which were analyzed.

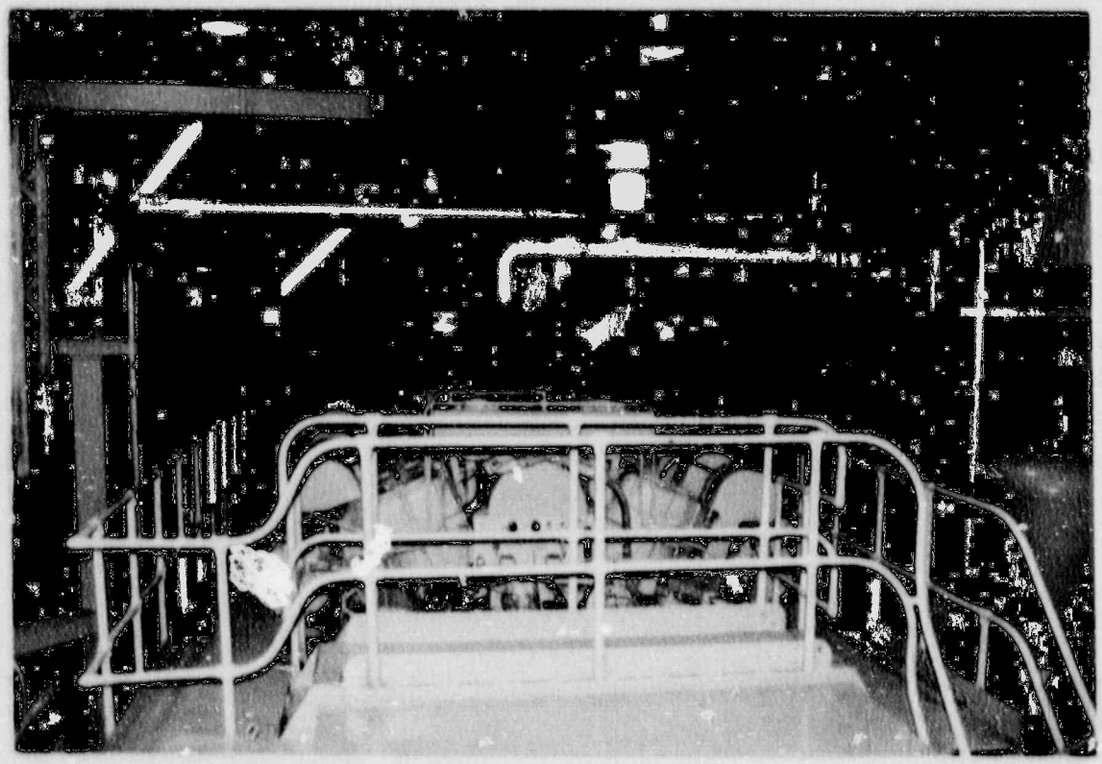
Attachment 1
Responses to STP PSA External Events Questions

References:

1. System Design Criteria 7Q019MQ1059, "DGB Overhead Cranes," Revision 2.

2. System Design Criteria 7A360NQ1003, "Systems Interaction Seismic II/I," Revision 3.

3. System Description 7A019MD0108, "Equipment Cranes, Hoists, and Monorails," Revision 1.



Overhead crane parked against north end of SDG cubicle in DGB.

DGB overhead crane detail, east side.

DGB overhead crane detail, west side.

Attachment 1
Responses to STP PSA External Events Questions

Q2: Provide SSPS cabinet anchorage details and fragility calculations.

Response:

A seismic fragility or failure vulnerability analysis was conducted by NTS Engineering and is included in Section E.2 of Appendix E to the STP PSA (Reference 1). A total list of equipment and other plant components considered in the plant model for internal initiating events, as well as the buildings that house them, was provided to the fragility analysts. As noted in Section 11.2.3 of the PSA, the purpose of the seismic analysis is as a bounding analysis. The approach was to rely on a plant walk-through by the fragility and systems analysts to determine by inspection the one or two buildings and the dozen or so plant components that appear to be the most vulnerable to seismic events beyond the design basis. The other buildings and equipment were either screened out as obviously being incapable of failing at predicted accelerations or were considered to be as strong as those analyzed. This selection process necessarily also relied on the experience of the expert analysts with similar equipment from previous PSAs and included a review of STP seismic qualification information for some components.

The results of the fragility analysis for the two structures are given in Table 11.2-1 of the PSA. Results of the equipment fragility analysis are given in Table 11.2-2. Both tables are attached for convenience (Attachments 1 and 2).

The electrical cabinets analyzed include the 4160V switchgear and the 120V AC 25 KVA inverters. Other components not examined were assumed to have "low" capacities similar to those in Table 11.2-2. Thus electrical cabinets in addition to the 4160V switchgear and the 120V AC 25 KVA inverters have been included as summarized in Table 11.2-3 (Attachment 3). SSPS and all ESFAS cabinets have been assumed to have a fragility no worse than the 25 KVA inverters. This is judged to be acceptable as delineated in the following paragraphs.

The SSPS system at STPEGS is housed by one-, two- and three-cabinet units. These cabinets are arranged side-by-side as shown in the photograph of Attachment 4. The rack base is bolted to the floor in each cabinet with four (4) 3/4" diameter bolts. The bolting of the rack base is shown in drawing 7242D10, Sheet 10 (Attachment 5). The seismic qualification testing for SSPS is performed by Westinghouse in accordance with the W methodology for low seismic plants (Section 3.10N of the STPEGS UFSAR, and WCAP-7817, Supplement 3, "Seismic Testing of Electrical and Control Equipment (W Solid State Protection System, Low Seismic Plants")). These cabinets for a W "low-seismic plant" design have been qualified by W to an acceleration of 0.25g (Reference 2).

The STPEGS UFSAR presents information to justify the SSE for the plant as being a peak ground acceleration of 0.07g and the OBE as being 0.035g (Reference 3). However, to comply with the minimum requirements of 10CFR100 Appendix A, the plant was designed for an SSE of 0.10g and an OBE of 0.05g. Thus the seismic design criteria for STP are the lowest of those for the current vintage plants. The W qualification program for "low-seismic plant" SSPS design for STPEGS is 0.25g.

Thus, based upon the above discussion, the fragility of the SSPS cabinets has been adequately considered as part of the PSA seismic evaluations.

