SEQUOYAH NUCLEAR PLANT

INTEGRATED CONTAINMENT ANALYSIS

IDCOR TASK 23.1

FINAL REPORT

TENNESSEE VALLEY AUTHORITY
NUCLEAR ENGINEERING BRANCH
KNOXVILLE, TENNESSEE

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PRELIMINARY

4.0 Sequences Analyzed

Considerations of the dominant accident sampling sequences leading to potential core damage as given in the draft report of IDCOR Task 3.2, resulted in six small LOCAs and two transient initiators, comprising 94.4 percent of the likely core damage initiators. These sequences were developed by reviewing the Sequoyah RSSMAP study with some regrouping of sequences. The AD accident sequence was added to determine the plant response to a 10 inch diameter LOCA. Translation of these sequences into the Sequoyah reference plant input model include the following assumptions:

1. All LOCA sequences incorporate manual reactor coolant pump trip via operator action subsequent to reactor scram.

2. Credit is taken for the full complement of emergency safeguards for accident sequences where they are available unless otherwise specified. Table 4.0-1 illustrates the status of both primary and containment systems for each accident sequence used in the analysis. The sequences analyzed are:

1. S_2D - Small LOCA with loss of ECCS injection,
2. S_2H - Small LOCA with loss of ECCS recirculation,
3. S_2HF - Small LOCA with loss of ECCS and containment sprays in the recirculation mode,
4. TMLB' - Loss of all AC power and auxiliary feedwater,
5. $T_{23}ML$ - Transient with loss of auxiliary feedwater and loss of charging pumps, and
6. AD - Large LOCA with loss of ECCS injection.

PRIMARY SYSTEMS STATUS

EVENT	S2H	S2D	S2HF	TMLB'	T23ML	AD
RCP COASTDOWN	X	X	X	X	X	X
UPPER HEAD INJECTION	X	X	X	X	X	X
CHARGING PUMPS	X		X			
SAFETY INJ PUMPS	X		X			
RHR PUMPS	X		X			
COLD LEG ACCUMULATORS	X	X	X	X	X	X
ECCS RECIRC						
ECCS HT XCHNG						
MAIN FEEDWATER						
AUX FEEDWATER	X	X	X			X

CONTAINMENT SYSTEMS STATUS

EVENT	S2H	S2D	S2HF	TMLB'	T23ML	AD
AIR RETURN FANS	X	X	X		X	X
SPRAY	X	X	X		X	X
SPRAY RECIRC	X	X			X	X
SPRAY HT. XCHNG	X	X			X	X
IGNITORS	X	X	X		X	X

PRELIMINARY

4.1 Sequence No. 1 - S_2D

4.1.1 Accident Sequence Description

S_2D consists of a small LOCA initiator with subsequent failure of the ECCS in the injection mode. The ECCS continues to be unavailable in the recirculation mode. Containment safeguards systems (ice condenser, sprays, air return fans, and igniters) are available throughout the accident.

4.1.2 Reactor Coolant System Response

Upon initiation of a 0.0218 ft^2 cold leg break, the reactor is scrammed, followed by reactor coolant pump coastdown and auxiliary feedwater startup at five seconds. Figures C.1-1 through C.1-5 illustrate the variables of interest. Immediately following break initiation, the primary system pressure decreases to approximately 1250 lb/in^2a. At this time (approximately 0.2 hours) the UHI rupture disk fails and relatively cool water injection is initiated. The rate of inventory loss out of the break is partially offset by the injection of UHI water. The primary system depressurization continues as decay heat is being transferred to the steam generators and lost through the break. This gradual depressurization continues until 0.8 hours at which time the core begins to uncover. As the water level in the core continues to drop, the cladding temperature begins to increase. Approximately 0.2 hours after core uncovery the metal-water reaction initiates hydrogen generation.

