GE Nuclear Energy

General Electric Company
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April 30, 1993

Docket No. STN 52-001

Chet Poslusny, Senior Project Manager
Standardization Project Directorate
Associate Directorate for Advanced Reactors
and License Renewal
Office of the Nuclear Reactor Regulation

Subject: Submittal Supporting Accelerated ABWR Review Schedule - **DFSER Chapters 3 and 6 Outstanding Items and Question Response**

Dear Chet:

Enclosed are SSAR markups addressing Confirmatory Items 3.6.1-2 and 6.2.1.7-1, and response to Open Item 6.2.1.6-3. In addition, the response to a question on Subsection 6.2.1.2.2 Design Features is enclosed.

It must be noted that the pressure/temperature values in revised Table 3I.3-15 (responding to Confirmatory Item 3.6.1-2) do not include adjustments for blowout panel failure consideration. The applicability of including blowout panel failure considerations in RB/SC compartment pressurization analyses was discussed with the Staff during the April 13 - 15, 1993, Plant Systems Branch meeting in San Jose. Current regulations, standard review plan requirements and previous safety evaluations do not suggest on imposing the failure of a passive blowout panel devise for subcompartment pressurization analyses. In conclusion, the Staff agreed that subcompartment pressurization analyses need not to consider failure of blowout panel.

Please provide copies of this transmittal to Butch Burton and Tony D'Angelo.

Sincerely,

Jack Fox

Jack Fox
Advanced Reactor Programs

060037

cc: Norman Fletcher (DOE)
Umesh Saxena (GE)

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CI 3.6.1-2

Table 3I.3-15

Thermodynamic Environment Conditions Inside Reactor Building (Secodary Contaiment) Plant Accident condition

a) Pressure, temperature and relative humidity

Plant Zone /Typical Equipment					
Control rod drive hydraulic system (scram etc. of hydraulic control unit) [Fig's. 1.2-4/4.6-8]	Temperature (C)	120	100	66	66
	Pressure (Kg/cm^2 g)	1.05	0.035	0.035	0
	Humidity (%)	Steam	Steam	100	90 Max
	Time(2)	1(h)	6(h)	12(h)	100(day)
Control rod hydraulic pumps [Fig's. 1.2-4/4.6-8]	Temperature (C)	120	66		
	Pressure (Kg/cm^2 g)	1.05	0		
	Humidity (%)	Steam	90 Max		
	Time(2)	1 to 6(h)	6h to 100(day)		
RCIC valves (except isolation valves), assemblies, cable turbine [Fig's. 1.2-4/ 5.4-8]	Temperature (C)	142	66	66	
	Pressure (Kg/cm^2 g)	1.05	0.035	0	
	Humidity (%)	Steam	100	90 Max	
	Time(2)	6(h)	12(h)	100(day)	
RCIC turbine electric control system (3),(6) [Fig's. 1.2-5/5.4-8]	Temperature (C)	142	66	66	
	Pressure (Kg/cm^2 g)	1.05	0.035	0	
	Humidity (%)	Steam	100	90 Max	
	Time(2)	6(h)	12(h)	100(day)	
RHR (LPFL, cooling system at S/D, containment cooling. Service water system) valve, pump (motor, seal cooler) instrument control electric equipment (including cable and sources of electricity) [Fig's. 1.2-4/5.4-10]	Temperature (C)	120	66	66	
	Pressure (Kg/cm^2 g)	1.05	0.035	0	
	Humidity (%)	Steam	100	90 Max	
	Time(2)	6(h)	12(h)	100(day)	
HPCF pump, motor (seal cooler) instrument, control electric equipment (including cable and sources of electricity [Fig's. 1.2-4/6.3-7]	Temperature (C)	120	66	66	
	Pressure (Kg/cm^2 g)	1.05	0.035	0	
	Humidity (%)	Steam	100	90 Max	
	Time(2)	6(h)	12(h)	100(day)	
Neutron monitor system (6), (cable of IRM, preamplifier drive relay panel, cable of LPRM) [Fig's. 1.2-3b/7.6-1]	Temperature (C)	120	66	66	
	Pressure (Kg/cm^2 g)	1.05	0.035	0	
	Humidity (%)	Steam	100	90 Max	
	Time(2)	6(h)	12(h)	100(day)	
Leak detection installation (steam water)(4),(6) (instrument, sources of electricity) instrument and sources of electricity for surveillance after accident [Fig's. 1.2-6/5.2-8]	Temperature (C)	120(3)	100	66	66
	Pressure (Kg/cm^2 g)	1.05	0.035	0.035	0
	Humidity (%)	Steam	Steam	100	90 Max
	Time(2)	1(h)	6(h)	12(h)	100(day)

Table 3I.3-15

Thermodynamic Environment Conditions Inside Reactor Building (Secodary Containment) Plant Accident condition

a) Pressure, temperature and relative humidity

Plant Zone /Typical Equipment					
Switchgear and MCC for ECCS system (6) [Fig's. 1.2-6/8.3-1]	Temperature (C)	120 (3)	66	66	
	Pressure (Kg/cm^2 g)	1.05	0.035	0	
	Humidity (%)	Steam	100	90 Max	
	Time(2)	6(h)	12(h)	100(day)	
FPC (cooling system, SPCU [make-up] water system] valve, pump motor, heat exchanger, instrument, control electric equipment) cable sources of electricity [Fig's. 1.2-9/9.1-1]	Temperature (C)	120	66	66	
	Pressure (Kg/cm^2 g)	1.05	0.035	0	
	Humidity (%)	Steam	100	90 Max	
	Time(2)	6(h)	12(h)	100(day)	
Isolation valve(1) (Water line(4), air line(4)) [Fig's. 1.2-4/4.6-8]	Temperature (C)	171-100(3)	100	66	66
	Pressure (Kg/cm^2 g)	1.05	0.035	0.035	0
	Humidity (%)	Steam	Steam	100	90 Max
	Time(2)	1(h)	6(h)	12(h)	100(day)
Main Steam Tunnel (outside secondary containment)					
MS isolation valve (1) MS drain isolation valve Nitrogen line isolation valve (1),(4) Process water line isolation valve (1),(4) [Fig's. 1.2-2, 1.2-3, 1.2-3a, 5.1-3]	Temperature (C)	171	100	66	66
	Pressure (Kg/cm^2 g)	1.05	0.035	0.035	0
	Humidity (%)	Steam	Steam	100	90 Max
	Time(2)	1(h)	6(h)	12(h)	100(day)
Feedwater isolation valve (1) [Fig's. 1.2-2, 1.2-3, 1.2-3a//5.1-3]	Temperature (C)	171	100	66	66
	Pressure (Kg/cm^2 g)	1.05	0.035	0.035	0
	Humidity (%)	Steam	Steam	100	90 Max
	Time(2)	1(h)	6(h)	12(h)	100(day)
RCIC injection valve(1), check valve (inside MS tunnel), steam line isolation valve [Fig's. 1.2-2, 1.2-3, 1.2-3a/5.4-8]	Temperature (C)	171	100	66	66
	Pressure (Kg/cm^2 g)	1.05	0.035	0.035	0
	Humidity (%)	Steam	Steam	100	90 Max
	Time(2)	1(h)	6(h)	12(h)	100(day)
RHR only division A) LPFL injection valve (1), check valve (inside MS tunnel [Fig's. 1.2-2, 1.2-3, 1.2-3a/5.4-10]	Temperature (C)	171	100	66	66
	Pressure (Kg/cm^2 g)	1.05	0.035	0.035	0
	Humidity (%)	Steam	Steam	100	90 Max
	Time(2)	1(h)	6(h)	12(h)	100(day)
Isolation valve(1) (MS line steam drain line) [Fig's. 1.2-2, 1.2-3, 1.2-3a/5.1-3]	Temperature (C)	171-100(3)	100	66	66
	Pressure (Kg/cm^2 g)	1.05	0.035	0.035	0
	Humidity (%)	Steam	Steam	100	90 Max
	Time(2)	1(h)	6(h)	12(h)	100(day)

Table 3I.3-15

Thermodynamic Environment Conditions Inside Reactor Building (Secodary Contaiment) Plant Accident condition

(1) Valve assemblies and cables required for valve operation are included

(2) Time means the time from the occurrence of LOCA

(3) The saturation temperature corresponding with the design pressure in secondary containment or the design pressure of blowout panel shall be applied.

(4) 100C may be applied in the case that adequate separation in the arrangement is ensured and there is no possibility of exposure to steam environment.

(5) Among the equipments required to operate during the accident and post accident conditions, the equipments that are related to the above equipments and arranged in the turbine building or reactor building (outside secondary containment) will use the conditions specified in these

(6) MCC and switchgear etc. related to ECCS that can not stand 100% humidity or high temperature shall be installed outside the secondary containment or in a room with other than reactor building (secondary containment) HVAC system.

CT 6.2.1.7-1

6.2.3.3.1.1 Design Bases

The design of secondary containment compartments with respect to pressurization due to a pipe rupture is based upon the worst-case DBA rupture of a high energy line postulated to occur in each compartment through which high energy line passes (For detail regarding the pipe rupture location and configuration see Subsection 3.6.2). The pipe rupture producing the highest mass and energy release rate, in conjunction with a worst case single active component failure was chosen for the pressurization analysis of each compartment. For this analysis, a worst case single active component failure is defined as the failure to close an isolation valve which separates the reactor pressure vessel from the high energy pipe break in the secondary containment. The design pressure for the compartment structure design will include some margin over the calculated peak differential pressure. The design margin is intended to make allowance for changes (piping, equipment layout arrangement) in the as-built compartment design.

6.2.3.3.1.2 Design Features

The following paragraphs are brief description of the compartments analyzed for pressurization. Figures 1.2-3 through 1.2-10 show compartment configurations, and component and equipment locations. The schematic layout of the compartments, with the interconnecting vent paths and blowout panels, which were modeled and analyzed for various line breaks are shown in Figures 6.2-37A through 2.2-37C.

6.2.3.3.1.2.1 Reactor Core Isolation Cooling (RCIC) Compartments

The RCIC compartment is located in the secondary containment at Elevation (-)8200 mm, in the 0-90 degree quadrant of the reactor building. The design basis break for the RCIC compartments is determined to be the single-ended break of 150 mm steam supply line to the RCIC turbine. This line is a high energy line out to normally closed isolation valve inside the RCIC compartment. It supplies high energy steam to RCIC turbine in the event of reactor vessel isolation. In the event of a postulated design basis high energy line break in a compartment, the steam/air mixture from that compartment is directed into adjoining compartments and is eventually purged into the turbine building through the steam tunnel.

6.2.3.3.1.2.2 Reactor Water Cleanup (RWCU) Equipment Rooms and Pipe Spaces

The RWCU equipment (pump, heat exchanger, Filter/demineralizer, valves) and pipe spaces are located in the 0 - 270 degree quadrant of the reactor building, with floor elevations ranging are from Elevation (-) 8200 mm to Elevation (+) 12300 mm. The design basis pipe break for the RWCU system compartment network is determine to be a 200 mm double-ended break of the cleanup water suction line from the RPV. This high energy piping, which connects the RWCU equipment, originates at the reactor pressure vessel. After being routed through the RWCU system, this line is directed back to the reactor pressure vessel through special pipe spaces and the steam tunnel. In the event of a postulated design basis high energy line break in a compartment, the steam/air mixture from that compartment is directed into adjoining compartments and eventually purged into the turbine building through the steam tunnel.

6.2.3.3.1.2.3 Main Steam Tunnel

The reactor building main steam tunnel is located between the primary containment vessel and the turbine building at Elevation (+) 12300 mm and 0 degree azimuthal position. The DBA for the steam tunnel is determine to be double-ended break of one of the four main steam lines. These lines originate at the reactor pressure vessel and are routed through the main steam tunnel to the turbine building. In the event of postulated design basis high energy line break, the steam/air mixture from the steam tunnel is purged into the turbine building.

6.2.3.3.1.3 Design Evaluation

The compartment response to the postulated high energy line break was calculated using the engineering computer program SCAM. A detail discussion of methodology and assumptions used in this program can be found in reference 4.

The initial conditions for the analysis include the assumption of 102% rated reactor power and the compartment pressures, temperatures and relative humidity as tabulated in Table 6.2-3. Blowout panels are used in place of open vent pathways when the environmental conditions of one compartment must be isolated from the environment in another compartment. The blowout panels are assumed to open fully against a differential pressure of 0.0352 Kg/cm^2 g, and are assumed to remain open.

For the postulated high energy line break, the blowdown mass and energy release rates from the break were determined using moody's homogeneous equilibrium model for critical flow described in reference 2. The blowdown mass and energy release rate for the postulated High Energy Line Break (HELB) in a given compartment comprised of initial inventory depletion followed by steady critical flow from the ruptured pipe. After the inventory depletion period, break flow, limited by critical flow consideration, continues until isolation valve is fully closed.

The following paragraphs describe the key assumptions and calculation of mass and energy release rates for the postulated HELB in the RCIC, RWCU, and Main Steam Tunnel compartments.

6.2.3.3.1.3.1 RCIC compartment

For RCIC a single-ended pipe break ,as noted earlier, was postulated. The mass and energy blowdown release rate comprised only of flow from the RPV side. The flow from the other side of the break was assumed to be negligible. The blowdown flow comprised of initial inventory depletion followed by steady critical flow from the RPV. In computing the critical flow rate, flow loss factors between RPV and break location were ignored for conservatism. Tabulated values of mass energy release rate for the postulated break is shown in Table 6.2-4B-1. The total blowdown duration of 41 seconds, as obvious from tabulated values, is based on assumption that isolation valve starts closing at 11 seconds (1 second instrument response time and 10 seconds built in logic time delay) after the break and is fully closed in 30 seconds. Considering that the isolation valve is gate valve, a non-linear flow area changes with respect to time were used during the valve closure period.

Figure 6.2.-37A shows the compartment nodalization scheme used for the pressurization analysis model for different break cases. Table 6.2.3 shows the free volume,initial environmental conditions and DBA characteristics for the compartments which were analyzed. Table 6.2-4 tabulates subcompartment vent path characteristic. The calculated peak differential pressures for the RCIC compartments are tabulated in Table 6.2-3.

6.2.3.3.1.3.2 **RWCU compartment**

For RWCU a double-ended pipe break ,as noted earlier, was postulated. The mass and energy blowdown release rate comprised of flow from both The RPV and BOP sides of the break location. The flow from the RPV side comprised of initial inventory depletion followed by steady critical flow. The flow from the BOP side is the depletion of inventory between the break location and the closest check valve. Flow loss factors due to pipe friction , and other mechanical devises such as valves, elbows, tees, etc. were accounted for only in determining steady critical flow rate, and not in determining the depletion flow rate. Table 6.6-4A tabulates the flow loss factor considered for different postulated pipe break locations.