References:

1. South Texas Project (STP) Probabilistic Safety Assessment (PSA), Volume 8.

2. W Solid State Protection System (SSPS) Qualification Report 14926-9999(?)-00016-CWN.

3. STPEGS Updated Final Safety Analysis Report (UFSAR), Section 2.5.1.

QUESTION 2

ATTACHMENT 1

Table 11.2-1. Seismic Capacity of Structures

Structure	Critical Element	Median Acceleration Capacity a(g)	β_R	β_U	HCLPF
DGB	Shear Wall Failure	4.6	0.48	0.63	0.74
FHB	Shear Wall Failure	3.6	0.45	0.63	0.61

QUESTION 2
ATTACHMENT 2

Table 11.2-2. Equipment Fragilities

System or Component	Location (elevation in feet)	Failure Mode	Ground Acceleration Capacity			
			$\tilde{a}$(g)	β_R	β_U	HCLPF
SIS Accumulator Tank	Containment (-11)	Anchorage	>6.0	–	–	–
HHSI Pump	Fuel Handing (-21)	Motor Stand Bolts	>6.0	–	–	–
CCW Heat Exchanger	MEAB (26)	Anchorage	1.63	0.41	0.49	0.37
CCW Surge Tank	MEAB (60)	Anchorage	1.09	0.42	0.51	0.23
Chemical and Volume Control Tank	MEAB (41)	Anchorage	>4.5	–	–	–
ECW Pump	Intake (34)	Seismic Restraint Bolts	2.01	0.39	0.48	0.48
ECH 150-ton Chillers	MEAB (10)	Anchorage	>2.5	–	–	–
ECH 300-ton Chillers	MEAB (10)	Anchorage	1.46	0.42	0.47	0.34
EDG	Diesel Generator (25)	Lube Oil Filter Anchorage	1.62	0.40	0.48	0.38
Technical Support Center Diesel Generator	Yard	Anchorage	<0.3*	–	–	–
Offsite Power	Yard	General Failure	0.30	0.25	0.50	0.09
4,160V Switchgear	MEAB (50)	Function	1.69	0.41	0.56	0.34
125V DC Batteries and Racks	MEAB (60)	Battery Failure	1.91	0.41	0.53	0.40
120V AC 25 kVA Inverters	MEAB (60)	Function	1.31	0.41	0.52	0.28
120V AC 7.5 kVA Inverters	MEAB (35)	Function	>2.0	–	–	–
Cable Trays and Supports	Various	Support Failure	>2.0	–	–	–
Relays	Various	Chatter	0.50**	0.20	0.43	0.18

*Fails before LOOP.
**Reference 3.4.4-6.

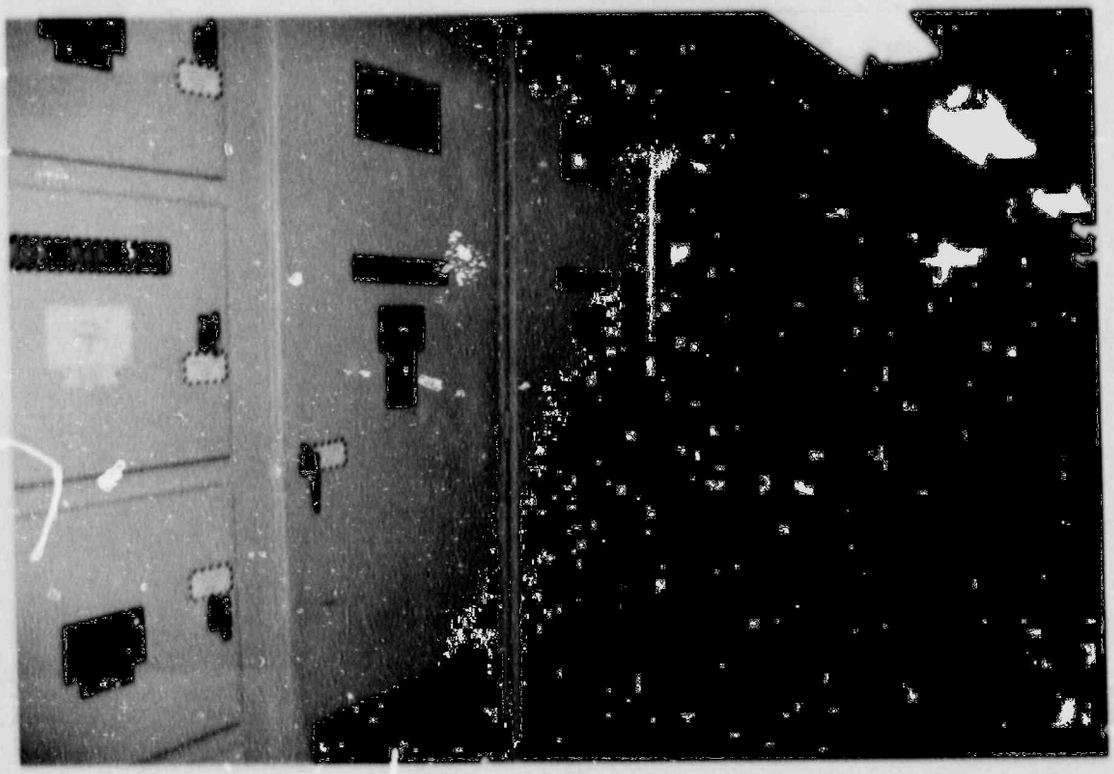
QUESTION 2
ATTACHMENT 3

Table 11.2-3. Seismic Fragilities

Component	Failure Mode	$\tilde{a}$(g)	β_R	β_U
1. Technical Support Center Diesel Generator	Anchorage	>0.3* (guaranteed failure on LOOP)		
2. Offsite Power	General Failures	0.30	0.25	0.50
3. Relays	Chatter	0.50	0.20	0.43
4. CCW Surge Tank	Anchorage	1.09	0.42	0.51
5. ECH Tanks	Anchorage	1.09	0.42	0.51
6. Fuel Oil Day Tanks	Anchorage	1.09	0.42	0
7. AFW Storage Tank	Anchorage	1.09	0.42	[illegible]
8. 120V AC 25-kVA Inverters and 125V DC Battery Chargers	Function	1.31	0.41	0.52
9. RPS Cabinets	Function	1.31	0.41	0.52
10. ESFAS Cabinets	Function	1.31	0.41	0.52
11. SSPS Cabinets	Function	1.31	0.41	0.52
12. QDPS Cabinets	Function	1.31	0.41	0.52
13. ECH 300-ton Chillers	Anchorage	1.46	0.42	0.47
14. EDGs	Lube Oil Filter Anchorage	1.62	0.40	0.48
15. CCW Heat Exchangers	Anchorage	1.63	0.41	0.49
16. 4,160V Switchgear	Function	1.69	0.41	0.56
17. 125V DC Batteries and Racks	Battery Failure	1.91	0.41	0.53
18. ECW Pumps	Seismic Restraint Bolts	2.01	0.39	0.48

*Because of low fragility, conservatively assumed to fail before LOOP.

ATTACHMENT 4 TO QUESTION 2



Row of SSPS cabinets in relay room.

QUESTION 2
ATTACHMENT 5

OVERSIZE DOCUMENT PAGE PULLED

SEE APERTURE CARDS

NUMBER OF OVERSIZE PAGES FILMED ON APERTURE CARDS 1

APERTURE CARD/HARD COPY AVAILABLE FROM

RECORDS AND REPORTS MANAGEMENT BRANCH

Attachment 1
Responses to STP PSA External Events Questions

Q3: Trace the quantification of the top two seismic plant damage states (HXXXS and MXXXS) and provide plant damage state fragilities.

Response:

NOTE: In the following discussion, it is assumed that MXXXS as identified above is MAXXS as identified in Table 11.4-1 of the STPEGS PSA. Plant damage state MXXXS does not include seismically induced sequences as indicated by its absence from Table 11.4-1, and therefore is not germane to this question. HXXXS and MAXXS respectively are the two most frequent plant damage states resulting from seismic initiating events.