The primary system pressure continues to decrease as the remaining water from the UHI is injected (UHI water depletes at 2.02 hours). At approximately 2.2 hours, the primary system pressure has dropped below the 415 lb/in^2a set point for the cold leg accumulators and cool water injection begins. At the time of injection initiation the reactor vessel water level is about 10 feet which indicates the bottom of the active core is uncovered. The effect of this "bottom to top " reflood is to initially quench the lower nodes of the core. However, this quenching is not maintained and the heat-up of the injected water supplies steam to the cladding-water reaction and hydrogen production is restarted. As core nodes reach the melting temperature, the mass of molten core collecting on the core support increases until about 110,000 lbm (40 percent of the original core mass) have accumulated at 2.80 hours. At this time, the lower core support plate fails and the molten core material falls into the lower plenum of the reactor vessel. Approximately one minute later (2.81 hours), the molten core material fails one of the penetrations in the bottom of the vessel and the melt is discharged through the hole into the reactor cavity. Following the molten core, the remaining hydrogen, steam, and water is discharged into the cavity along with the remaining accumulator water. The core nodes remaining in the vessel continue heating adiabatically. As each node reaches 5144°F it then falls into the cavity. The corium discharge rate after vessel failure decreases with the final core node reaching the melting temperature at 7.7 hours. Total hydrogen production from in-vessel Zircaloy oxidation is 660 lbs. The average rate is 0.10 lb/sec and the reaction is equivalent to a total core average clad oxidation of 32 percent.

4.1.3 Containment Response

Immediately following the accident initiation, the lower compartment pressurizes as RCS inventory is discharged. At 64 seconds the containment spray pressure set point is reached. The containment sprays take suction from the RWST until recirculation realignment occurs at 0.4

hours. At 2.81 hours the vessel fails causing a pressure spike to about 21.0 lb/in^2a. The available air return fans, ice, and containment sprays rapidly decrease the pressure to approximately 18 lb/in^2a. Since the ice has not been depleted at this time, the temperature response in the upper compartment remains relatively constant. Pressure suppression is effective as anticipated. As the ice continues to melt and RCS inventory is lost from the break, the water level in the lower compartment exceeds the necessary curb height required for spilling water into the cavity at approximately 0.8 hours. Therefore, by the time reactor vessel failure occurs, the cavity is flooded. This flooded condition limits core-concrete ablation to the "jet" attack resulting in a 0.14 ft penetration depth. The flooded cavity results in immediate quenching of the corium.

The remaining ice mass at time of vessel failure is approximately 9.1×10^5 lbs (about 57 percent melted). At 4.92 hours all of the ice has melted and containment pressurization begins. Following ice depletion, the ice condenser and ice condenser upper plenum temperatures immediately increase to approximately the lower compartment temperature. The containment sprays continue to remove heat from the containment atmosphere with the continued molten corium discharge from the vessel and the decay heat from quenched debris generating steam. This heat removal rate matches the decay heat at approximately 7.5 hours when the containment pressure reaches about 20.5 lb/in^2a. Afterward, the containment spray heat removal rate exceeds that of decay heat and the containment pressure continues to decrease, thus precluding containment failure.