After the initial inventory depletion period, the steady RPV blowdown is chocked at the venturi located upstream of the isolation valve, since venturi flow area is smaller then the isolation valve flow area. At some point in time, after the isolation valve start closing, valve flow area will become equal to the venturi flow area. From that point in time flow will chock at the isolation valve. The break flow ceased when isolation valve is fully closed.

Compartment pressurization analyses were done for postulated pipe breaks in different compartments. Tabulated mass and energy release rate for the postulated break cases are shown in Table 6.2-4B-2. The total blowdown duration of 76 second, as obvious from the tabulated values, is base on the assumption that isolation valve starts to close at 46 seconds (1 second instrument response

time and 45 seconds built in logic time delay) after the break and the isolation valve is fully closed in 30 seconds. Considering that the isolation valve is a gate valve, non-linear flow area changes with respect to time were used during the valve closure period.

Figures 6.2-37-C1 through 6.2-37-C3 show compartment nodalization scheme for the pressurization analyses for different break cases. Table 6.2-3 shows the free volume,initial environmental conditions and DBA characteristics for the compartments which were analyzed. Table 6.2-4 tabulates subcompartment vent path characteristic. The calculated peak differential pressures for the RWCU compartments are tabulated in Table 6.2-3

6.2.3.3.1.3.3 Main Steam Tunnel

A double ended Main steam Line (MSL) break was postulated. The mass and energy release rate comprised of flow from both the RPV and BOP sides. The blowdown flow comprised of initial inventory depletion followed by steady critical flow from the RPV and BOP sides. In calculating the critical flow rate flow loss factors were ignored for conservatism.

Tabulated values of mass and energy release rate for the postulated MSL break is shown in Table 6.2-4B-3. The total blowdown duration of 5.5 seconds, as obvious from the tabulated values, is based on the assumption that the main steam isolation valve (MSIV) starts closing at .5 second after the break and is fully closed in 5 seconds. The duration of 5.5 seconds is the longest closing time for the MSIVs.

Figure 6.2-37B shows compartment nodalization scheme for the pressurization analyses for different postulated break cases. Table 6.2.3 shows the free volume,initial environmental conditions and DBA characteristics for the compartments analyzed. Table 6.2-4 tabulates subcompartment vent path characteristic. The calculated peak differential pressures for the main steam tunnel compartments are tabulated in Table 6.2-3.

TABLE 6.2-3
SUBCOMPARTMENT NODAL DESCRIPTION

VOLUME ID	DESCRIPTION	INITIAL CONDITIONS: VOLUME m^3	TEMP. (c)	PRESSURE Kg/cm^2 a	HUMIDITY (%)	DESIGN BASIS ACCIDENT BREAK CHARACTERISTICS: BREAK [2] LOCATION VOLUME ID	BREAK LINE IDENTIFICATION	CALC. PEAK PRESSURE Kg/cm^2 g	DESIGN [4] PRESSURE (MARGIN) Kg/cm^2 g	MARGIN %
SS1	STEAM TUNNEL REACTOR BUILD.	1948	60	1.03	10.0	SS1	MAIN STEAM	0.60	0.77	28
SS2	STEAM TUNNEL BETW. RB. &TB.	244	60	1.03	10.0	SS2	MAIN STEAM	0.34	0.77	127
SS3	STEAM TUNNEL INSIDE TB.	850	60	1.03	10.0	[3]	[3]	[3]	[3]	-
SS4	STEAM TUNNEL INSIDE TB.	178	60	1.03	10.0	[3]	[3]	[3]	[3]	-
SS5	TURBINE BUILDING	144982	40	1.03	10.0	[3]	[3]	[3]	[3]	-
SA1	RHR PUMP & HEAT EXCHANGER	631	40	1.03	10.0	SA2 [1]	RCIC (STEAM)	0.25	1.05	318
SA2	RCIC PUMP & TURBINE ROOM	542	40	1.03	10.0	SA2	RCIC (STEAM)	0.24	1.05	345
SA3	ECCS-DIV A B1F,B2F, &B3F PS	356	40	1.03	10.0	SA2	RCIC (STEAM)	0.20	1.05	419
SA4	FLOOR BM1F	389	40	1.03	10.0	SA2 [1]	RCIC (STEAM)	0.15	1.05	622
SA5	FPC DEMIN BACKWASH PUMPS	263	40	1.03	10.0	SA2 [1]	RCIC (STEAM)	0.18	See SR3	-
SA6	FPC PIPESPACE	61	40	1.03	10.0	SA2 [1]	RCIC (STEAM)	0.08	See SR5	-
SA7	STEAM TUNNEL & PART OF TB.	3220	40	1.03	10.0	SA2 [1]	RCIC (STEAM)	0.22	1.05	378
SA8	TURBINE BUILDING	144982	40	1.03	10.0	[3]	[3]	[3]	[3]	
SR1	TURBINE BUILD.	144982	40	1.03	10.0	[3]	[3]	[3]	[3]	-
SR2	RWCU PIPE ENTR/EXIT ROOM	122	40	1.03	10.0	SR2	RWCU	0.37	1.05	184
SR3	FPC DEMIN BACKWASH PUMPS	263	40	1.03	10.0	SR8 [1]	RWCU	0.52	1.05	101
SR4	RWCU REGENER. HEAT EXCHANGER VALVE ROOM	143	40	1.03	10.0	SR8	RWCU	0.60	1.05	75
SR5	FPC PIPESPACE	61	40	1.03	10.0	SR8 [1]	RWCU	0.51	1.05	108
SR6	RWCU PIPESPACE	36	40	1.03	10.0	SR6	RWCU	0.67	1.05	58
SR7	RWCU NON-REGENER. HEAT EXCHANGER VALVE ROOM & RWCU PUMP VALVE ROOM	110	40	1.03	10.0	SR8	RWCU	0.75	1.05	40
SR8	RWCU NON-REGENER. & REGEN. HX. ROOMS	361	40	1.03	10.0	SR8	RWCU	0.76	1.05	38
SR9	EL -8200 cooridor	937	40	1.03	10.0	SR8 [1]	RWCU	0.75	1.05	41
SR10	RWCU PUMP ROOM A & B	249	40	1.03	10.0	SR8	RWCU	0.73	1.05	45
SR11	RWCU FILTER/DEMIN. RM. B	51	40	1.03	10.0	SR11	RWCU	0.73	1.05	45
SR12	RWCU FILTER/DEMIN. RM. A	51	40	1.03	10.0	SR12	RWCU	0.79	1.05	34
SR13	RWCU FILTER/DEMIN. VALVE ROOM A & B	421	40	1.03	10.0	SR8	RWCU	0.52	1.05	101

Note
[1]No RCIC or RWCU High Energy Line passes through the compartment.
[2]Break subcompartment causing maximum peak pressure.
[3]High Energy Line Break analysis inside the Turbine Building is not required.
[4]The design pressures are to be used in conjunction with appropriate dynamic load factors for structural evaluations.

TABLE 6.2-4.

SUBCOMPARTMENT VENT PATH DESCRIPTION

VENT PATH ID	FROM VOLUME NODE ID	TO VOLUME NODE ID	FLOW CHOKED OR UNCHOKED	FLOW SONIC OR SUBSONIC	VENT AREA (m^2)	VENT LENGTH (m)	HEAD LOSS COEFFICIENT FORWARD	HEAD LOSS COEFFICIENT REVERSE	BLOWOUT OPENING PRESSURE (DP) (kg/cm2 g)
FA1	SA1	SA3	UNCHOKED	SUBSONIC	48.77	0.5	1.56	1.69	(3)
FA2	SA2	SA3	↓	↓	152.40	0.5	0.88	1.13	(3)
FA3	SA3	SA4			24.38	0.5	1.35	(2)	0.035
FA4	SA4	SA6			30.48	1.0	1.21	(2)	0.035
FA5	SA5	SA6			30.48	0.5	1.66	0.02	(3)
FA6	SA6	SA7			30.48	2.0	0.75	(2)	0.035
FA7	SA3	SA4			24.38	0.5	1.39	(2)	0.035
FA8	SA3	SA4			24.38	0.5	1.35	(2)	0.035
FA9	SA3	SA4			24.38	0.5	1.35	(2)	0.035
FA10	SA1	SA2			6.10	0.7	1.02	1.02	0.035
FA11	SA7	SA8			170.63	27.7	0.56	0.62	(3)
FA12	SA7	SA8			106.25	0.3	0.48	1.61	(3)
FR1	SR2	SR1			60.96	2.0	0.78	(2)	0.035
FR2	SR5	SR1			30.48	2.0	0.75	(2)	0.035
FR3	SR6	SR2			24.38	0.9	1.40	0.02	(3)
FR4	SR8	SR4			15.24	0.9	1.31	1.24	(3)
FR5	SR4	SR6			24.38	0.9	0.02	0.73	(3)
FR6	SR8	SR7			30.48	0.9	1.43	1.29	0.035
FR7	SR8	SR7			30.48	0.9	1.43	1.29	0.035
FR8	SR10	SR7			24.38	0.9	1.22	1.36	0.035
FR9	SR13	SR4			30.48	0.9	1.40	1.44	0.035
FR10	SR13	SR4			30.48	0.9	1.40	1.44	0.035
FR11	SR3	SR5			30.48	0.5	1.66	0.02	(3)
FR12	SR7	SR9			30.48	0.9	1.41	1.48	0.035
FR13	SR8	SR9			91.44	0.9	1.36	(2)	0.035
FR14	SR10	SR9			64.01	0.9	1.46	(2)	0.035
FR15	SR8	SR4			76.20	0.9	1.42	0.9	0.035
FR16	SR6	SR5			27.43	0.9	0.88	0.88	0.035
FR17	← Deleted →				← Deleted →				
FR18	SR11	SR6			18.29	0.9	1.30	(2)	0.035
FR19	SR11	SR6			18.29	0.9	1.30	(2)	0.035
FR20	SR13	SR3			18.29	0.9	1.39	1.26	0.035
FR21	SR13	SR3			18.29	0.9	1.39	1.26	0.035
FR22	(see note 1 below)				59.13		(see note 1 below)		
FR23	(see note 1 below)				106.07		(see note 1 below)		
FR24	SR12	SR11			45.72	0.9	1.24	(2)	0.035
FR25	SR12	SR11			45.72	0.9	1.24	(2)	0.035
FR26	(see note 1 below)				109.73		(see note 1 below)		
FR27	↓	↓			15.24	↓	↓	↓	
FR28					15.85				
FR29					92.05				
FS1	SS1	SR2			194.83	0.3	1.58	0.49	(3)
FS2	SS2	SR3			194.83	0.3	0.49	1.72	(3)
FS3	SS3	SS4			106.25	0.3	1.76	0.48	(3)
FS4	SS2	SS5			170.63	27.7	0.56	0.62	(3)
FS5	SS4	SS5			106.25	0.3	0.48	1.61	(3)
FS6	SR5	ATM.			60.96	0.9	0.52	(2)	0.035
FS7	SR5	ATM.			60.96	0.9	0.52	(2)	0.035
FS8	SR5	ATM.			60.96	0.9	0.52	(2)	0.035

NOTES:
(1) Indicates vent paths internal to a node.
(2) Indicates one-directional blow-out panel. Reverse loss coefficient not applicable.
(3) Indicates flowpath without blowout panel.

TABLE 6.2-4A

FLOW LOSS FACTOR

BREAK NODE	PIPE ID (m)	PIPE LENGTH (m)	PIPE FRICTION FACTOR	PIPE LOSS COEFFICIENT	MECHANICAL LOSS COEFFICIENT	OVERALL [1] LOSS COEFFICIENT
SS1				LOSSES NOT CONSIDERED		
SS2				LOSSES NOT CONSIDERED		
SS3				NO BREAK POSTULATED		
SS4				NO BREAK POSTULATED		
SS5				NO BREAK POSTULATED		
SA1				NO HIGH ENERGY LINES PRESENT		
SA2				LOSSES NOT CONSIDERED		
SA3				LOSSES NOT CONSIDERED		
SA4				NO HIGH ENERGY LINES PRESENT		
SA5				NO HIGH ENERGY LINES PRESENT		
SA6				NO HIGH ENERGY LINES PRESENT		
SA7				NO HIGH ENERGY LINES PRESENT		
SR1				NO BREAK POSTULATED		
SR2	0.05816	56	0.015	4.4	1.7	6.1
SR3				NO HIGH ENERGY LINES PRESENT		
SR4	0.05816	89	0.015	7.0	3.4	10.4
SR5				NO HIGH ENERGY LINES PRESENT		
SR6	0.05816	66	0.015	5.2	1.7	6.9
SR7	0.05816	98	0.015	7.7	57.1	64.7
SR8	0.05816	93	0.015	7.3	3.7	11.0
SR9				NO HIGH ENERGY LINES PRESENT		
SR10	0.05816	171	0.015	13.4	92.6	100.0
SR11	0.05816	210	0.015	16.5	203.3	100.0
SR12	0.05816	210	0.015	16.5	203.3	100.0
SR13	0.05816	210	0.015	16.5	203.3	100.0

Note [1] Overall Loss Coefficient is limited to 100

Table 6.2.4B-1
MASS AND ENERGY RELEASE RATE

Break in subcompartment SA2
RCIC Pump & Turbine Room
and in subcompartment SA3
ECCS Division A B1F,B2F, & B3F
Pipespace(Figure 6.2.37A)

Time (sec)	Mass Flowrate (kg/sec)	Enthalpy (Joule/gram)	Enthalpy Release Rate (KJ/sec)
0.00	189.9	2754.57	5.23E+05
11.00	189.9	2754.57	5.23E+05
17.00	170.8	2754.57	4.70E+05
23.00	140.4	2754.57	3.87E+05
41.00	0.0	2754.57	0.00E+00
1.00E+08	0.0	2754.57	0.00E+00

Table 6.2.4B-2
MASS AND ENERGY RELEASE RATE

Break in subcompartment SR2
RWCU Entrance Room
(Figure 6.2.37c-2)

Time (sec)	Mass Flowrate (kg/sec)	Enthalpy (Joule/gram)	Enthalpy Release Rate (KJ/sec)
0.00	782.4	1224.67	9.58E+05
3.12	782.4	1224.67	9.58E+05
3.12	655.8	1224.67	8.03E+05
9.85	655.8	1224.67	8.03E+05
9.85	376.3	1002.25	3.77E+05
59.65	376.3	1002.25	3.77E+05
59.65	376.3	923.62	3.48E+05
64.05	376.3	923.62	3.48E+05
70.56	232.1	923.62	2.14E+05
70.56	120.3	1224.67	1.47E+05
76.00	0.0	1224.67	0.00E+00
1.00E+08	0.0	0.00	0.00E+00