Each path (i.e., sequence of events which are characterized by top event successes and failures, known as "split fractions") through the plant model event trees represents a specific plant state which, if it results in core damage, must be evaluated in terms of its impact on containment, and ultimately in terms of its source term contribution. The plant model quantification is performed by linking event trees through several separate steps (or "stages") of quantification using impact vectors as input to the next stage. Once the quantification is completed, the information from each stage must be linked together (or "unraveled") to produce the event tree path constituting the front-to-back sequence.

These paths are traced through the electric power event trees (LOSP and NO LOSP), the mechanical-auxiliary event tree, the appropriate front-line event tree (general transient, LOCA, SGTR, etc., depending on the initiating event being evaluated), and containment state event trees (LT1 and LT2). These paths number in the millions so that it becomes convenient for the purpose of quantification of containment event trees (CETs) to group paths which result in similar final physical conditions. Each grouping, or plant damage state (PDS), is characterized by thermodynamic conditions in the RCS and the containment at the time of severe core damage, and the availability or unavailability of both passive and active plant features that can terminate the accident or mitigate the release of radioactive materials into the environment.

The STPEGS PSA identifies a mnemonic classification which is used to bin PDSs. This mnemonic system is identified by Table 16.1-2 of the PSA and consists of a 5-character designation, for example, HXXXS or MAXXS. In the case of HXXXS, this PDS collects sequences in which

- RCS pressure is above 1500 psig at melt,
- no steam generator cooling is available,
- the RWST has not been injected,
- no containment heat removal is available,
- no fission product scrubbing is available, and
- a small containment isolation path is open.

Similarly, the MAXXS PDS collects sequences in which

- RCS pressure is between 400 psig and 1500 psig at melt,
- steam generator cooling is available,
- the RWST has not been injected,
- no containment heat removal is available,
- no fission product scrubbing is available, and
- a small containment isolation path is open.

In order to model a seismic event, a seismic pre-tree is defined as illustrated in Figure 11.3-1 in the PSA, a similar version of which is attached as Figure 1, using the EPRI or LLNL seismic hazard curve as input to determine the frequencies of specific plant states for equipment failures resulting from the seismic event. These equipment state freqencies then become initiating event frequencies with boundary conditions which are then passed through the linked event tree model for the general transient class of internal events.

Each top event in the seismic pre-tree is as defined in PSA Section 11. The initiating events with boundary conditions for which the plant model is quantified are identified by the "event" designator beginning "EQ" in Figure 11.3-1 of the PSA, or "End State" in Figure 1 attached. The plant model is quantified for each seismic initiating event from the seismic pre-tree. The seismic initiating events which result directly in core melt are identified in Table 1-1 in the attached discussion of the "Plant Level Fragility Curve" (Attachment 1).

Table 1 lists several of the highest frequency seismic core damage scenarios as generated by the "unraveling" computer code, SQLINK. The seismic pre-tree is quantified four times, once for each of the four discrete seismic ground acceleration levels into which the EPRI or LLNL seismic hazard curve is separated (see Tables 11.1-2 and 2.2-8 respectively in the PSA. Table 11.1-2 is attached as Attachment 2 to correct typographical errors in the exponents for 0.4 and 0.6g accelerations). The pre-tree split fractions are dependent on the ground acceleration level and are calculated by the computer code FRAGILE. Table 2 attached shows the seismic pre-tree top event failure fractions calculated for each ground acceleration level. Table 3 attached shows the total end state frequency for all the seismic initiators and the contributions to the total from each of the four pre-tree quantifications. The frequency of a seismic initiating event is calculated as the sum of the total end state frequencies for all four of the pre-tree quantifications. In this example, the mean hazard curve used to generate these results was based on the EPRI hazard curve. The total sequence frequencies for the respective seismic initiating events shown in Table 1 are reduced from the frequencies shown in Table 3 by the success terms in the plant model event trees.

Approximately 46% of the total CDF frequency due to seismically induced sequences fall into PDS HXXXS. As seen from Table 11.4-1 of the PSA, the seismic sequences total 8.61E-08/year of the total for the PDS of 2.39E-05/year, or 0.36% of the total CDF in HXXXS (the other contributions in HXXXS are due primarily to internally induced sequences).

The major seismic contributors to state HXXXS are a seismically induced loss of offsite power (top event OG) in coincidence with failures of the diesel generators (top event DG), the essential 4160V switchgear (top event AB), or the battery chargers (top event IV). Referring to the seismic event tree in Figure 1, many sequences involve these failures. For example, sequence 50, which is binned to event EQ20, results from failure of the offsite grid (top event OG) and failure of the diesel generators (top event DG) and is included in HXXXS. Other events identified in the event tree, for example EQ19B, EQ21, EQ22, and EQ23A&B, also contribute to HXXXS. In these events, core damage results directly from the seismically induced failures so that no additional conditional independent failures are required. The conditional core damage frequencies from independent failures are summarized for each event in the attached "Plant Level Fragility Curve" discussion, which is provided in response to the above request for plant damage state fragilities.

Initiating event EQ20 is shown as the first sequence summarized by Table 1. Table 1-1 of Attachment 1 indicates EQ20 has a conditional core damage frequency of 1.0 which means that EQ20, without operator action, goes to core damage state HXXXS with no additional random internal failures.

PDS MAXXS includes sequences which result from seismically induced failures including loss of offsite power (top event OG) with loss of the essential chilled water system (top event CW) or loss of SSPS and ESFAS (top event SF). Essential chilled water provides cooling for the Electrical Auxiliary Building (EAB) HVAC system. SSPS and ESFAS provides safety equipment actuation. Failure of EAB HVAC is assumed to lead to loss of all AC power in the PSA. As seen in Table 1, EQ12 (failure of top events OG and CW) and EQ15 (failure of top events OG and SF) contribute to PDS MAXXS.

Seismically induced sequences totaling 37% of the seismic CDF (6.97E-08) contribute to MAXXS. Seismic contributions comprise only 0.41% of the total CDF in MAXXS. Similar to the case above, seismic pre-tree end states EQ12 and EQ15 result directly in core damage without any additional random failures.

As can be seen from the above discussion, the seismic contributions to a plant damage state is dominated by the

fragility of a single component or a few components. Since this is the case, since the development of each fragility curve represents a significant level of effort, and since the plant level composite fragility is the most useful, a plant level fragility has been provided. This approach has been discussed previously with the NRC reviewer and he has concurred with the approach.