TABLE 4.1-1 PRELIMINARY

S2D U1MAAP

SEC	HR	EVENT DESCRIPTION	CODE
0.0	0.00	REACTOR SCRAM	13
0.0	0.00	LETDOWN FLOW OFF	46
0.0	0.00	AUX FEEDWATER ON	154
0.0	0.00	MSIV CLOSED	156
0.0	0.00	PS BREAK FAILED	209
0.0	0.00	HPI FORCED OFF	216
0.0	0.00	LPI FORCED OFF	217
0.0	0.00	MANUAL SCRAM	227
0.0	0.00	CHARGING PUMPS FORCED OFF	232
0.0	0.00	MAKEUP SWITCH OFF	242
0.0	0.00	LETDOWN SWITCH OFF	243
60.5	.02	MAIN COOLANT PUMPS OFF	4
60.5	.02	MCP SWITCH OFF OR HI-VIBR TRIP	215
63.7	.02	CONTMT SPRAYS ON	103
1466.3	.41	RECIRC SYSTEM IN OPERATION	181
1466.3	.41	RECIRC SWITCH: MAN ON	220
1483.9	.41	CH PUMPS INSUFF NPSH	183
1483.9	.41	HPI PUMPS INSUFF NPSH	185
2945.5	.82	FP RELEASE ENABLED	14
4597.5	1.28	BURN IN PROGRESS IN I/C UPPER PLENUM	141
5122.7	1.42	BURN IN PROGRESS IN UPPER CMPT	102
5186.7	1.44	BURN IN PROGRESS IN ANNULAR CMPT	122
5545.2	1.54	BURN IN PROGRESS IN LOWER CMPT	75
5629.1	1.56	NO BURN IN LOWER CMPT	75
7281.5	2.02	UHI ACCUM EMPTY	190
7774.8	2.16	BURN IN PROGRESS IN LOWER CMPT	75
8441.8	2.34	NO BURN IN LOWER CMPT	75
10037.3	2.79	SUPPORT PLATE FAILED	2
10100.4	2.81	RV FAILED	3
10115.5	2.81	BURN IN PROGRESS IN LOWER CMPT	75
10191.8	2.83	NO BURN IN I/C UPPER PLENUM	141
10195.2	2.83	BURN IN PROGRESS IN I/C UPPER PLENUM	141
10199.3	2.83	ACCUMULATOR WATER DEPLETED	188
10207.0	2.84	NO BURN IN LOWER CMPT	75
10210.8	2.84	NO BURN IN I/C UPPER PLENUM	141
10213.8	2.84	BURN IN PROGRESS IN I/C UPPER PLENUM	141

TABLE 4.1-1 PRELIMINARY

S2D U1MAAP CONT.

SEC	HR	EVENT DESCRIPTION	CODE
10245.0	2.85	NO BURN IN I/C UPPER PLENUM	141
10247.3	2.85	NO BURN IN UPPER CMPT	102
10251.5	2.85	BURN IN PROGRESS IN I/C UPPER PLENUM	141
10261.4	2.85	BURN IN PROGRESS IN UPPER CMPT	102
11514.8	3.20	NO BURN IN UPPER CMPT	102
11554.3	3.21	BURN IN PROGRESS IN UPPER CMPT	102
11594.0	3.22	NO BURN IN UPPER CMPT	102
11768.8	3.27	BURN IN PROGRESS IN UPPER CMPT	102
11813.5	3.28	NO BURN IN UPPER CMPT	102
11956.2	3.32	BURN IN PROGRESS IN UPPER CMPT	102
11975.1	3.33	NO BURN IN UPPER CMPT	102
12026.6	3.34	NO BURN IN ANNULAR CMPT	122
12042.3	3.35	BURN IN PROGRESS IN ANNULAR CMPT	122
12120.6	3.37	NO BURN IN ANNULAR CMPT	122
12126.2	3.37	BURN IN PROGRESS IN ANNULAR CMPT	122
12213.8	3.39	NO BURN IN ANNULAR CMPT	122
12232.8	3.40	BURN IN PROGRESS IN ANNULAR CMPT	122
12406.2	3.45	NO BURN IN ANNULAR CMPT	122
12432.3	3.45	BURN IN PROGRESS IN ANNULAR CMPT	122
12500.7	3.47	NO BURN IN ANNULAR CMPT	122
12505.2	3.47	BURN IN PROGRESS IN ANNULAR CMPT	122
12582.2	3.50	NO BURN IN ANNULAR CMPT	122
12593.2	3.50	BURN IN PROGRESS IN ANNULAR CMPT	122
12593.2	3.50	NO BURN IN I/C UPPER PLENUM	141
12604.2	3.50	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12611.9	3.50	NO BURN IN ANNULAR CMPT	122
12619.7	3.51	BURN IN PROGRESS IN ANNULAR CMPT	122
12624.1	3.51	NO BURN IN I/C UPPER PLENUM	141
12626.8	3.51	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12711.2	3.53	NO BURN IN ANNULAR CMPT	122
12711.2	3.53	NO BURN IN I/C UPPER PLENUM	141
12764.4	3.55	BURN IN PROGRESS IN ANNULAR CMPT	122
12793.1	3.55	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12800.1	3.56	NO BURN IN I/C UPPER PLENUM	141
12807.0	3.56	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12842.0	3.57	NO BURN IN I/C UPPER PLENUM	141

TABLE 4.1-1.