Break in subcompartment SR4
Regenerative Heat Exchanger
Valve Room & Pipespace
(Figure 6.2.37c-2)

Time (sec)	Mass Flowrate (kg/sec)	Enthalpy Joule/gram	Enthalpy Release Rate (KJ/sec)
0.00	782.4	1224.67	9.58E+05
4.92	782.4	1224.67	9.58E+05
4.92	621.3	1224.67	7.61E+05
8.05	621.3	1224.67	7.61E+05
8.05	341.9	979.92	3.35E+05
57.85	341.9	979.92	3.35E+05
57.85	341.9	893.14	3.05E+05
64.05	341.9	893.14	3.05E+05
68.76	251.1	893.14	2.24E+05
68.76	139.4	1224.67	1.71E+05
76.00	0.0	1224.67	0.00E+00
1.00E+08	0.0	0.00	0.00E+00

Break in subcompartment SR6
RWCU Pipespace
(Figure 6.2.37c-2)

Time (sec)	Mass Flowrate (kg/sec)	Enthalpy (Joule/gram)	Enthalpy Release Rate (KJ/sec)
0.00	782.4	1224.67	9.58E+05
3.66	782.4	1224.67	9.58E+05
3.66	649.5	1224.67	7.95E+05
9.31	649.5	1224.67	7.95E+05
9.31	370.0	998.53	3.70E+05
59.12	370.0	998.53	3.70E+05
59.12	370.0	918.50	3.40E+05
64.05	370.0	918.50	3.40E+05
70.02	240.9	918.50	2.21E+05
70.02	129.1	1224.67	1.58E+05
76.00	0.0	1224.67	0.00E+00
1.00E+08	0.0	0.00	0.00E+00

Break in subcompartment SR7
Non-Regenerative Heat Exchanger
Valve Room & RWCU Pump pipe space
(Figure 6.2.37c-2)

Time (sec)	Mass Flowrate (kg/sec)	Enthalpy Joule/gram	Enthalpy Release Rate (KJ/sec)
0.00	503.0	1058.32	5.32E+05
12.97	503.0	1058.32	5.32E+05
12.97	204.4	815.20	1.67E+05
60.29	204.4	815.20	1.67E+05
60.29	92.6	1224.67	1.13E+05
64.05	92.6	1224.67	1.13E+05
76.00	0.0	1224.67	0.00E+00
1.00E+08	0.0	0.00	0.00E+00

Table 6.2.4B-2 continued
MASS AND ENERGY RELEASE RATE

Break in subcompartment SR8
RWCU Regenerative Heat Exchanger &
Non-Regenerative Heat Exchanger
(Figure 6.2.37c-2)

Time (sec)	Mass Flowrate (kg/sec)	Enthalpy (Joule/gram)	Enthalpy Release Rate (KJ/sec)
0.00	782.4	1224.67	9.58E+05
5.14	782.4	1224.67	9.58E+05
5.14	617.1	1224.67	7.56E+05
7.83	617.1	1224.67	7.56E+05
7.83	337.7	976.90	3.30E+05
57.63	337.7	976.90	3.30E+05
57.63	337.7	888.95	3.00E+05
64.05	337.7	888.95	3.00E+05
68.54	252.7	1224.67	3.10E+05
68.54	141.0	1224.67	1.73E+05
76.00	0.0	1224.67	0.00E+00
1.00E+08	0.0	0.00	0.00E+00

Break in subcompartment SR10
RWCU Pump A & B Rooms
(Figure 6.2.37c-2)

Time (sec)	Mass Flowrate (kg/sec)	Enthalpy Joule/gram	Enthalpy Release Rate (KJ/sec)
0.00	223.5	1224.67	2.74E+05
17.02	223.5	1224.67	2.74E+05
17.02	111.8	1224.67	1.37E+05
34.69	111.8	1224.67	1.37E+05
34.69	111.8	1224.67	1.37E+05
36.77	111.8	1224.67	1.37E+05
36.77	391.2	1224.67	4.79E+05
49.73	391.2	1224.67	4.79E+05
49.73	68.5	1224.67	8.39E+04
64.05	68.5	1224.67	8.39E+04
76.00	0.0	1224.67	0.00E+00
1.00E+08	0.0	1224.67	0.00E+00

Break in subcompartment SR11
and SR12 RWCU Filter/Demin B Room
RWCU Filter/Demin A or B
(Figure 6.2.37c-3)

Time (sec)	Mass Flowrate (kg/sec)	Enthalpy (Joule/gram)	Enthalpy Release Rate (KJ/sec)
0.00	194.8	590.00	1.15E+05
9.90	194.8	590.00	1.15E+05
9.90	503.0	1167.67	5.87E+05
30.55	503.0	1167.67	5.87E+05
30.55	180.2	1065.77	1.92E+05
64.05	180.2	1065.77	1.92E+05
64.05	180.2	1065.77	1.92E+05
76.00	111.8	968.52	1.08E+05
136.42	111.8	968.52	1.08E+05
136.42	0.0	0.00	0.00E+00
1.00E+08	0.0	0.00	0.00E+00

Break in subcompartment SR13
RWCU Filter/Demin A & B Valve Rooms
(Figure 6.2.37c-1)

Time (sec)	Mass Flowrate (kg/sec)	Enthalpy Joule/gram	Enthalpy Release Rate (KJ/sec)
0.00	503.0	999.46	5.03E+05
9.90	503.0	999.46	5.03E+05
9.90	503.0	1167.67	5.87E+05
30.55	503.0	1167.67	5.87E+05
30.55	180.2	1065.77	1.92E+05
64.05	180.2	1065.77	1.92E+05
64.05	180.2	1065.77	1.92E+05
76.00	111.8	968.52	1.08E+05
136.42	111.8	968.52	1.08E+05
136.42	0.0	0.00	0.00E+00
1.00E+08	0.0	0.00	0.00E+00

Table 6.2.4B-3
MASS AND ENERGY RELEASE RATE

Break in subcompartment
SS1 (steam tunnel)
Main Steam Line Break
(Figure 6.2.37B)

Time (sec)	Mass Flowrate (kg/sec)	Enthalpy (Joule/gram)	Enthalpy Release Rate (KJ/sec)
0.0000	5142.9	2770.86	1.43E+07
0.0010	10450.8	1431.96	1.50E+07
0.0059	10450.8	1431.96	1.50E+07
0.0062	7306.6	1431.96	1.05E+07
0.0685	7306.6	1431.96	1.05E+07
0.1779	7301.6	1431.73	1.05E+07
0.2872	7296.1	1431.26	1.04E+07
0.3966	7286.6	1431.03	1.04E+07
0.4747	7281.6	1430.79	1.04E+07
0.5060	7271.7	1430.79	1.04E+07
0.5216	7250.8	1430.56	1.04E+07
0.5841	7155.6	1430.33	1.02E+07
0.6622	7034.5	1430.10	1.01E+07
0.8029	6823.1	1429.63	9.75E+06
0.9103	6661.7	1429.40	9.52E+06
1.0001	6525.6	1429.17	9.33E+06
1.0782	6409.5	1428.93	9.16E+06
1.9982	5049.0	1426.84	7.20E+06
3.0607	3521.1	1427.30	5.03E+06
5.4357	95.7	1438.70	1.38E+05
5.5	0	1438.70	0.00E+00

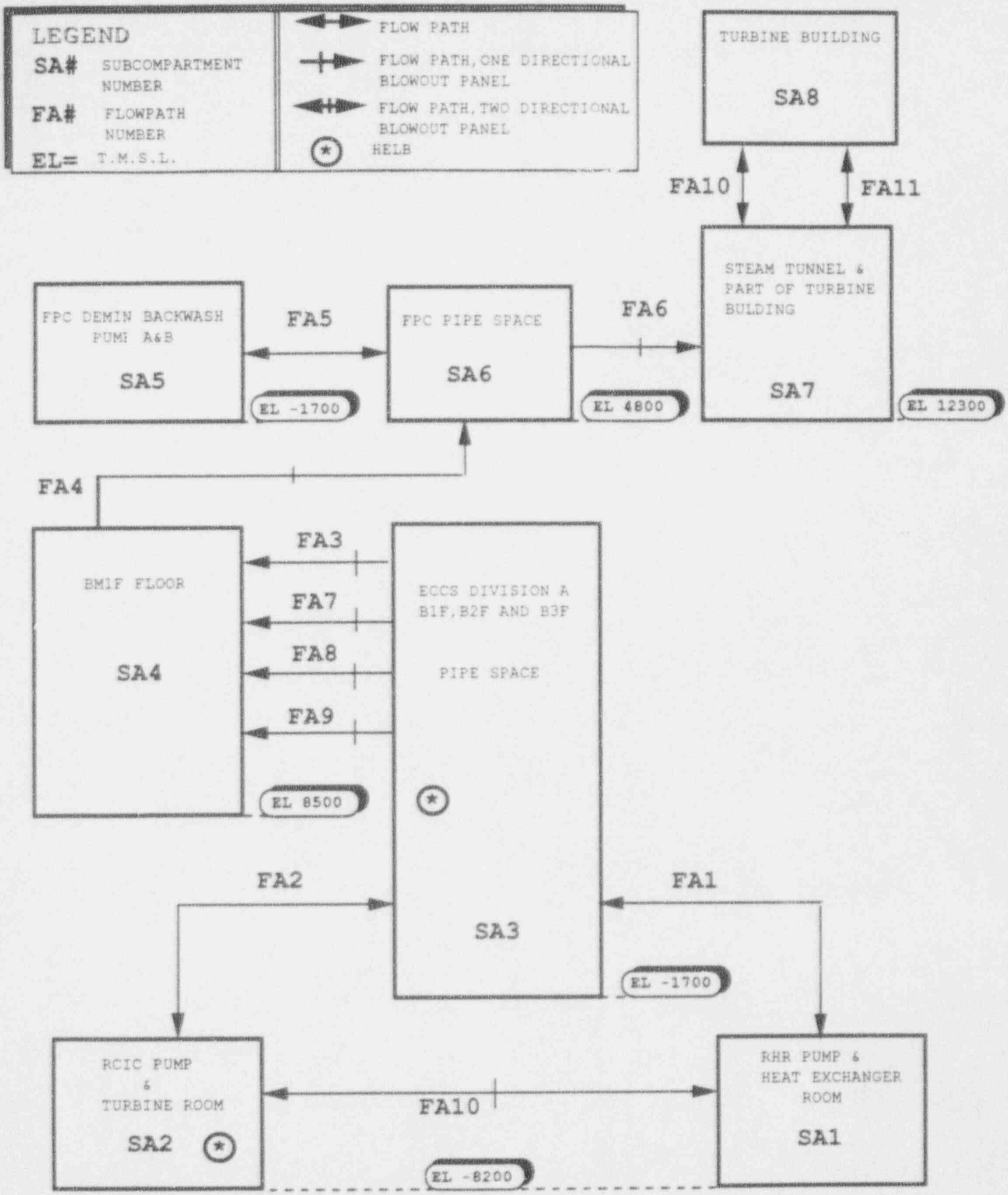


FIGURE 6.2-37A. SECONDARY CONTAINMENT SCHEMATIC FLOW DIAGRAM.
(EMERGENCY CORE COOLING/REACTOR CORE ISOLATION COOLING)

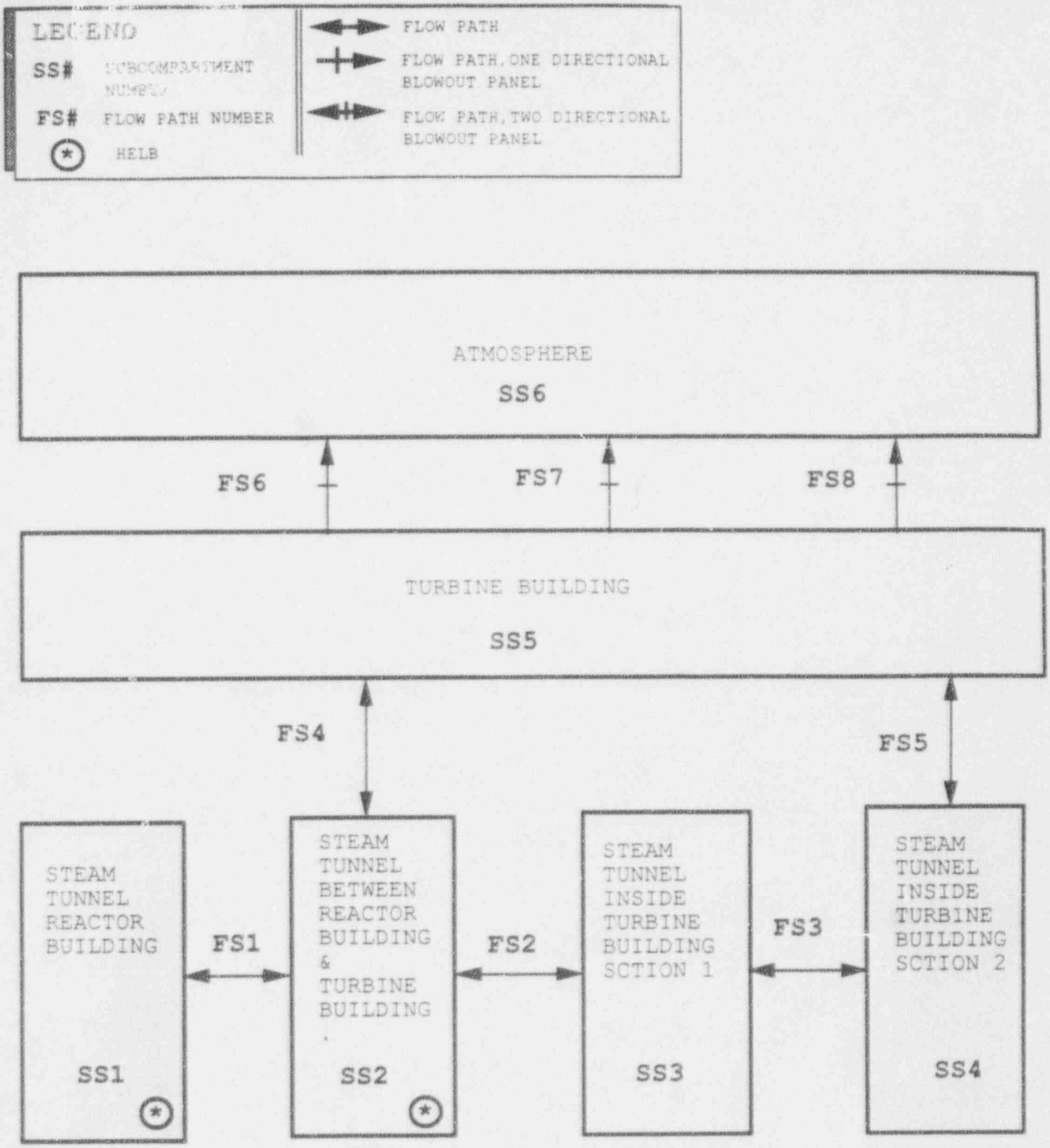


FIGURE 6.2-37B. SECONDARY CONTAINMENT SCHEMATIC FLOW DIAGRAM.
(MAIN STEAM/FEEDWATER)