TABLE 1. DOMINANT SEISMIC CORE DAMAGE SEQUENCES FROM SQLINK

DOMINANT SEQUENCE LIST FOR TOTAL DAMAGE

FREQUENCY OF TOTAL DAMAGE 2.04E-07

NO.	(FREQ)	INIT. EVENT	SUP STATE	E.P. TREE END	SEQ	RUN NUM.	A.H. TREE END	SEQ	RUN NUM.	F.L. TREE END	SEQ	RUN NUM.	REC. TREE END	SEQ	RUN NUM.	SEQUENCE PER YEAR	PERCENT. OF TOTAL	CUMUL. % OF TOTAL
1	EQ20	IV126	GGGSS	318	10	XXFFF 4167	108	2ESNN	765	236	HXXXS	362	155	2.289E-08	11.223	11.223
			FAILED SPLIT FRACTIONS													
+			STAGES 1 AND 2, GAZ GBZ GCZ ORZ OMZ/WAZ WBZ WCZ FAZ FBZ FCZ/													
			STAGES 3 AND 4, CDZ AFZ OBZ/HIZ CFZ RAZ RBZ RCZ CIZ WIZ													
2	EQ5	IV69	VVVFF	36	3	XXFFF 2536	43	2ESNN	765	4	HXXXS	362	153	2.083E-08	10.211	21.434
			FAILED SPLIT FRACTIONS													
+			STAGES 1 AND 2, SBZ RTZ ORZ/WBZ SAZ SBZ SCZ FCZ OSZ/													
			STAGES 3 AND 4, CDZ AFZ OBZ/HIZ CFZ RAZ RBZ RCZ CIZ WIZ													
3	EQ12	IV126	RRRSS	3	7	XXFFF 1156	123	2CSXU	656	224	HAXXS	362	102	1.760E-08	8.628	30.062
			FAILED SPLIT FRACTIONS													
+			STAGES 1 AND 2, ORZ OMZ/SAZ SBZ SCZ OSZ/													
			STAGES 3 AND 4, CDZ SZZ CHZ PDZ LIZ HAZ HBZ HCZ/HIZ CFZ RAZ RBZ+													
4	EQ11	IV9	RRRSS	3	7	SXNSS 11	113	1ASSI	622	237	HABFI	67	446	1.040E-08	5.098	35.160
			FAILED SPLIT FRACTIONS													
+			STAGES 1 AND 2, ORZ OMZ/KAZ KBZ KCZ/													
			STAGES 3 AND 4, CDZ SZZ CHZ PDZ SEZ/CFZ RXZ													
5	EQ15	IV69	EPBIN 3143		9	XXFFF 4167	108	2ASXU	593	245	HAXXS	362	81	9.915E-09	4.860	40.030
			FAILED SPLIT FRACTIONS													
+			STAGES 1 AND 2, EAZ EBZ ECZ DAZ DBZ DCZ ORZ OMZ/WAZ WBZ WCZ FAZ+													
			STAGES 3 AND 4, CDZ SZZ CHZ LIZ HAZ HBZ HCZ/HIZ CFZ RAZ RBZ RCZ+													
6	EQ23B	IV69	EPBIN 3143		13	XXFFF 4167	108	2LSNN	765	220	HXXXS	362	153	6.421E-09	3.147	43.167
			FAILED SPLIT FRACTIONS													
+			STAGES 1 AND 2, EAZ EBZ ECZ DAZ DBZ DCZ ORZ OMZ/WAZ WBZ WCZ FAZ+													
			STAGES 3 AND 4, CDZ AFZ OBZ/HIZ CFZ RAZ RBZ RCZ CIZ WIZ													
7	EQ19B	IV69	SPBIN 3143		13	XXFFF 4167	108	2ESNN	765	220	HXXXS	362	153	5.922E-09	2.903	46.070
			FAILED SPLIT FRACTIONS													
+			STAGES 1 AND 2, EAZ EBZ ECZ DAZ DBZ DCZ ORZ OMZ/WAZ WBZ WCZ FAZ+													
			STAGES 3 AND 4, CDZ AFZ OBZ/HIZ CFZ RAZ RBZ RCZ CIZ WIZ													

TABLE 2. STP PHASE2 COMPONENT FRAGILITY ANALYSIS
CALCULATION OF SEISMIC EVENT TREE SPLIT FRACTIONS FOR EACH S LEVEL

TOP EVENTS CONTRIBUTING SEISMIC FAILURE FRAGILITY	MEDIAN ACCEL.	BETA R	BETA U	BETA C	HCLPF VALUE	SEISMIC SPLIT FRACTIONS(AND CONTRIBUTORS)FOR EACH G LEVEL 0.100	0.200	0.400	0.600
1 OFFSITE POWER -SUM						1.47E-02	1.91E-01	5.36E-01	8.81E-01
SEIS2 OFFSITE POWER	0.30	0.250	0.500	0.559	0.087	1.47E-02	1.91E-01	5.36E-01	8.81E-01
0									
2 INVERTORS/BATTERY CHARGER -SUM						4.16E-05	1.75E-03	1.94E-02	1.19E-01
SEIS7 INVERTORS, BATT. CHARG.	1.31	0.410	0.520	0.662	0.282	4.16E-05	1.75E-03	1.94E-02	1.19E-01
0									
3 4160V SWITCHGEAR -SUM						1.86E-05	8.12E-04	9.83E-03	6.81E-02
SEIS15 4160V SWITCHGEAR	1.69	0.410	0.560	0.694	0.341	1.86E-05	8.12E-04	9.83E-03	6.81E-02
0									
4 125V DC POWER -SUM						5.03E-06	2.89E-04	4.86E-03	4.27E-02
SEIS16 125V DC BATTERIES,RACKS	1.91	0.410	0.530	0.670	0.405	5.03E-06	2.89E-04	4.86E-03	4.27E-02
0									
5 DIESEL GENERATORS -SUM						1.19E-04	4.28E-03	4.15E-02	2.28E-01
SEIS5 FUEL OIL DAY TANKS	1.09	0.420	0.510	0.661	0.235	1.15E-04	3.96E-03	3.56E-02	1.81E-01
SEIS13 EMERGENCY DIESEL GEN.	1.62	0.400	0.480	0.625	0.379	4.39E-06	3.12E-04	6.12E-03	5.68E-02
0									
6 SSPS/ESFAS -SUM						8.32E-05	3.49E-03	3.84E-02	2.23E-01
SEIS9 ESFAS CABINETS	1.31	0.410	0.520	0.662	0.282	4.16E-05	1.75E-03	1.94E-02	1.19E-01
SEIS10 SSPS CABINETS	1.31	0.410	0.520	0.662	0.282	4.16E-05	1.75E-03	1.94E-02	1.19E-01
0									
7 ESSENTIAL COOLING WATER -SUM						7.50E-07	7.34E-05	2.11E-03	2.63E-02
SEIS17 ECW PUMPS	2.01	0.390	0.480	0.618	0.478	7.50E-07	7.34E-05	2.11E-03	2.63E-02
0									
8 ESSENTIAL CHILLED WATER -SUM						1.66E-04	6.32E-03	6.37E-02	3.36E-01
SEIS4 ECW TANKS	1.09	0.420	0.510	0.661	0.235	1.15E-04	3.96E-03	3.56E-02	1.81E-01
SEIS11 QDPS CABINETS	1.31	0.410	0.520	0.662	0.282	4.16E-05	1.75E-03	1.94E-02	1.19E-01
SEIS12 ECH 300 TON CHILLERS	1.46	0.420	0.470	0.630	0.336	1.03E-05	6.17E-04	9.97E-03	7.96E-02
0									
9 COMPONENT COOLING WATER -SUM						1.21E-04	4.36E-03	4.23E-02	2.30E-01
SEIS3 CCW SURGE TANK	1.09	0.420	0.510	0.661	0.235	1.15E-04	3.96E-03	3.56E-02	1.81E-01
SEIS14 CCW HEAT EXCHANGERS	1.63	0.410	0.490	0.639	0.369	6.20E-06	3.92E-04	6.87E-03	5.96E-02
0									
10 AUXILIARY FEEDWATER -SUM						1.15E-04	3.96E-03	3.56E-02	1.81E-01
SEIS6 AFW STORAGE TANK	1.09	0.420	0.510	0.661	0.235	1.15E-04	3.96E-03	3.56E-02	1.81E-01
0									