PRELIMINARY

S2D U1MAAP CONT.

SEC	HR	EVENT DESCRIPTION	CODE
12856.0	3.57	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12881.9	3.58	NO BURN IN I/C UPPER PLENUM	141
12916.8	3.59	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12930.9	3.59	BURN IN PROGRESS IN UPPER CMPT	102
12951.3	3.60	NO BURN IN UPPER CMPT	102
12975.2	3.60	NO BURN IN I/C UPPER PLENUM	141
12988.9	3.61	BURN IN PROGRESS IN I/C UPPER PLENUM	141
13002.5	3.61	NO BURN IN ANNULAR CMPT	122
13002.5	3.61	NO BURN IN I/C UPPER PLENUM	141
13032.5	3.62	BURN IN PROGRESS IN ANNULAR CMPT	122
13108.5	3.64	BURN IN PROGRESS IN I/C UPPER PLENUM	141
13117.4	3.64	NO BURN IN I/C UPPER PLENUM	141
13135.3	3.65	BURN IN PROGRESS IN I/C UPPER PLENUM	141
13153.2	3.65	NO BURN IN I/C UPPER PLENUM	141
13199.8	3.67	NO BURN IN ANNULAR CMPT	122
13211.5	3.67	BURN IN PROGRESS IN ANNULAR CMPT	122
13226.8	3.67	NO BURN IN ANNULAR CMPT	122
13242.0	3.68	BURN IN PROGRESS IN ANNULAR CMPT	122
13257.3	3.68	NO BURN IN ANNULAR CMPT	122
13272.1	3.69	BURN IN PROGRESS IN ANNULAR CMPT	122
13367.5	3.71	NO BURN IN ANNULAR CMPT	122
13398.9	3.72	BURN IN PROGRESS IN ANNULAR CMPT	122
13498.6	3.75	NO BURN IN ANNULAR CMPT	122
13513.5	3.75	BURN IN PROGRESS IN ANNULAR CMPT	122
13526.8	3.76	NO BURN IN ANNULAR CMPT	122
13533.6	3.76	BURN IN PROGRESS IN ANNULAR CMPT	122
13603.3	3.78	NO BURN IN ANNULAR CMPT	122
13620.2	3.78	BURN IN PROGRESS IN ANNULAR CMPT	122
13632.2	3.79	NO BURN IN ANNULAR CMPT	122
13646.8	3.79	BURN IN PROGRESS IN ANNULAR CMPT	122
13796.0	3.83	NO BURN IN ANNULAR CMPT	122
13805.0	3.83	BURN IN PROGRESS IN ANNULAR CMPT	122
13821.2	3.84	NO BURN IN ANNULAR CMPT	122
13828.6	3.84	BURN IN PROGRESS IN ANNULAR CMPT	122
13863.5	3.85	NO BURN IN ANNULAR CMPT	122
13876.7	3.85	BURN IN PROGRESS IN ANNULAR CMPT	122

TABLE 4.1-1 PRELIMINARY

S2D U1MAAP CONT.