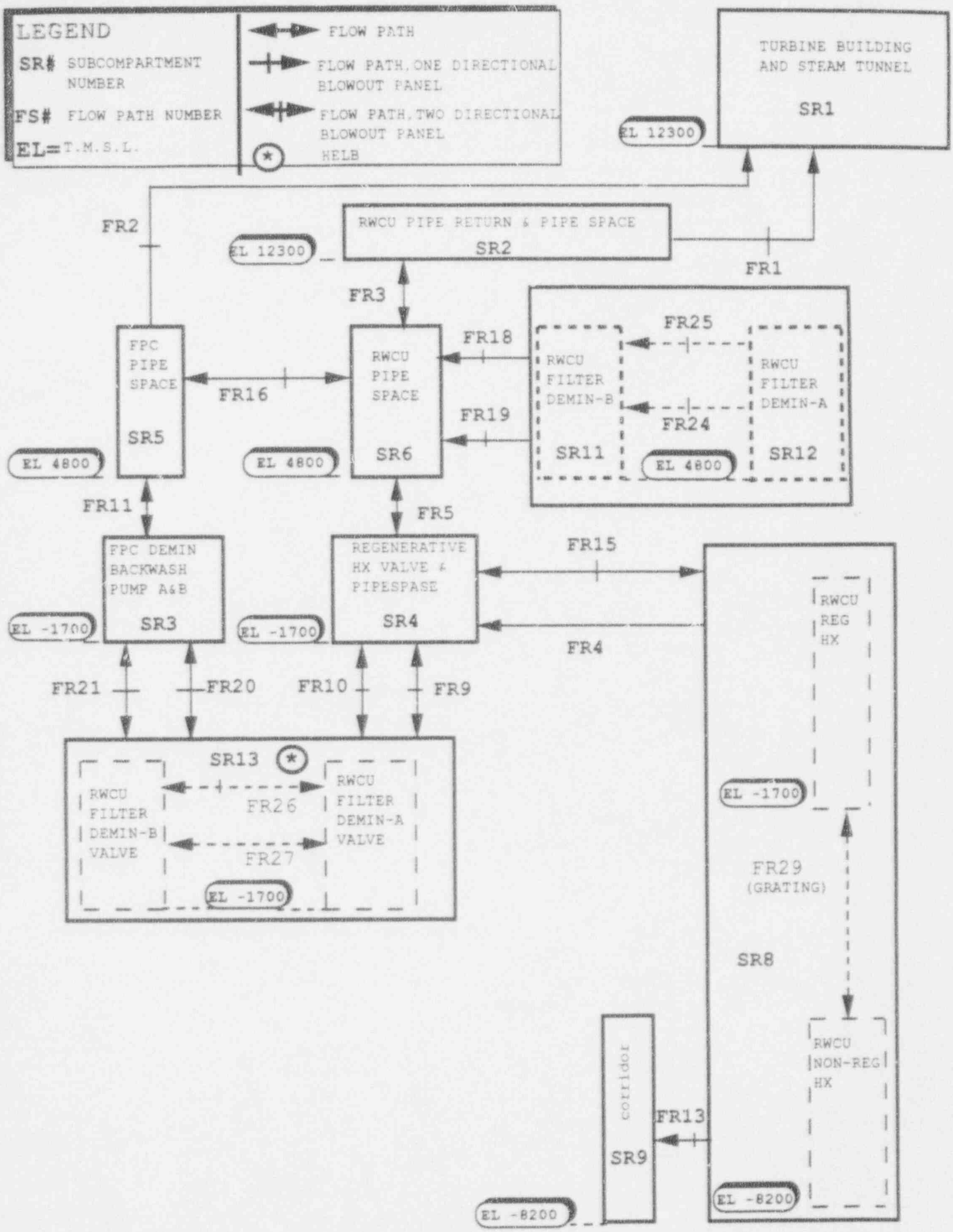


FIGURE 6.2-37C-1. SECONDARY CONTAINMENT SCHEMATIC FLOW DIAGRAM. (REACTOR WATER CLEAN UP SYSTEM)

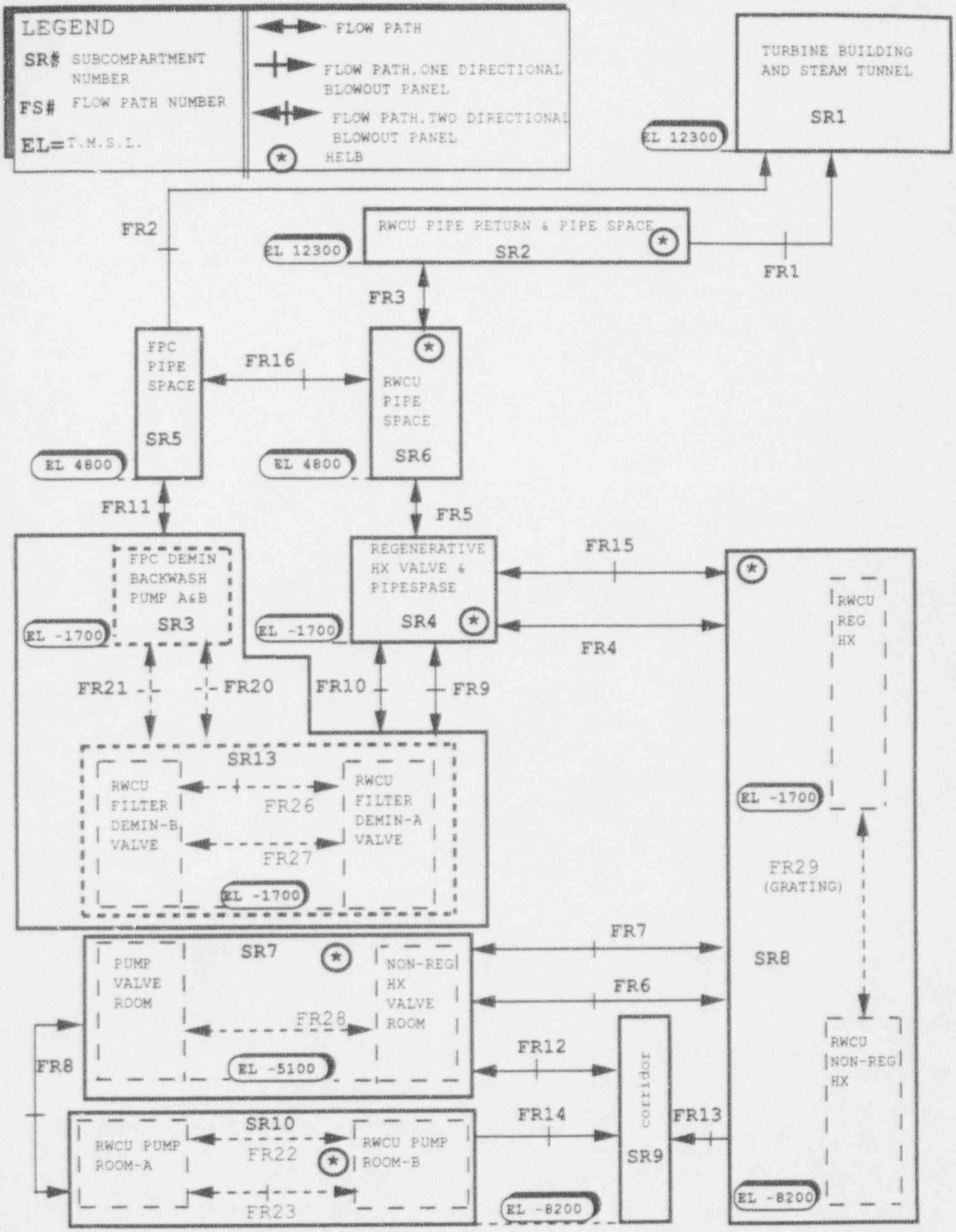


FIGURE 6.2-37C-2. SECONDARY CONTAINMENT SCHEMATIC FLOW DIAGRAM (REACTOR WATER CLEAN UP SYSTEM)

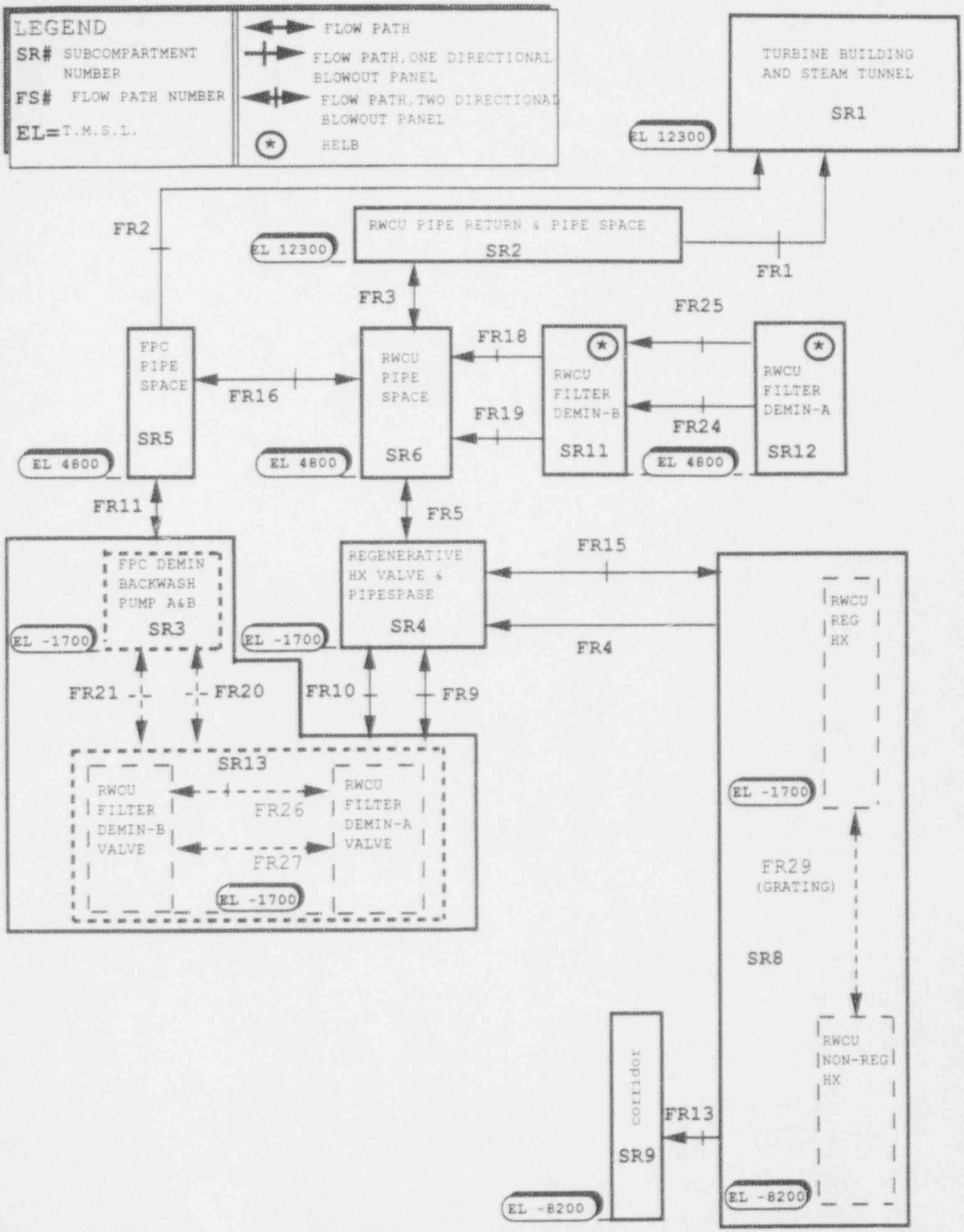


FIGURE 6.2-37C-3. SECONDARY CONTAINMENT SCHEMATIC FLOW DIAGRAM.
(REACTOR WATER CLEAN UP SYSTEM)

DFSER OPEN ITEM 6.2.1.6.3: CONTAINMENT MODELING CONCERN

RESPONSE

In response to the Open Item 6.2.1.6-3, the following paragraphs provide an overview of ABWR containment design features, containment loads and load application methodology, and a discussion of key features of the ABWR test results and their comparison with those observed from prior BWR tests. Significance of ABWR design features to containment loads is also discussed, as and where applicable.

ABWR CONTAINMENT DESIGN FEATURES

The basic features and configuration of the ABWR containment design are shown in Figure 1. The ABWR containment design utilizes horizontal vent system similar to prior Mark III design, and a confined wetwell air space separated from the drywell by a diaphragm floor similar to that in Mark II design. In addition, as a unique feature, the ABWR design includes a lower drywell (L/D).

The ABWR containment design uses the same X-quencher discharge device as that used in Mark II and Mark III designs. The discharge device, shown in Figure 2, is a diffuser device comprised of a short conical extension of the vertical terminus of the SRV discharge line and a capped cylindrical central section or, plenum from which four perforated, capped arms extend. The development and design of this quencher device was based on many years of testing and development work, and performance of this device has been well tested and confirmed through scaled and large-scale (including in-plant tests) testing.

ABWR CONTAINMENT LOADS

As with prior BWR containment designs, ABWR containment structure will be subjected to hydrodynamic loads due to a loss-of-coolant accident (LOCA) and SRV actuation events, in a manner similar to that in prior containment designs. These loads were

developed using ABWR test results and approved methodology, and they were defined for ABWR containment structure design evaluation.

1. *LOCA Loads*

During a postulated loss-of-coolant accident (LOCA) inside the drywell, containment structure will be subjected to the following three sequential loading conditions significant to the containment structure design:

A Pool Swell loads
B Condensation Oscillation (CO) loads
C Chugging loads

1.A. Pool Swell Loads

Following a postulated LOCA and after the water is cleared from the vents, air/steam mixture from the drywell flows into the suppression pool creating a large bubble at vent exit as it exits into the pool. Bubble at vent exit expands to suppression pool hydrostatic pressure, as the air/steam mixture flow continues from the pressurized drywell. Water ligament above the expanding bubble is accelerated upward by the difference between the bubble pressure and the air space pressure above the pool. This acceleration of water ligament gives rise to pool swell phenomena, which, typically, lasts for a couple of seconds.