NOTE: FRAGILITIES ARE SUMMED IN THE FOLLOWING WAY:
SUM = FRAGILITY1 + FRAGILITY2 - (FRAGILITY1) * (FRAGILITY2)

TABLE 3. SUMMARY OF SEISMIC PRE-TREE END STATE TOTALS

END STATE	TOTAL FOR ALL G LEVELS	END STATE FREQUECIES FOR EACH G LEVEL 0.10 G	0.20 G	0.40 G	0.60 G
EQ1	3.21E-05	2.95E-05	2.28E-06	2.88E-07	1.81E-09
EQ2	2.35E-08	3.39E-09	9.10E-09	1.06E-08	4.02E-10
EQ3A	3.99E-08	4.90E-09	1.45E-08	1.95E-08	9.20E-10
EQ3B	2.68E-08	3.57E-09	1.00E-08	1.27E-08	5.43E-10
EQ3C	1.20E-09	5.93E-13	6.37E-11	8.65E-10	2.75E-10
EQ3D	9.67E-10	2.21E-11	1.69E-10	6.79E-10	9.61E-11
EQ4	1.75E-09	9.77E-13	9.86E-11	1.25E-09	4.05E-10
EQ5	2.30E-08	2.45E-09	8.04E-09	1.19E-08	6.37E-10
EQ6	2.13E-09	7.07E-13	8.72E-11	1.40E-09	6.43E-10
EQ7A	1.11E-08	1.22E-09	4.01E-09	5.69E-09	2.45E-10
EQ7B	2.29E-09	1.48E-10	6.61E-10	1.40E-09	8.11E-11
EQ7C	2.32E-10	4.57E-14	6.61E-12	1.32E-10	9.35E-12
EQ7D	2.66E-09	7.64E-13	9.86E-11	1.69E-09	8.76E-10
EQ8	5.89E-09	5.49E-10	1.88E-09	3.19E-09	2.67E-10
EQ9	1.30E-06	4.40E-07	5.38E-07	3.18E-07	1.04E-08
EQ10	1.62E-08	5.06E-11	2.14E-09	1.17E-08	2.29E-09
EQ11	1.96E-08	5.33E-11	2.35E-09	1.40E-08	3.10E-09
EQ12	3.29E-08	7.31E-11	3.43E-09	2.26E-08	6.83E-09
EQ13	1.34E-09	3.30E-13	3.99E-11	7.51E-10	5.49E-10
EQ14	3.72E-09	1.45E-14	2.32E-11	1.38E-09	2.31E-09
EQ15	1.76E-08	3.66E-11	1.88E-09	1.27E-08	2.98E-09
EQ16	1.13E-09	4.21E-15	1.49E-12	4.70E-10	6.59E-10
EQ17	6.84E-10	1.21E-15	6.06E-14	5.41E-11	6.30E-10
EQ18	52E-09	1.05E-14	2.04E-11	1.49E-09	3.01E-09
EQ19A	.38E-09	2.21E-12	1.56E-10	1.62E-09	6.00E-10
EQ19B	6.41E-09	1.14E-14	2.04E-11	1.54E-09	4.85E-09
EQ20	2.39E-08	5.24E-11	2.33E-09	1.54E-08	6.16E-09
EQ21	6.12E-09	8.20E-12	4.44E-10	3.69E-09	1.97E-09
EQ22	1.42E-09	1.62E-15	3.32E-12	2.89E-10	1.13E-09
EQ23A	8.67E-09	1.83E-11	9.43E-10	6.30E-09	1.40E-09
EQ23B	6.95E-09	1.15E-14	2.26E-11	1.76E-09	5.17E-09

FIGURE 1. SEISMIC PRE-TREE(USED TO QUANTIFY SEISMIC INITIATING EVENT FREQUENCIES)