SEC	HR	EVENT DESCRIPTION	CODE
13892.5	3.86	NO BURN IN ANNULAR CMPT	122
13919.9	3.87	BURN IN PROGRESS IN ANNULAR CMPT	122
13994.5	3.89	NO BURN IN ANNULAR CMPT	122
14020.9	3.89	BURN IN PROGRESS IN ANNULAR CMPT	122
14040.9	3.90	NO BURN IN ANNULAR CMPT	122
14064.9	3.91	BURN IN PROGRESS IN ANNULAR CMPT	122
14166.3	3.94	NO BURN IN ANNULAR CMPT	122
14193.6	3.94	BURN IN PROGRESS IN ANNULAR CMPT	122
14340.4	3.98	NO BURN IN ANNULAR CMPT	122
14397.8	4.00	BURN IN PROGRESS IN ANNULAR CMPT	122
14449.6	4.01	NO BURN IN ANNULAR CMPT	122
14470.3	4.02	BURN IN PROGRESS IN ANNULAR CMPT	122
14573.3	4.05	NO BURN IN ANNULAR CMPT	122
14593.3	4.05	BURN IN PROGRESS IN ANNULAR CMPT	122
14607.7	4.06	NO BURN IN ANNULAR CMPT	122
14626.3	4.06	BURN IN PROGRESS IN ANNULAR CMPT	122
14711.4	4.09	NO BURN IN ANNULAR CMPT	122
14718.4	4.09	BURN IN PROGRESS IN ANNULAR CMPT	122
14735.7	4.09	BURN IN PROGRESS IN UPPER CMPT	102
14757.2	4.10	NO BURN IN UPPER CMPT	102
14797.2	4.11	NO BURN IN ANNULAR CMPT	122
14851.3	4.13	BURN IN PROGRESS IN ANNULAR CMPT	122
14912.4	4.14	NO BURN IN ANNULAR CMPT	122
14925.8	4.15	BURN IN PROGRESS IN ANNULAR CMPT	122
14939.1	4.15	NO BURN IN ANNULAR CMPT	122
14957.8	4.15	BURN IN PROGRESS IN ANNULAR CMPT	122
15002.7	4.17	NO BURN IN ANNULAR CMPT	122
15061.9	4.18	BURN IN PROGRESS IN ANNULAR CMPT	122
15134.4	4.20	NO BURN IN ANNULAR CMPT	122
15177.0	4.22	BURN IN PROGRESS IN ANNULAR CMPT	122
15218.4	4.23	NO BURN IN ANNULAR CMPT	122
15314.1	4.25	BURN IN PROGRESS IN ANNULAR CMPT	122
15375.7	4.27	NO BURN IN ANNULAR CMPT	122
15390.8	4.28	BURN IN PROGRESS IN ANNULAR CMPT	122
15439.0	4.29	NO BURN IN ANNULAR CMPT	122
15488.2	4.30	BURN IN PROGRESS IN ANNULAR CMPT	122

TABLE 4.1-1 PRELIMINARY

S2D U1MAAP CONT.

SEC	HR	EVENT DESCRIPTION	CODE
15554.1	4.32	NO BURN IN ANNULAR CMPT	122
15641.8	4.34	BURN IN PROGRESS IN ANNULAR CMPT	122
15722.0	4.37	NO BURN IN ANNULAR CMPT	122
15759.5	4.38	BURN IN PROGRESS IN ANNULAR CMPT	122
15825.5	4.40	NO BURN IN ANNULAR CMPT	122
15861.9	4.41	BURN IN PROGRESS IN ANNULAR CMPT	122
15941.9	4.43	NO BURN IN ANNULAR CMPT	122
15995.2	4.44	BURN IN PROGRESS IN ANNULAR CMPT	122
16007.2	4.45	NO BURN IN ANNULAR CMPT	122
16062.6	4.46	BURN IN PROGRESS IN ANNULAR CMPT	122
16108.0	4.47	NO BURN IN ANNULAR CMPT	122
16172.7	4.49	BURN IN PROGRESS IN ANNULAR CMPT	122
16213.3	4.50	NO BURN IN ANNULAR CMPT	122
16267.6	4.52	BURN IN PROGRESS IN ANNULAR CMPT	122
16344.4	4.54	NO BURN IN ANNULAR CMPT	122
16355.5	4.54	BURN IN PROGRESS IN ANNULAR CMPT	122
16433.5	4.56	NO BURN IN ANNULAR CMPT	122
16484.7	4.58	BURN IN PROGRESS IN ANNULAR CMPT	122
16539.9	4.59	NO BURN IN ANNULAR CMPT	122
16598.3	4.61	BURN IN PROGRESS IN ANNULAR CMPT	122
16680.0	4.63	NO BURN IN ANNULAR CMPT	122
16739.6	4.65	BURN IN PROGRESS IN ANNULAR CMPT	122
16750.9	4.65	NO BURN IN ANNULAR CMPT	122
16773.6	4.66	BURN IN PROGRESS IN ANNULAR CMPT	122
16784.9	4.66	NO BURN IN ANNULAR CMPT	122
16816.2	4.67	BURN IN PROGRESS IN ANNULAR CMPT	122
16907.2	4.70	NO BURN IN ANNULAR CMPT	122
16926.8	4.70	BURN IN PROGRESS IN ANNULAR CMPT	122
16994.8	4.72	NO BURN IN ANNULAR CMPT	122
17010.8	4.73	BURN IN PROGRESS IN ANNULAR CMPT	122
17018.1	4.73	NO BURN IN ANNULAR CMPT	122
17025.4	4.73	BURN IN PROGRESS IN ANNULAR CMPT	122
17052.9	4.74	NO BURN IN ANNULAR CMPT	122
17078.6	4.74	BURN IN PROGRESS IN ANNULAR CMPT	122
17085.2	4.75	NO BURN IN ANNULAR CMPT	122
17091.8	4.75	BURN IN PROGRESS IN ANNULAR CMPT	122