During this pool swell phase, wetwell region is subjected to the hydrodynamic loading conditions, and they are:

- Loads on suppression pool boundary and drag loads on structures initially submerged in the pool, due to the pressurized and expanding bubble at vent exit;

- Loads on wetwell airspace boundary (including the diaphragm floor), due to rising pool which compresses the wetwell air space.

- Impact and drag loads on structures located above the initial pool surface, due to the rising pool surface.

From structure design standpoint, the most important aspects of the pool swell phenomena are peak pool swell height and peak pool swell velocity. The former determines region of impact/drag loading condition, whereas the later determines severity of the loading condition.

<u>ABWR Pool Swell Loads</u>

ABWR pool swell response calculations to quantify pool swell loads were based on a simplified, one dimensional analytical model, same as that reviewed and accepted by the staff (NEDE-21544P/NUREG-0808) for application to Mark II plants. This analytical model was qualified against Mark II full-scale test data.

The ABWR design utilizes a confined wetwell air space similar to that in Mark II design, but its vent system design is quite different than that in Mark II design. The ABWR vent system design utilizes horizontal vents similar to that in Mark III design. Therefore, recognizing this difference in vent system design, additional studies comparing model against Mark III horizontal vent test data were performed to assure adequacy of the model for application to ABWR.

<u>Model Vs Mark III Horizontal Vent Test Data</u>

Model input/assumptions used in predicting Mark III test data for model comparison were same as prescribed in NEDE-21544P. Mark III horizontal vent system features were modeled in the following manner:

- Pool swell water slug was approximated by a constant thickness equal to top vent submergence;

- Drywell pressure transient and vent clearing times input based on test data;

- o Vent flow area increased in order with the clearing of middle and bottom vents.

Test data used for model comparison were taken from full-scale and sub-scale tests, and they were representative of ABWR submergence to pool width ratio. The test data used in model comparison are listed in Table 1.

Comparison results, summarized in Table 2 and sample results shown in Figures 3 and 4, demonstrate that the model over predicts the horizontal vent test data. These comparison results demonstrated and assured adequacy of the model for calculating ABWR pool swell response.

ABWR pool swell response calculations were done using the analytical model described above. Modeling scheme for ABWR calculations was consistent with that used in model vs test data comparison. For an added conservatism in model predictions , water slug surface area occupied by the air bubble was taken as 80% of the total pool surface area in pool swell response calculations. Calculation results, exhibited in Figures 5 and 6, show that 80% pool area assumption yields conservative pool swell response results.

ABWR Pool Swell Response

ABWR pool swell response calculation results exhibited trend similar to that in Mark II and Mark III designs. However, in comparison with Mark II and Mark III pool swell response values, ABWR results were found to be milder milder. Also, ABWR response calculations showed wetwell airspace pressure remaining below the drywell pressure during the pool swell transient, indicating no negative pressure on the diaphragm floor. Key aspects of the pool swell response results are presented below:

	ABWR	Mark II (Typ)	Mark III (GESSAR)
Peak Pool Swell Velocity (ft/sec)	19	32	40
Peak Pool Swell Height (ft)	23	18	18

Higher pool swell velocity for Mark II can be attributed to higher drywell pressurization rate (drywell volume/break area of 260E+3 for ABWR vs 60E+3 for Mark II.). Higher velocity for Mark III can be attributed to higher drywell pressurization rate (260E+3 for ABWR vs 80E+3 for Mark III) combined with a much larger wetwell airspace volume (2.1E+5 cu ft for ABWR vs 11.4E+5 for Mark III).

ABWR peak pool swell height is conservatively represented by maximum swell height calculated with the model (i.e., elevation corresponding to zero velocity), which turns out to be about two times top vent initial submergence. Mark II and Mark III peak swell height based on conservative envelope of test data are:

- o Mark II Height: 1.5 times initial submergence
- o Mark III Height: 2.4 times initial submergence

<u>ABWR Pool Swell Loads</u>

Impact and drag loads on structures above the initial pool surface were determined using the same methodology as that approved for Mark II/III containment designs. The design loads for structure evaluation were determined using the ABWR pool swell transient response results based on 80% pool area assumption, which are:.

- o Peak Pool Swell Velocity (ft/sec) = 19
- o Peak Pool Swell Height (ft) = 23

Drag loads on structures initially submerged in the pool were determined based on the methodology approved for Mark II/III designs.

1.B: <u>Condensation Oscillation (CO) Loads</u>

The condensation oscillation (CO) period of a postulated LOCA follows the pool swell transient. During the CO period, the steam condensation process at the vent exit induces pressure loads on the containment system including the suppression pool boundary and structures initially submerged in the pool. The CO loads were determined based on data from ABWR horizontal-vent tests.

ABWR Horizontal-Vent Tests

A test program was conducted to confirm the condensation oscillation (CO) loading conditions which could occur in the event of LOCA in an ABWR plant. This test program was conducted anticipating that CO loads might differ from prior (Mark III) testing in horizontal- vent facilities for several reasons. These included i) pressurization of the wetwell airspace, ii) the presence of a lower drywell (L/D), iii) the smaller number of horizontal vents (30 in ABWR vs 120 in Mark III), iv) extension of the vents into the suppression pool, v) vent submergence (11 ft in ABWR vs 7.5 ft in Mark III), and vi) suppression pool width (24.6 ft in ABWR vs 20.5 ft in Mark III).

The test program consisted of a total of 13 simulated blowdowns in sub-scaled test facility representing a one-cell (360°) sector of the ABWR horizontal vent design, which included a single vertical/horizontal vent module. The sub-scaled (SS) test facility was geometrically (all linear dimensions scaled by a factor of 2.5) similar to the prototypical ABWR design, and the single vertical/horizontal vent module included all three horizontal vents, as shown in Figure 7. In these tests, full-scale thermodynamic conditions were employed. This approach is based on the belief that condensation phenomena at the vent exit are mainly governed by the thermodynamic properties of the liquid and vapor phases. In accordance with this scaling procedure, measured pressure amplitudes are equal to full-scale values at geometrically similar locations whereas measured frequencies are 2.5 times higher than the corresponding full-scale frequencies. Thus, this scaling procedure made it possible to use the measured SS data directly for load definition purpose after the time scale is compressed by a factor of 2.5.

ABWR CO Data

In general, basic features of the ABWR CO data were consistent with those observed in tests for prior BWRs.

Liquid breaks resulted in pressure amplitudes greater than with steam breaks and CO amplitudes increase significantly with increasing pool temperature and break size, same trend as observed in Mark II/III tests. Prepurging of the vent system and the L/D showed no significant effect on maximum CO amplitudes. Maximum CO amplitudes showed a weak sensitivity to increasing wetwell overpressure (a slight increase in Maximum CO amplitude with increasing overpressure).

The CO pressure oscillations were characterized by two dominant frequencies, one around 2.5 hertz and a second around 5 hertz. It is hypothesized that the lower frequency is representative of vent acoustic frequency whereas the higher frequency is associated with the vent exit frequency. The vent acoustic frequency is representative of drywell-to-wetwell connecting vent, and the vent exit frequency is representative of diameter at vent exit. This observation is consistent with prior BWR CO tests which exhibited presence of vent acoustic and vent exit frequencies.

ABWR CO Loads

The ABWR load definition used the "source-load" approach, instead of using the "wall-load" approach. With a source load approach, it becomes possible to account for the spatial distribution of the load and the variation of pool and vent fluid properties in a mechanistic way. The major criterion for the development of the source load is to show that it produces pool pressures which match the envelope PSDs of the SS tests at the pressure measurement locations. A second criterion is that the pressure histories produced by the source show behavior similar to the measured pressures.

Figure 8 shows pressure time history representative of ABWR CO load determined using the source load approached described above. Figure 9 shows pressure time history representative of Mark III CO loads. This pressure time history is based on Mark III CO correlation described and discussed in GFSSAR. In comparison, ABWR pressure amplitudes are higher than for Mark III design.

The higher amplitudes in ABWR can be attributed to deeper submergence in ABWR (11.6 ft vs 7.5 ft), and the fact that in ABWR tests all three horizontal vents remained open during the maximum CO period whereas in Mark III tests the bottom and middle vents were closed at the onset of CO conditions. There may be some partial contribution from increasing wetwell overpressure in ABWR tests.

Load Application Methodology

For design evaluation of containment structure, the pool boundary pressure loads obtained from analysis of single-vent (36°) model of the prototypical ABWR design were specified and applied over the full (360°) model of the ABWR configuration. This CO loading specification implies all vertical vents are in phase (i.e., no credit for phasing among vents), which is considered to be a conservative load definition approach.

1.C: ABWR Chugging Loads

Chugging (CH) loading condition, which follows the CO loading condition, occurs during periods of low vent steam mass flux. Steam condensation process during low vent mass flux, typically, produces a sharp pressure pulse followed by a damped oscillation. Chugging, an intermittent event, is the result of unsteady condensation occurring in the last stage of the LOCA blowdown. The CH loads were determined and based on data from ABWR horizontal-vent tests.

A test program was conducted to confirm CH loading condition which could occur in the event of LOCA in an ABWR plant. The tests were conducted using the same vessel as for the sub-scale testing, but with a full-scale

vertical/horizontal vent system, see Figure 10. This approach is termed as partial full-scale (FS^*) testing. Only two full scale horizontal vents maintaining prototypical vertical vent to vent spacing were installed, because of space limitation in the sub-scale pool. In all eleven tests were conducted with the vent system purged of air to produce conservative CH loads.

CH Loads

A chugging source load definition was developed, on the basis of FS^* tests, using key-chug approach. Chugs which produce large peak pressure amplitudes are termed key chugs. The criterion for the development of load definition was that the source load, when applied to an appropriate analytical model of the FS^* facility, produces a wall pressure which matches the measured key-chug wall pressure. The key-chug approach was used successfully for the Mark II chugging load definition.

Basic characteristic features of a typical large chug from the FS^* testing, shown in Figure 11. It is characterized by a small underpressure, followed by a positive pressure pulse, and a decaying ringout. Chugging data from Mark II and Mark III testing also exhibited similar features.

Load Application Methodology

The pool boundary pressure loads obtained from analysis of a single-vent (36^0) sector model of the prototypical ABWR design were specified for application over the full (360^0) model of the prototypical ABWR facility. To bound symmetric and asymmetric loading conditions, two load cases were defined.

Case 1: All vents chugging in phase.

Case 2: Vents in one half 180^0 out of phase with the other half vents

2. *SRV Actuation Loads*

After the air exits into the suppression pool, during the actuation of SRV, the air bubbles coalesce and oscillate as Rayleigh bubble while rising to the pool free surface. The oscillating air bubbles produce hydrodynamic loads on the pool boundary and drag loads on structures submerged in the pool. After the air has been expelled, steam exits steadily and condenses in the pool. This condensing steady state SRV steam flow has been found to produce negligible pressure loading on the pool boundary, as evident from testing of this X-quencher discharge device.

The calculation methodology used for defining the quencher air-clearing pool boundary loads for the ABWR design is based on and consistent with the staff approved methodology (documented in NUREG-0802) for Mark II and Mark III designs equipped with the X-quencher discharge device.

For design evaluation of containment structure, both single and multiple valve discharges for first and subsequent actuation were considered. As a conservative approach, the ABWR containment structure is evaluated and designed for the most severe symmetric and asymmetric loading conditions:

a. Symmetric loading condition - All oscillating air bubbles from all valves in phase.

b. Asymmetric loading condition - Oscillating air bubbles in one half of the pool 180° out of phase to those in the other half of the pool.

TABLE 1

POOL SWELL MODEL COMPARISON WITH PSTF TEST DATA

PSTF TEST CONDITIONS

PSTF TEST #	FLOW ORIF (in.)	VENT SIZE (in.)	# OF VENTS	TOP VENT SUBM (ft)	SUBM/WIDTH RATIO+
5701-5	2.125	27.5*	1	6.0	0.32
5702-11	3.625	27.5	3	8.1	0.43
5801-10	2.50	15.88**	3	7.5	0.68
5806-2	3.0	15.88	3	5.0	0.45
5806-4	2.5	15.88	3	5.0	0.45
5806-6	3.625	15.88	3	7.5	0.68