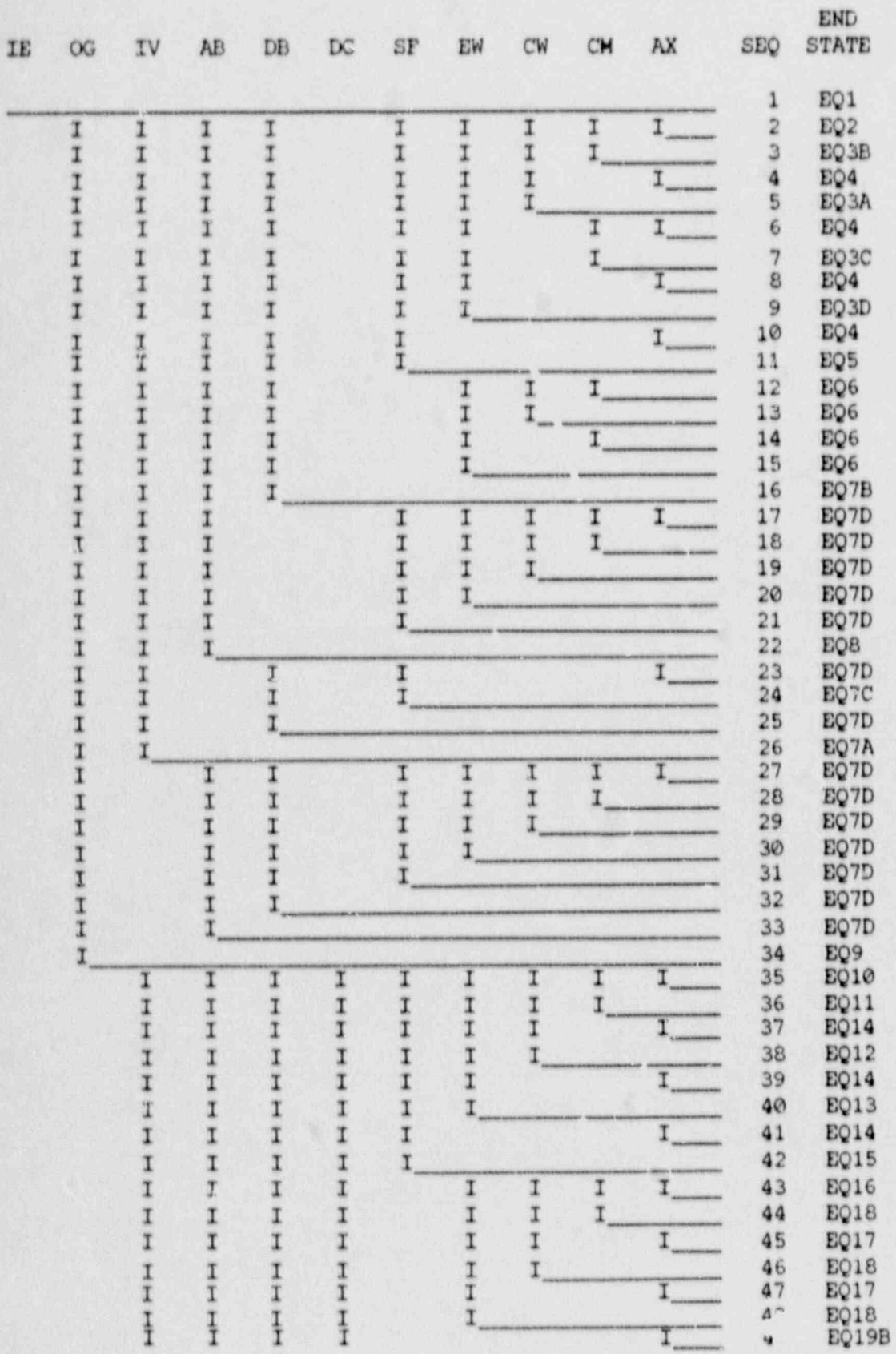
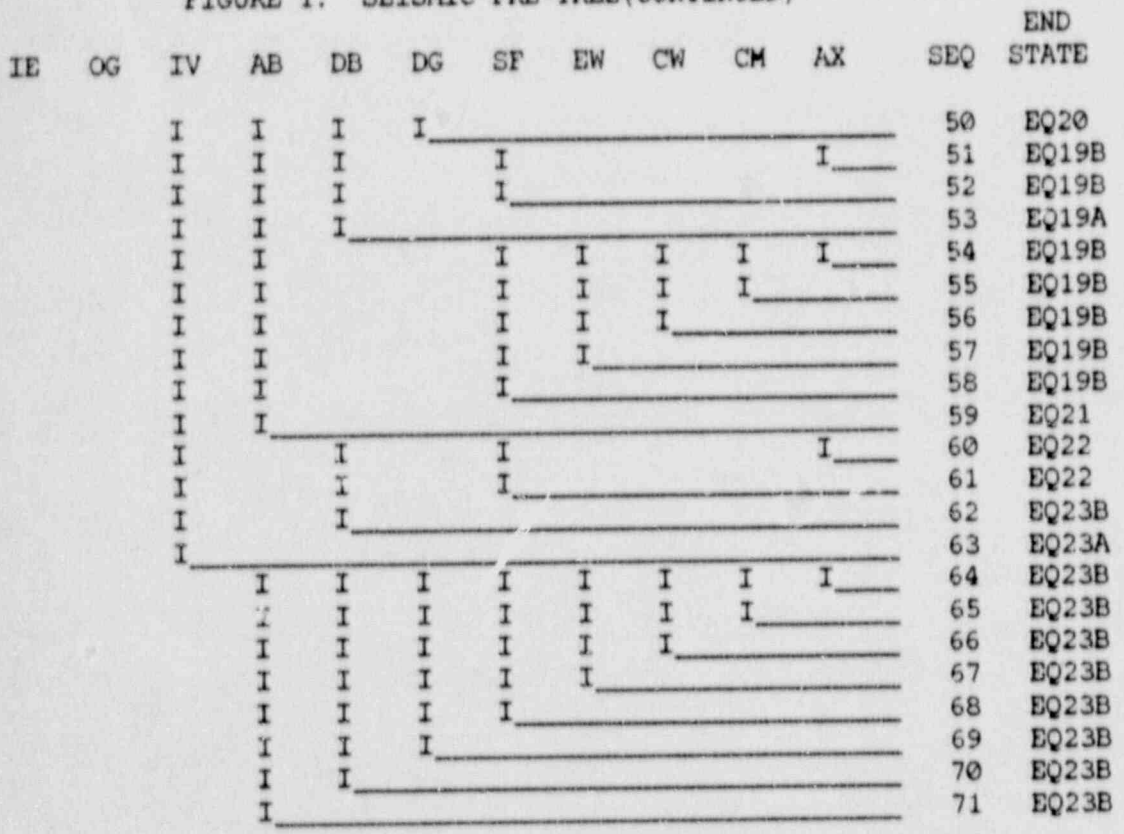


FIGURE 1. SEISMIC PRE-TREE(CONTINUED)



QUESTION 3
ATTACHMENT 1

PLANT LEVEL FRAGILITY CURVE

INTRODUCTION

The risk of core damage at the South Texas Project Electric Generating Station (STPEGS) due to seismic events was quantified as part of the STP Probabilistic Safety Assessment (PSA). The calculation was performed using seismic hazard curves developed by EPRI for nuclear power plant sites in the central and eastern United States. As a sensitivity study, the seismic contribution to core damage was also quantified based on a set of hazard curves developed for the STPEGS site by Lawrence Livermore National Laboratory (LLNL) published in NUREG/CR-5250.

In this report, a plant level core damage fragility curve is developed for the STPEGS site. The plant level fragility curve makes it possible to easily compare the seismic contribution to core damage based on various hazard curves.

SUMMARY OF THE PSA SEISMIC CORE DAMAGE QUANTIFICATION

Section 2.2.4 of the PSA presents the results of a seismic hazard sensitivity study. The methodology used to quantify the seismic core damage frequency is also discussed in Section 2.2.4 and is summarized in the following paragraphs.

The seismic core damage frequency was quantified with the linked event tree model used for the quantification of internal initiating events and an additional seismic event tree. This seismic failure event tree, as can be seen in Figure 2.2-3 of the PSA, depicts the seismic top event unavailability and defines seismic end states that were then input to the support and frontline event trees to consider potential nonseismic system unavailabilities. The relationships between potential seismic failures and their impact on systems and top events in the support and frontline event trees was determined and can be seen in Table 2.2-10 of the PSA.

The algorithm used to quantify the seismic core damage frequency is as follows:

1. The seismic event tree was quantified once for each of four discrete ground acceleration levels. The top event failure fractions used in these quantifications were calculated for each acceleration level by combining the failure fractions of one or more components listed in Table 2.2-11 of the PSA.

2. The frequency of each unique end state of the seismic event tree was summed over all four event tree quantifications.

3. The conditional frequency of core damage for each seismic tree end state was quantified using the support and frontline event trees. These conditional core damage frequencies are not a function of the seismic ground acceleration levels.

4. The unconditional core damage frequency contribution for each of seismic event tree end states is then calculated as the product of the seismic event tree end state frequency and the corresponding conditional core damage frequency.

DEVELOPMENT OF THE PLANT LEVEL FRAGILITY CURVE

The mean plant level fragility curve represents the conditional core damage frequency given a seismic event. The computer code SEIS4 was used to compute the plant level fragility curve for the STPEGS. The SEIS4 program combines the fragility curves for failures of individual elements of the system into a fragility curve for the failure state of system as a whole. This combination is done according to the system logic which is specified by the user. In the case of developing a plant level core damage fragility curve, the system logic is in the form of a Boolean expression representing combinations of top event failures that lead to core damage given a seismic event.

The development of this Boolean expression came directly from the structure of the seismic event tree and the conditional core damage frequencies corresponding to each of the seismic event tree end states. These conditional core damage frequencies are listed in Table 1-1 which is attached. From this table, it can be seen that the majority of the seismic event tree end states lead directly to core damage, i.e., the conditional frequency is equal to 1.0. Those end states that do not lead directly to core damage were multiplied by the corresponding conditional core damage frequency from Table 1-1.

SUMMARY AND RESULTS

The resultant mean plant level fragility curve is presented in tabular form in the attached Table 1-2. To calculate the unconditional mean seismic core damage frequency for a given hazard curve, the analyst must calculate the mean hazard frequency for each of the discrete ground acceleration listed, and then sum the products of the discretized hazard frequencies and the corresponding conditional core damage frequencies.