+ = 0.47 ABWR VALUE; 0.35 MARK III (TYP) VALUE

* = FULL SCALE HORIZONTAL VENT

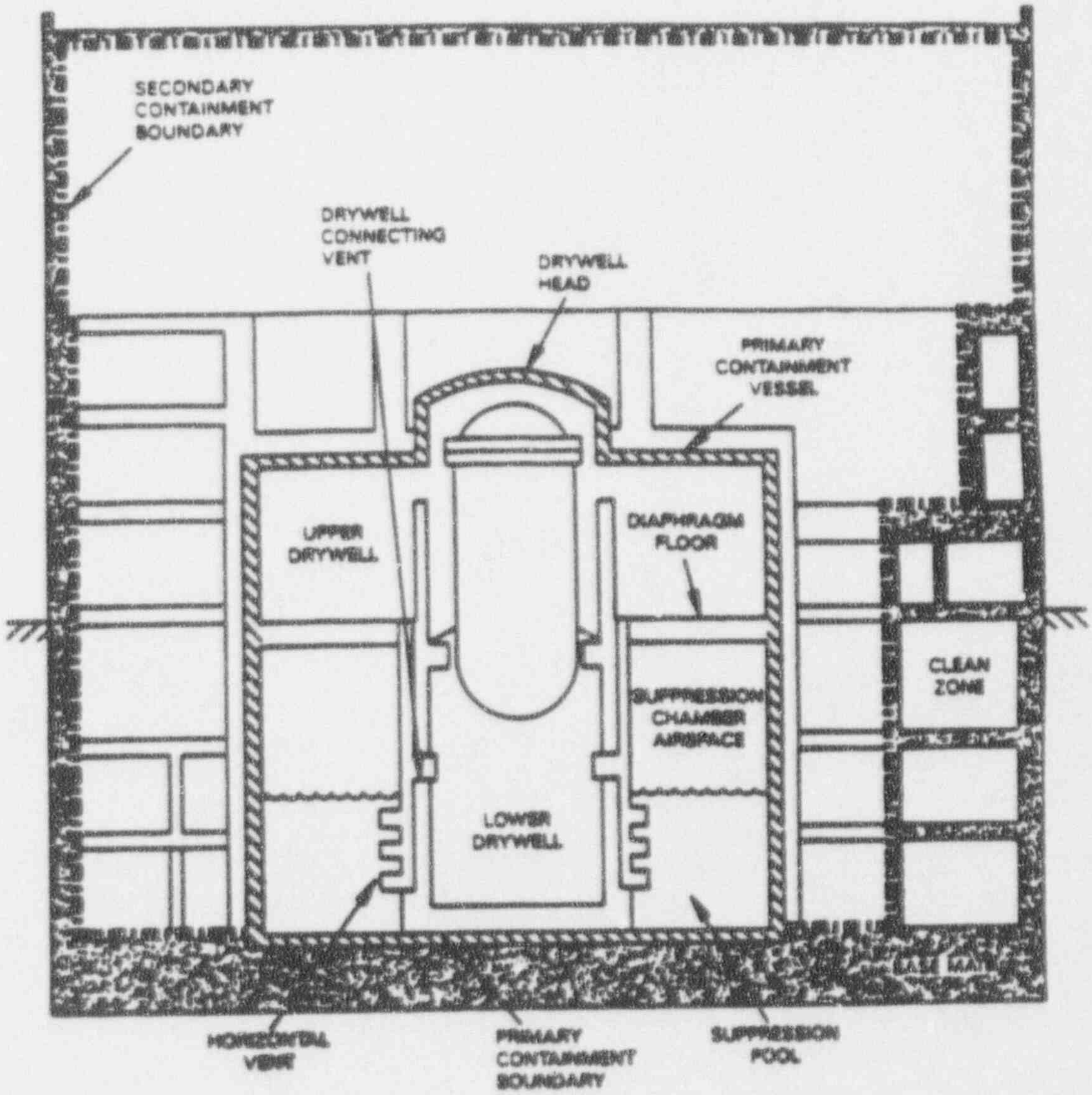
** = 1/3-AREA SCALED VENT

TABLE 2

MODEL vs PSTF TEST DATA COMPARISON

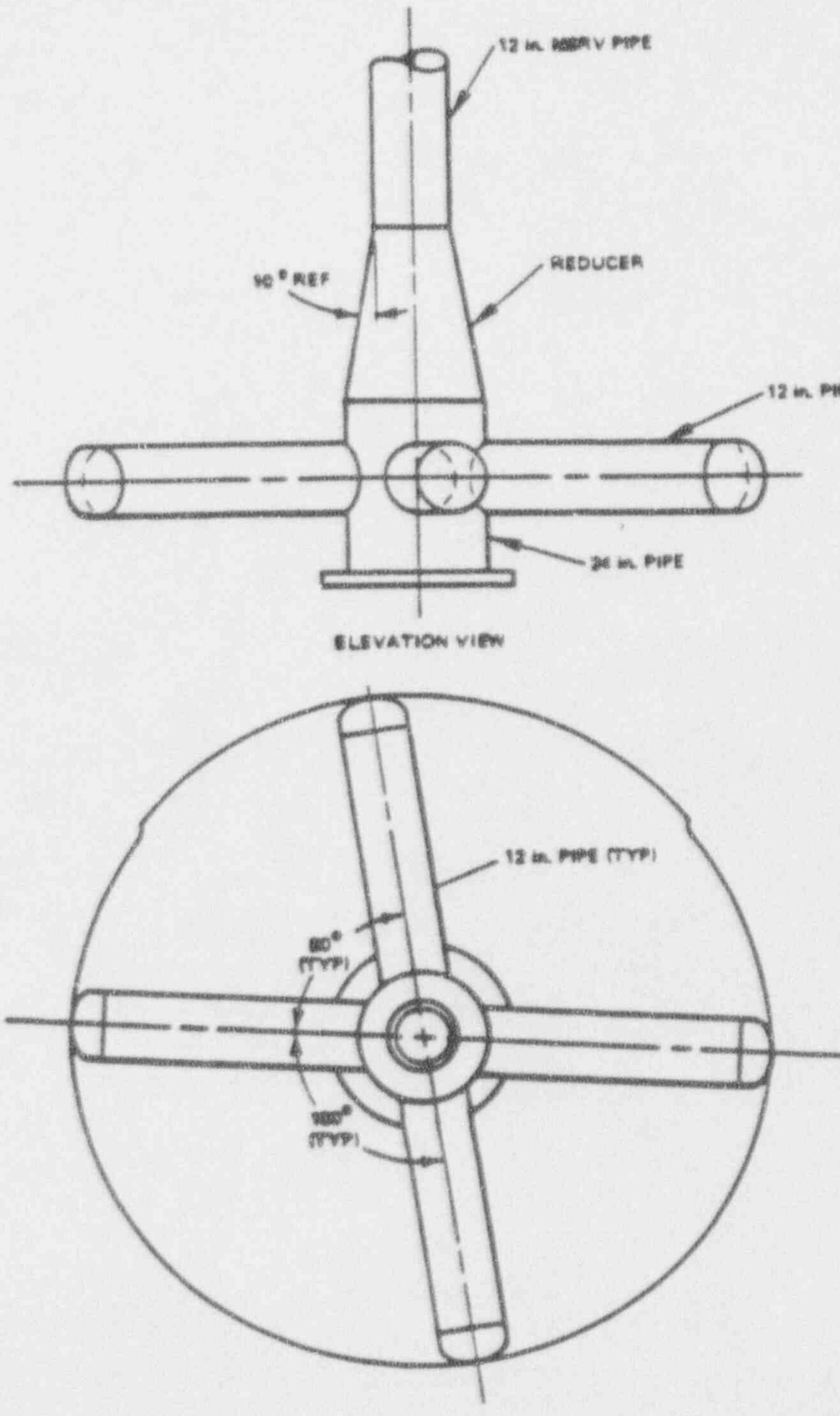
RESULTS SUMMARY AT SELECTED TIME

PSTF TEST	TIME (sec)	POOL RISE (ft) MODEL	POOL RISE (ft) TEST	POOL RISE (ft) MODEL/TEST	SWELL VELOCITY (ft/sec) TEST	SWELL VELOCITY (ft/sec) MODEL	SWELL VELOCITY (ft/sec) MODEL/TEST
5801-10	0.1	1.12	1.5	0.75	9.0	15.5	1.72
	0.3	5.66	3.9	1.45	16.0	29.10	1.82
	0.5	13.1	9.5	1.37	32.0	44.59	1.39
5806-2	0.1	0.85	0.8	1.06	10.0	11.86	1.19
	0.3	4.43	3.0	1.48	20.0	22.97	1.15
	0.5	10.3	7.0	1.47	26.0	35.64	1.37
5806-4	0.1	1.89	1.8	1.05	13.0	16.1	1.24
	0.3	6.0	4.2	1.43	21.0	24.4	1.16
	0.5	11.6	8.6	1.34	--	--	--
5806-6	0.1	1.85	1.8	1.03	13.0	21.63	1.66
	0.3	7.24	5.8	1.25	25.0	32.05	1.28
	0.5	15.2	12.8	1.19	40.0	47.20	1.18
5702-11	0.1	1.57	1.50	1.05	12.5	18.37	1.47
	0.3	7.16	4.5	1.59	23.0	35.14	1.53
	0.5	14.9	9.5	1.57	22.0	41.34	1.88
5701-5	0.1	0.98	1.0	0.98	5.0	16.5	3.3
	0.3	6.12	2.0	3.06	6.25	32.28	5.16
	0.5	13.0	3.75	3.47	8.75	34.43	3.93



ABWR Containment Configuration

FIGURE 1



X - QUENCHER SCHEMATIC

FIGURE 2

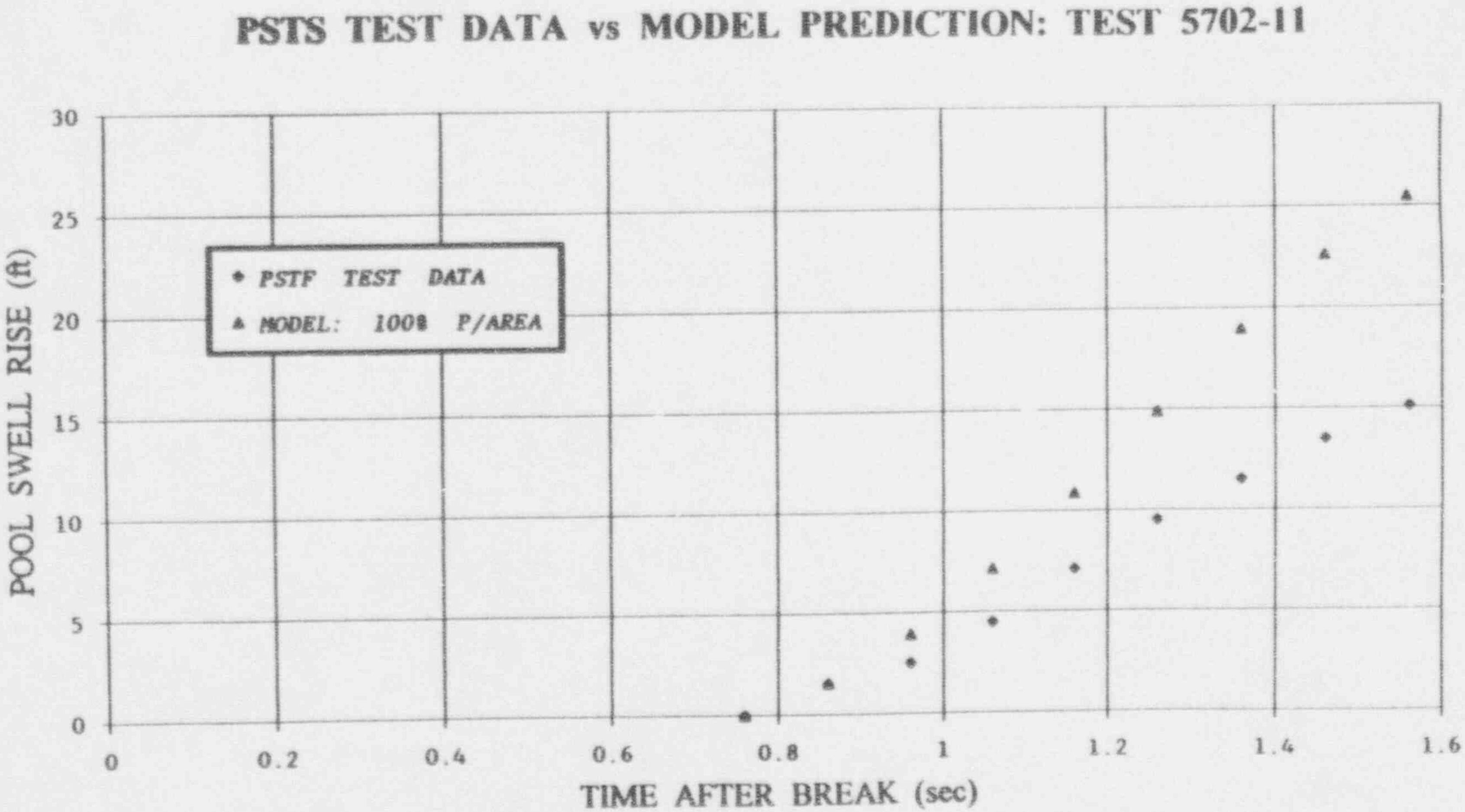
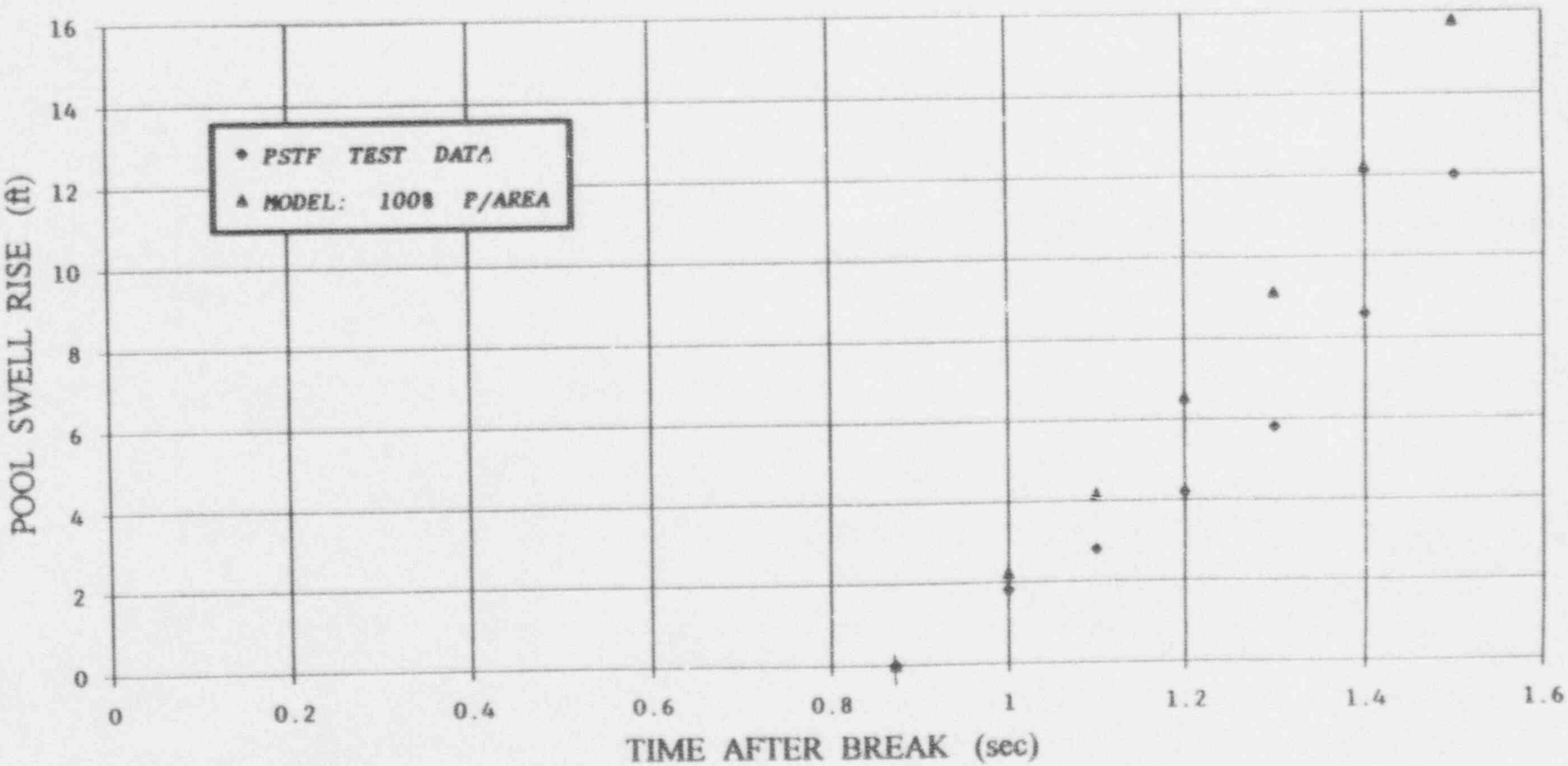