It should be noted that the structure of the seismic event tree was developed based on the unconditional frequencies of the end state frequencies. This was done to simplify the model by reducing the number of unique seismic event tree end states that need to be processed through the support and frontline event tree models. Many low frequency sequences in the seismic event tree were conservatively assigned to more severe end states to keep the model at a reasonable level of complexity. These conservatism's may need to be reevaluated if a new hazard curve is substituted into the analysis.

Table 1-1. Conditional Core Damage Frequencies For Seismic Event Tree End States	
Seismic Event Tree End State	**Conditional Core Damage Frequency**
EQ1	0.00E-00
EQ2	7.97E-02
EQ3A	1.49E-01
EQ3B	1.03E-01
EQ3C	1.96E-01
EQ3D	1.96E-01
EQ4	1.00E + 00
EQ5	1.00E + 00
EQ6	1.00E + 00
EQ7A	4.08E-01
EQ7B	8.22E-02
EQ7C	1.00E + 00
EQ7D	1.00E + 00
EQ8	1.00E + 00
EQ9	7.77E-03
EQ10	2.99E-01
EQ11	1.00E + 00
EQ12	1.00E + 00
EQ13	1.00E + 00
EQ14	1.00E + 00
EQ15	1.00E + 00
EQ16	1.00E + 00
EQ17	1.00E + 00
EQ18	1.00E + 00
EQ19A	1.00E + 00
EQ19B	1.00E + 00
EQ20	1.00E + 00
EQ21	1.00E + 00
EQ22	1.00E + 00
EQ23A	1.00E + 00
EQ23B	1.00E + 00

Table 1-2. Mean Plant Level Fragility Curve For Seismic Core Damage		
Seismic Ground Acceleration Range (g level)		Conditional Core Damage Frequency
High	Low	
5.0E-2	1.0E-1	6.416E-03
1.0E-1	1.5E-1	4.950E-02
1.5E-1	2.0E-1	1.162E-01
2.0E-1	2.5E-1	2.003E-01
2.5E-1	3.0E-1	2.789E-01
3.0E-1	3.5E-1	3.404E-01
3.5E-1	4.0E-1	3.950E-01
4.0E-1	4.5E-1	4.539E-01
4.5E-1	5.0E-1	5.209E-01
5.0E-1	5.5E-1	5.941E-01
5.5E-1	6.0E-1	6.684E-01
6.0E-1	6.5E-1	7.383E-01
6.5E-1	7.0E-1	7.998E-01
7.0E-1	7.5E-1	8.511E-01
7.5E-1	8.0E-1	8.920E-01
8.0E-1	8.5E-1	9.233E-01
8.5E-1	9.0E-1	9.467E-01
9.0E-1	9.5E-1	9.636E-01
9.5E-1	1.0E + 0	9.755E-01
1.0E + 0	1.05 + 0	9.838E-01

QUESTION 3
ATTACHMENT 2

Table 11.1-2. Discrete Annual Acceleration Frequencies			
Acceleration (g)			
0.1	0.2	0.4	0.6
3.02×10^{-5}	2.89×10^{-6}	7.77×10^{-7}	6.14×10^{-8}

Attachment 1
Responses to STP PSA External Events Questions

Q4: During the walkdown, an open penetration was noted in switchgear room C. Provide a discussion on how this penetration was treated in the PRA.

ponse:

Each of the three switchgear rooms have small open penetrations which communicate from the switchgear rooms to a corridor. These penetrations are either unused or may have a conduit or fire protection pipe passing through it. These penetrations are generally 8 or 10 feet off the floor. The ceiling in the switchgear rooms are much higher than these penetrations. A photograph is attached (Attachment 1) to illustrate these penetrations.

The open penetrations in the walls separating the switchgear room fire zones from the corridor fire zones are not in 3-hour fire barrier walls which separate fire areas (see the STPEGS Fire Hazards Analysis Report (FHAR), Figures 3-14, 3-16 and 3-17). The fire zones in the STPEGS PSA correspond to the fire zones in the STPEGS FHAR. These fire zones subdivide fire areas so that some fire zone boundaries coincide with fire area boundaries and some do not. Fire areas are sections of a building that are separated from other fire areas by boundary fire barriers, which are also described in the FHAR.

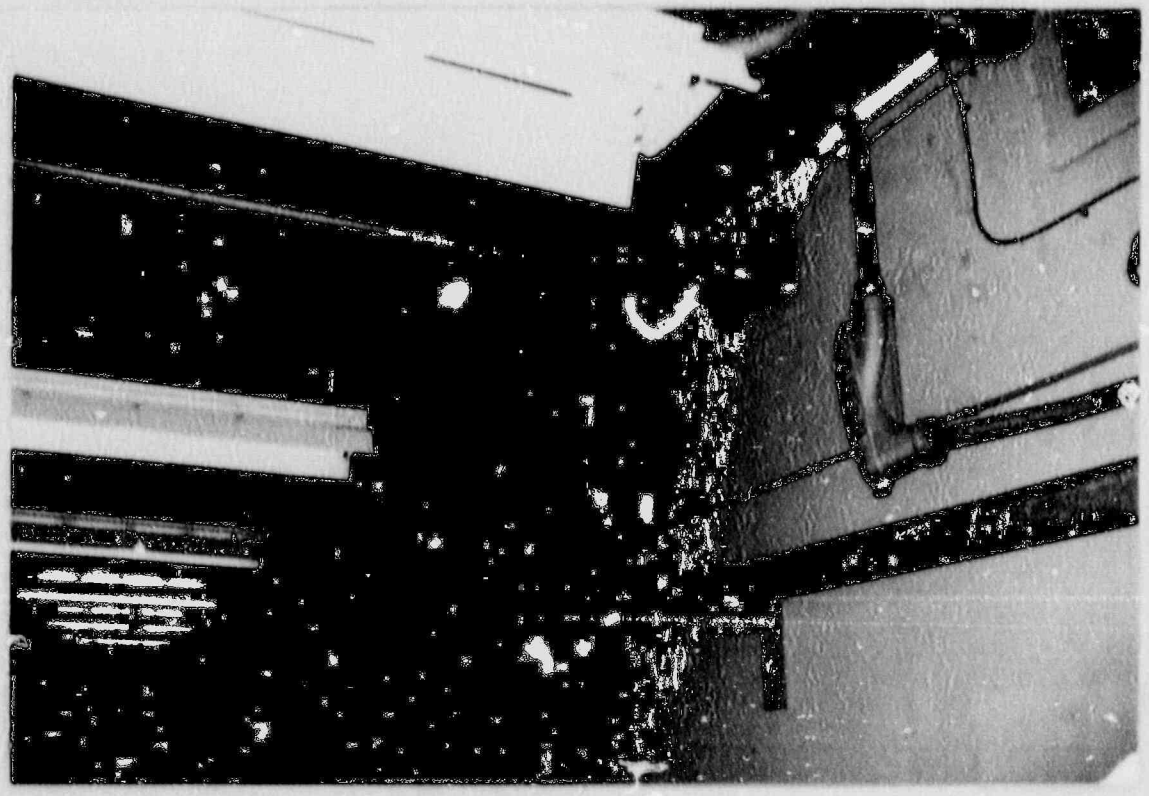
The fire zones represent defined areas which present a natural and/or substantial barrier to fire propagation, but may not be sufficient to meet Appendix R criteria for isolation. Fire zones are separated from each other by heavy concrete walls and are subdivisions of fire areas in which the fire suppression systems are designed to combat particular types of fires. In analyzing the consequences of a fire outside of containment for the FHAR relative to plant safe-shutdown capability, an entire area is conservatively assumed to be lost (for example, the switchgear rooms and corridors are separate fire zones separated by heavy concrete walls but are not in separate fire areas. Each train, however, including the switchgear and battery rooms, is separated from each redundant train by 3-hour rated or equivalent fire barriers. Fire areas meet Appendix R requirements for isolation.