PSTS TEST DATA vs MODEL PREDICTION: TEST 5702-11
POOL SWELL RISE (ft)
TIME AFTER BREAK (sec)
PSTF TEST DATA
MODEL: 100% P/AREA
0
5
10
15
20
25
30
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6

FIGURE 3

FIGURE 4

PSTF TEST DATA vs MODEL PREDICTION: TEST 5806-4



ABWR LOCA POOL SWELL TRANSIENT

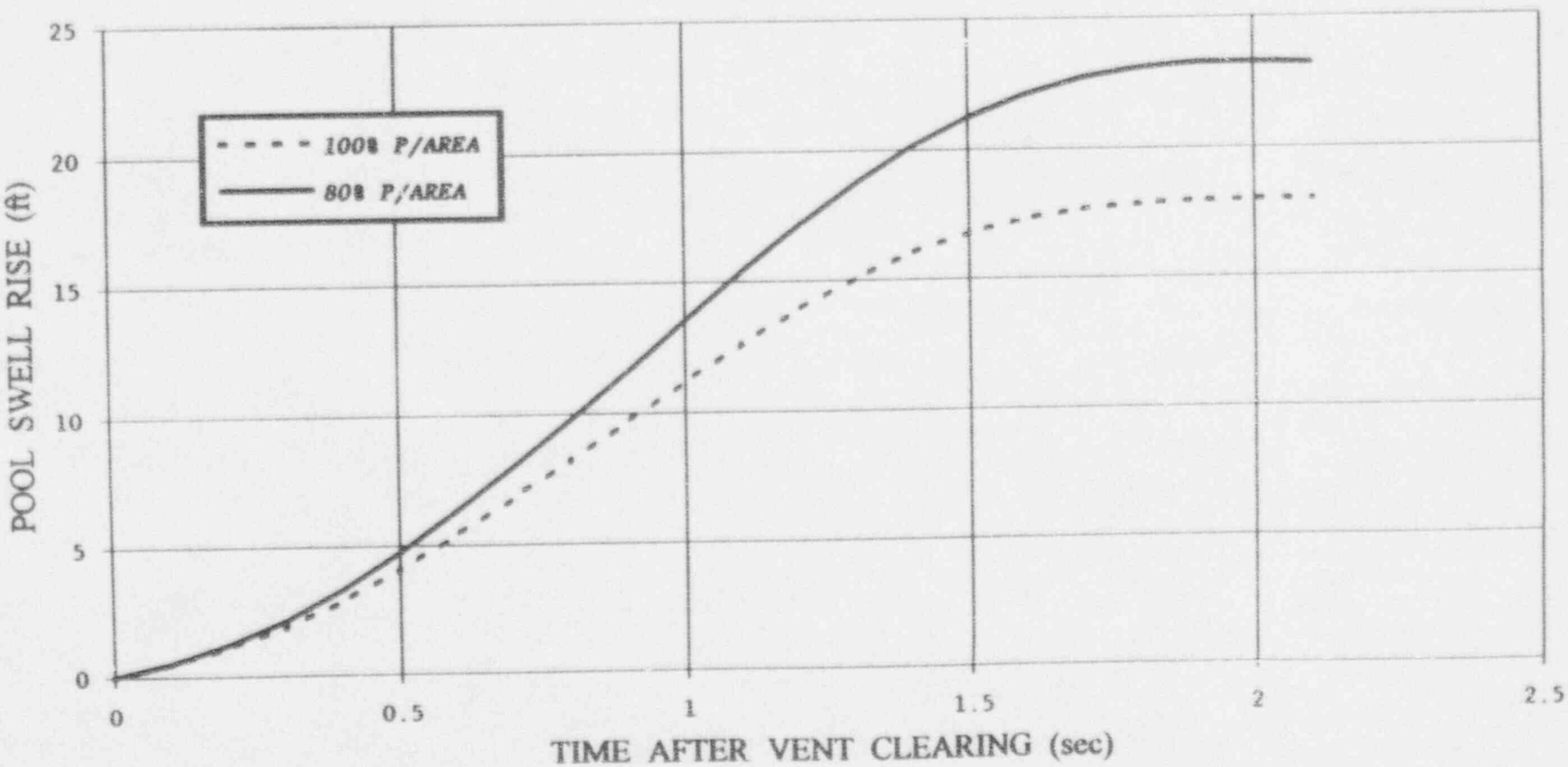


FIGURE 5

ABWR LOCA POOL SWELL VELOCITY TRANSIENT

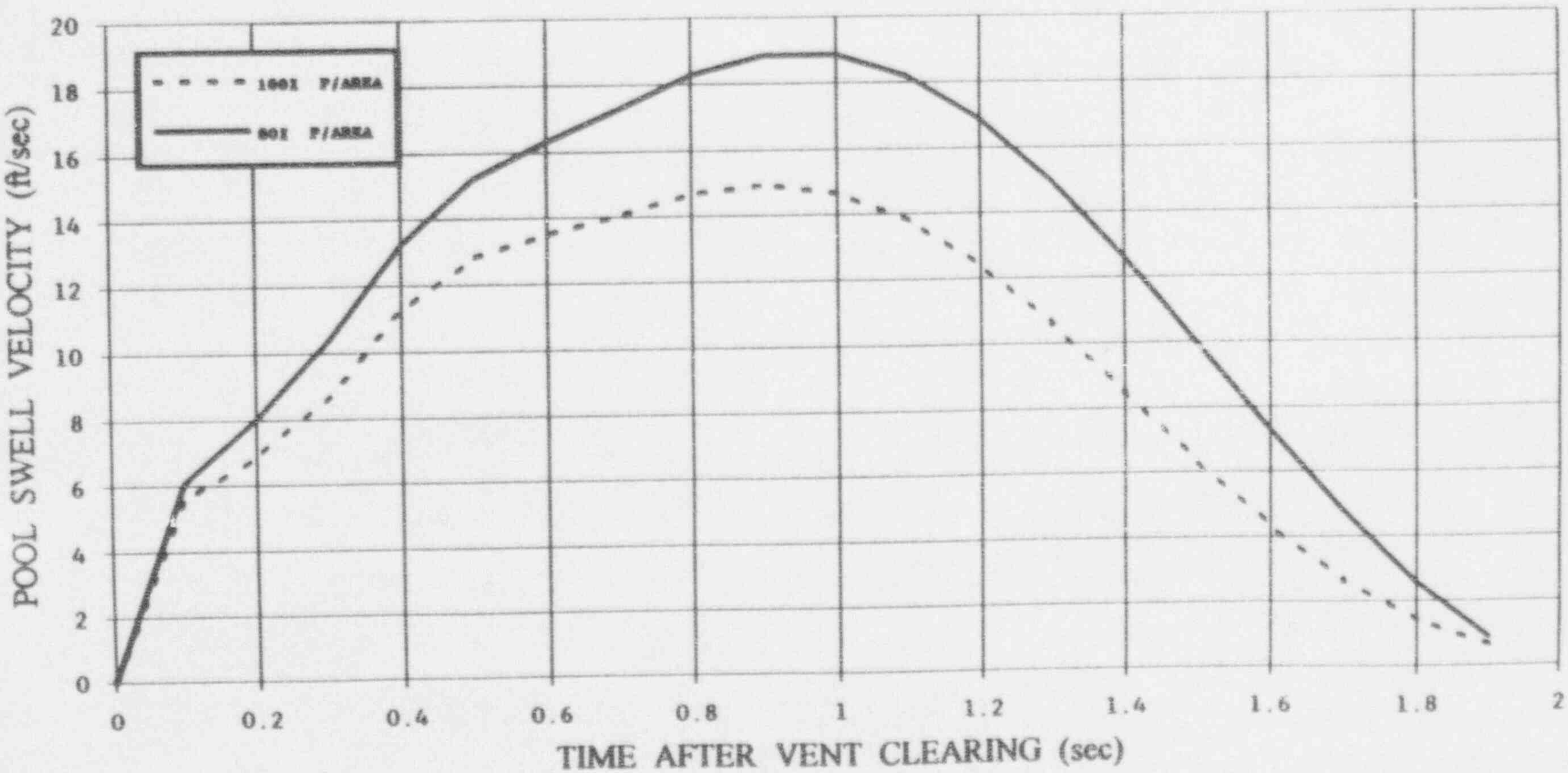
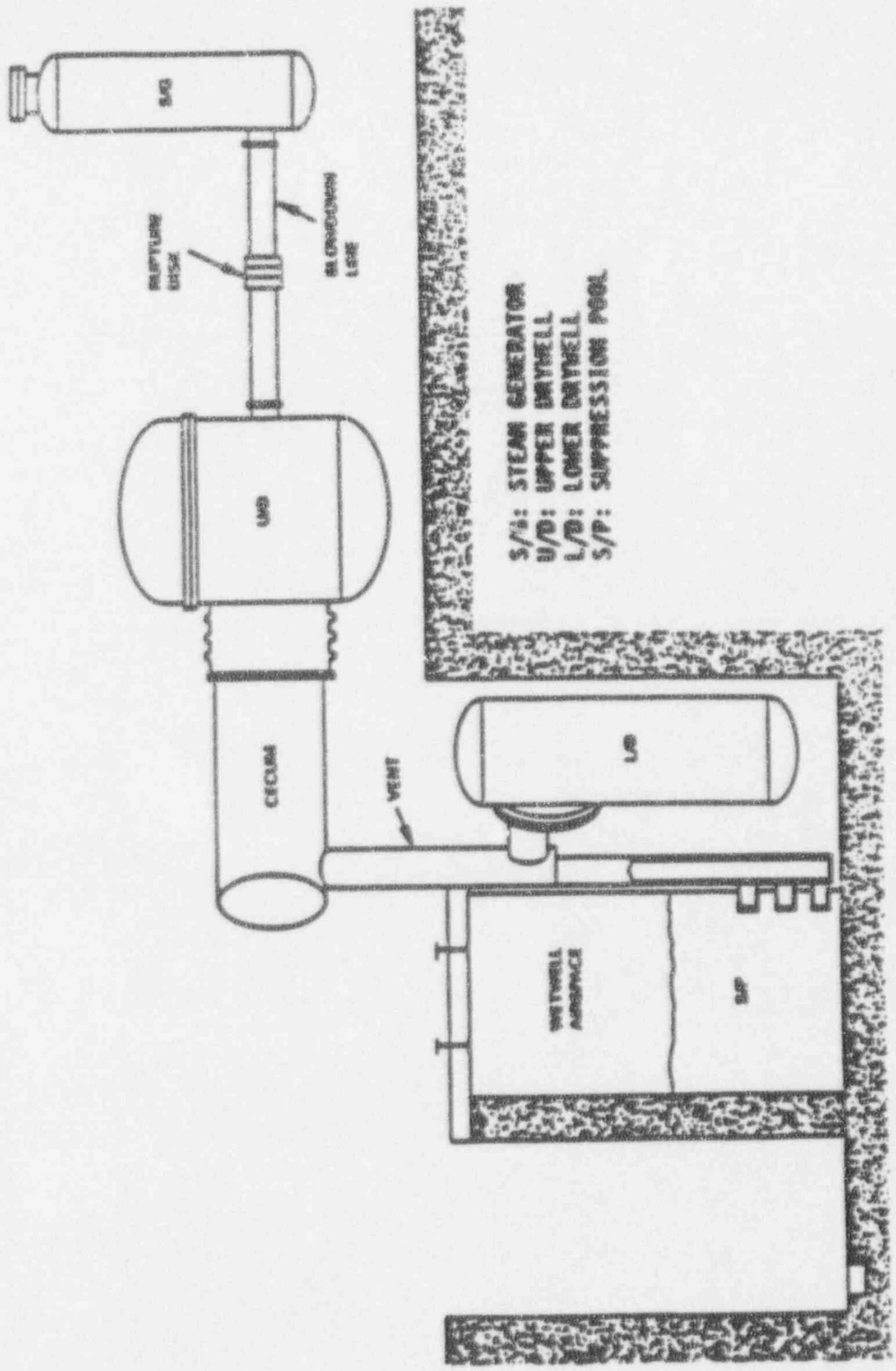