In the case of the three switchgear rooms, i.e., zones Z004, Z042 and Z052, these penetrations are not considered important for the analyses in the PSA for other than smoke propagation and thus are not considered in the PSA external events analysis. In the case of smoke propagation, the PSA assumed that the smoke in the switchgear rooms would be communicated into the corridors and these scenarios were analyzed.

Reference:

1. Fire Hazards Analysis Report, South Texas Project Units 1 and 2, Volumes 1 and 2.

ATTACHMENT 1 TO QUESTION 4



Open penetration in corridor to switchgear room (typical).

Attachment 1
Responses to STP PSA External Events Questions

Q5: Explain the external event quantification process by tracing scenarios 1 and 7 of Table 3.4.3-1 from the initiating event frequency to the core damage and plant damage state frequencies. The purpose is to illustrate intermediate calculation steps and clarify assumptions made in the quantification.

Response:

NOTE: A discussion with the NRC reviewer has clarified that the reference to Table 3.4.3-1 should be to Table 3.4.3-3. The sequences to be discussed were previously identified during the meetings at the STPEGS plant site on May 30 and 31, 1990. These sequences were Sequence 1, Z401-JW-01, and Sequence 7, Z407-HS-01, as identified in Table 3.4.3-3 of the STPEGS PSA.

Sequence Z401-JW-01: This sequence starts with a failure of the #11 AFW pump discharge line. The AFW pumps are located on the bottom floor of the Isolation Valve Cubicle (IVC) building at STPEGS. Each AFW pump is in a separate cubicle so the effects of flooding in one train will not be transmitted to the other trains. However, each AFW cubicle is open above to the associated main feedwater isolation valve and the main steam line isolation valve of that particular train. The PSA assumes that the water from an AFW line leads to direct failure of the associated main feedwater and main steam isolation valves. The sequence is quantified as an inadvertent safety injection initiating event with guaranteed failure of AFW pump #11.

Section 8.5.2 (page 8.5-3) of the PSA identifies that for a flood source which consists of only a few sections of pipe, a frequency of 8E-6 per year per pipe section was used for all systems other than safety related systems and 8E-7 per year per pipe section was used for safety related systems. Reference 1, Table 1 provides a comparison of mechanical component (water or steam working fluid) failure rates from several different sources, including Seabrook. The failure rate for rupture of pipes greater than 3" in diameter for Seabrook is 4.3E-11 per hour per foot using a pipe section length of 20 feet. Using the Seabrook values of 4.3E-11, a pipe break frequency of 8E-6 is calculated as follows:

$$(4.3E\text{-}11) \times (20 \text{ ft/section}) \times (8766 \text{ hrs/yr}) = 8E\text{-}6.$$

The pipe break value determined for Seabrook was for non-safety piping in the turbine building (see pages 9.5-14 and 15 of the Seabrook Station Probabilistic Safety Assessment). Safety-related pipe was assumed to fail at a frequency a factor of 10 less.

The initiating event frequency used for this event is 6.8E-7/year. As the result of the the plant walkdown performed

for the spatial interaction analysis it was estimated that 7 pipe sections or less are in the pump cubicle. After a review of the testing requirements for AFW, it was estimated that an AFW pump would be in operation no more that 1068 hours per year. Since AFW system is a safety system, the initiating event frequency was estimated to be

$$(8E-7)*7*1068/8766 = 6.8E-7$$

This event would fail AFW pump #11. Other random failures would include the other three AFW pumps and operator failure to initiate feed & bleed cooling. These independent failures have been quantified as follows:

Split fraction CDC = 3.784E-4/year found on page 5.5-76 of the PSA identifies the failure likelihood for two motor-driven AFW pumps and the turbine-driven AFW pump.

Split fraction OBA = 4.802E-2/year found on page 5.5-79 of the PSA identifies the failure likelihood for operators failing to open 2 of 2 PORVs for B&F.

The sequence frequency for this event then becomes

$$(6.8E-7)*(3.784E-4)*(4.802E-2) = 1.24E-11/year.$$

The frequency of this sequence is considered negligible. There is no impact on plant damage state frequency since it was not propagated through the plant model.

Sequence Z407-HS-01: This sequence is initiated by a main steam line failure in the IVC (train B). Failure of the train B main steam line is assumed to guarantee failure of the main steam and main feedwater isolation valves and the train B auxiliary feedwater pump. The sequence is quantified as an inadvertent safety injection initiating event with guaranteed failure of AFW pump #12 (i.e., train B AFW pump).

The initiating event frequency used for this sequence is 6.4E-6. In this case as in that above, a pipe break frequency of 8E-7/year per pipe section is used for safety systems. The main steam piping was estimated at 8 sections or less. The initiating event frequency for this event is then

$$(8E-7)*8 = 6.4E-6$$

This event would fail AFW pump #12. Similar to the analysis above, other random failures would include the other three AFW pumps and operator failure to initiate feed & bleed cooling. These independent failures are the same as those for sequence

Z401-JW-01 above, split fractions CDC and OBA. The sequence frequency for this event then becomes

(6.4E-6)*(3.784E-4)*(4.802E-2) = 1.16E-10/year.

The frequency of this sequence is considered negligible. There is no impact on plant damage state frequency since it was not propagated through the plant model.

References:

1. Eide, Steven A., et. al., "Generic Component Failure Data Base for Light Water and Liquid Sodium Reactor PRAs," EGG-SSRE-8875, February 1990.

2. Seabrook Station Probabilistic Safety Assessment, PLG-0300, Pickard, Lowe & Garrick, Inc., December, 1983.

Attachment 1
Responses to STP PSA External Events Questions

Q6: Provide a discussion on data used in the aircraft impact analysis performed in the PRA versus data used in the FSAR analysis. If there are no significant differences between the two analyses, then state so.

Response:

The information contained in the PSA for aircraft crash and the data used in the UFSAR have been reviewed. No changes to the data presented in the UFSAR has been made since the PSA was completed. The general aviation accidents per mile in the PSA is 2.3×10^{-7} while it is 1.8×10^{-7} in the UFSAR. These and other minor differences arise from using slightly different historical data bases. The UFSAR uses data from 1966-1976 (Reference 3.5-11 in the UFSAR) while the PSA uses data from 1980 (Reference 14-3 in the PSA). The basic methodology employed in both studies are the same. Since no significant quantitative difference exists, we believe that the PSA does not need to be revised.

Reference:

1. UFSAR, Chapter 3.5.1.6, Rev. 0.