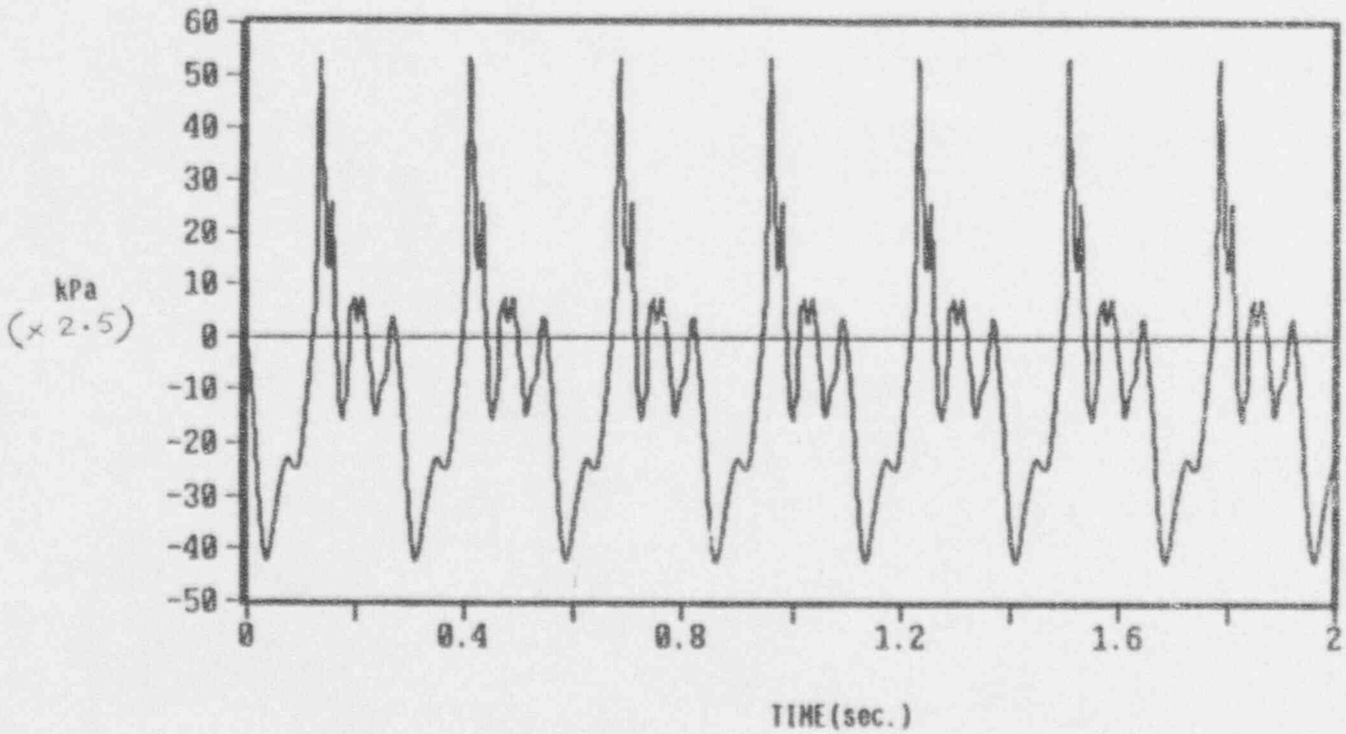
FIGURE 6



SS TEST FACILITY

FIGURE 7

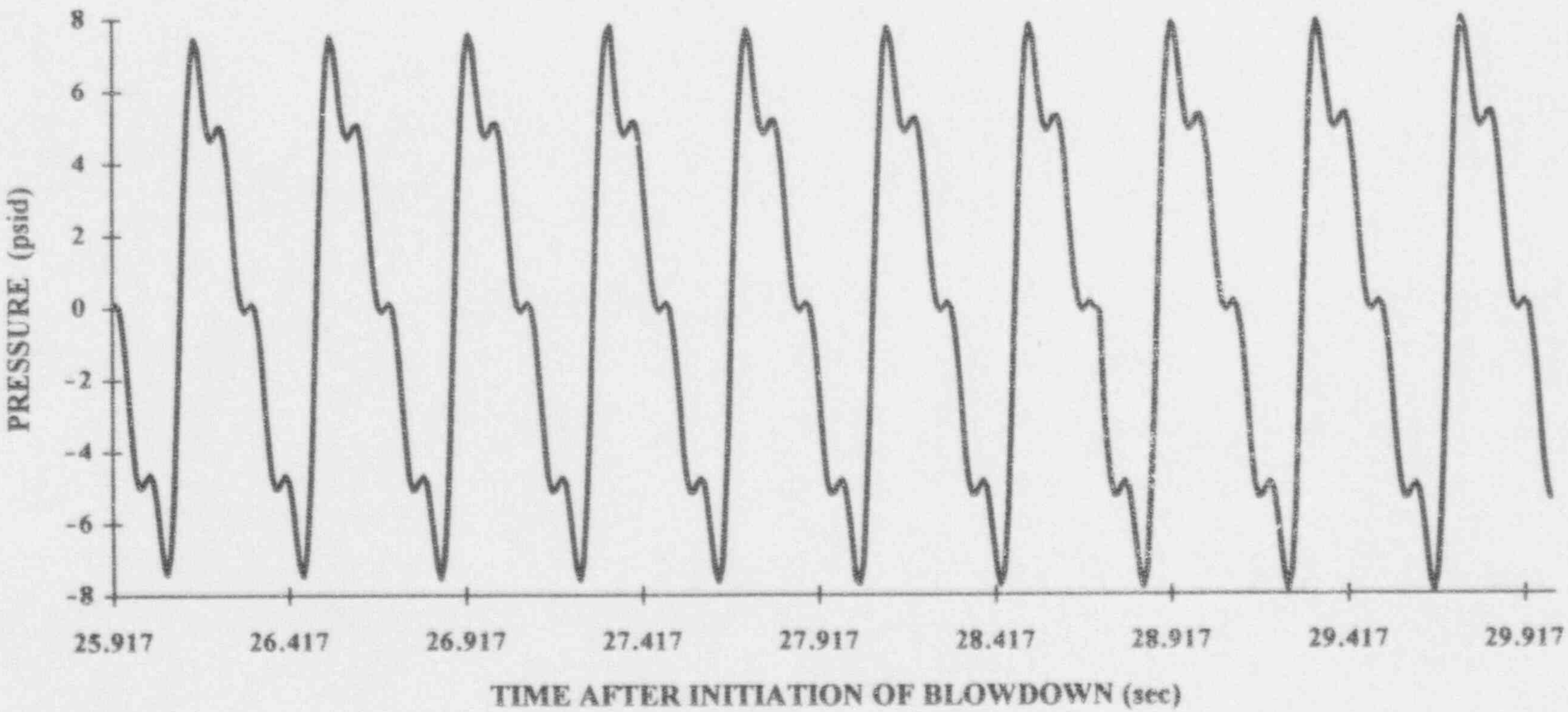
FIGURE 8

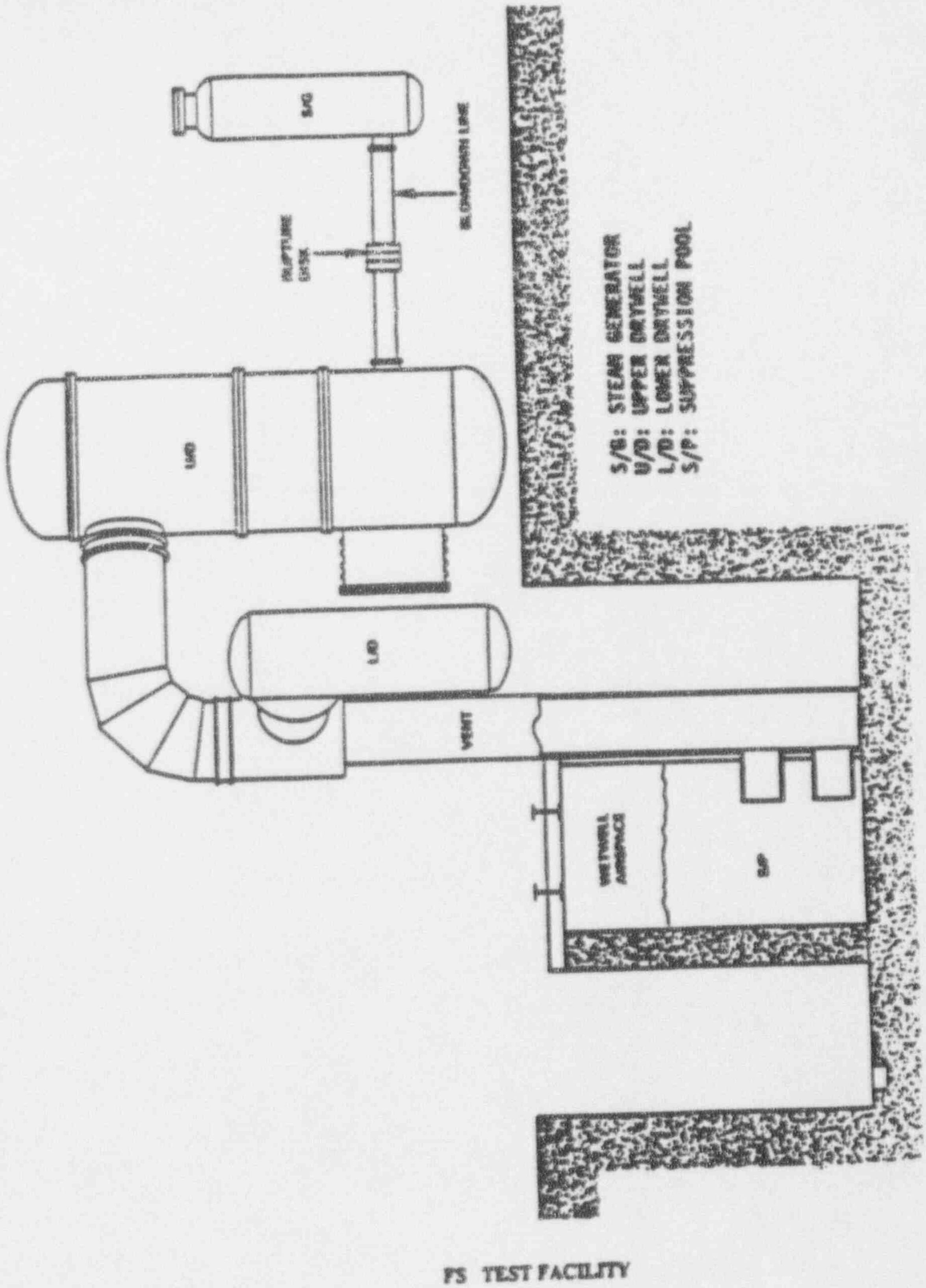


ABWR Typical Pressure Fluctuation by CO

FIGURE 9

Typical Pressure Fluctuation by CO - Mark III

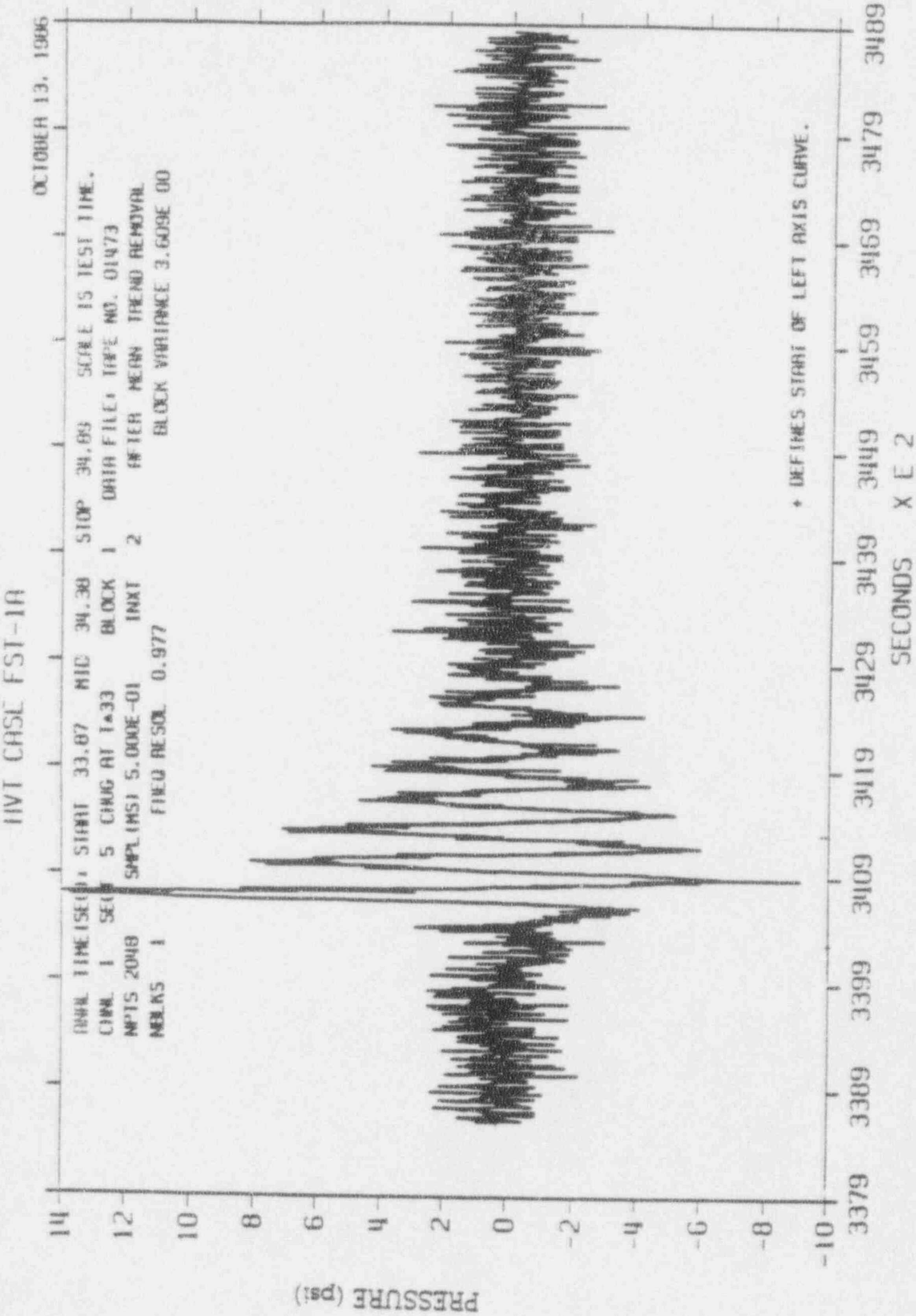




FS TEST FACILITY

FIGURE 10

GENERAL ELECTRIC COMPANY
PROPRIETARY INFORMATION
CLASS III



Typical Large Chug (025P)

FIGURE 11

Response to Question on subsection 6.2.1.2.2

SUBJECT: **SSAR 6.2.1.2.2: DESIGN FEATURES --**
Para (2): Reactor Shield Annulus

REFERENCES: 1. GE/NRC Meeting in San Jose, 4/14/93.
2. GE Transmittal of 1/22/93, Insert B to the subject item.

The following paragraphs provide clarification and answers to the staff questions (noted in Reference 1) on the material transmitted in Reference 2. Item numbers below correspond to those in Reference 1.

#1. <u>"Several high energy lines"</u>

High energy lines which connect to the reactor pressure vessel (RPV) at the vessel nozzle safe end are:

(a)* Steam outlet nozzle (4),
(b) Feedwater and CUW inlet nozzle (6),
(c) SD outlet nozzle (2),
(d) HPCF & SLC inlet nozzle (2),
(e) LPFL & SD inlet nozzle (2),
(f) SD & CUW outlet nozzle (1),

* No main steam line break inside RPV and the reactor shield wall (RSW) annulus is expected, because the steam outlet nozzle safe end connection to the main steam line is outside the annulus region.

#2. <u>DBA Break Definition</u>

The criterion for defining the DBA break size was based on mass and energy blowdown rate into the annulus due to an instantaneous double-ended break. The break type resulting in maximum mass and energy blowdown rate was defined as the "DBA Break".

In earlier annulus pressrization analyses (with the unextende shield wall), a break size of 0.06 sq meter at the FWL inlet nozzle was the limiting break area producing maximum mass and energy release rate. During later part of the ABWR design, RHR shutdown suction nozzle size was increased, which resulted in break flow area increasing from 0.047 to 0.075 sq meter. As a result of this increase in break area, break at the RHR SD suction nozzle, which results in flow area greater than that for the FWL break case, became the DBA break for the current RPV and RSW annulus (with the extended shield wall) pressurization analyses.

#3. Flow Area

Yes, the flow area mentiond in Reference 2 refers to the venting area from the RPV and RSW annulus region into the drywell region. See Figure ----. The total flow area, as noted in Reference 2, comprised of i) clearance area corresponding to the 0.1 m clearance between top of the shield wall and containment top slab, and ii) the area of penetration door openings.