TABLE 4.1-1 PRELIMINARY

S2D U1MAAP CONT.

SEC	HR	EVENT DESCRIPTION	CODE
17131.1	4.76	NO BURN IN ANNULAR CMPT	122
17144.0	4.76	BURN IN PROGRESS IN ANNULAR CMPT	122
17157.7	4.77	NO BURN IN ANNULAR CMPT	122
17198.5	4.78	BURN IN PROGRESS IN ANNULAR CMPT	122
17215.6	4.78	NO BURN IN ANNULAR CMPT	122
17251.9	4.79	BURN IN PROGRESS IN ANNULAR CMPT	122
17317.5	4.81	NO BURN IN ANNULAR CMPT	122
17375.9	4.83	BURN IN PROGRESS IN ANNULAR CMPT	122
17434.4	4.84	NO BURN IN ANNULAR CMPT	122
17448.5	4.85	BURN IN PROGRESS IN ANNULAR CMPT	122
17510.7	4.86	NO BURN IN ANNULAR CMPT	122
17537.2	4.87	BURN IN PROGRESS IN ANNULAR CMPT	122
17597.8	4.89	NO BURN IN ANNULAR CMPT	122
17614.4	4.89	BURN IN PROGRESS IN ANNULAR CMPT	122
17650.4	4.90	NO BURN IN ANNULAR CMPT	122
17654.6	4.90	BURN IN PROGRESS IN ANNULAR CMPT	122
17707.3	4.92	NO BURN IN ANNULAR CMPT	122
17729.6	4.92	ICE DEPLETED	132
17731.8	4.93	BURN IN PROGRESS IN ANNULAR CMPT	122
17792.0	4.94	NO BURN IN ANNULAR CMPT	122

4.2 Sequence No. 2 - S_2H

4.2.1 Accident Sequence Description

S_2H consists of a small LOCA initiator with subsequent failure of the ECCS in the recirculation mode. Emergency core cooling in the injection mode is successful and the containment safeguards systems (ice condenser, sprays, air return fans, and igniters) are available throughout the accident.

4.2.2 Reactor Coolant System Response

Upon initiation of a 0.0218 ft^2 cold leg break, the reactor is scrammed, followed by reactor pump coastdown, and auxiliary feedwater startup at five seconds. Figures C.2-1 through C.2-5 illustrate the variables of interest. Immediately following break initiation, the primary system pressure decreases to approximately 1250 lb/in^2a. During this depressurization period (0.0-0.1 hours) high pressure injection charging pumps and safety injection pumps start and UHI initiaties injection at 1255 lb/in^2a. This introduction of cool water into the reactor vessel results in initially cooling the primary system water. The primary system water mass continues to increase until 0.37 hours when the recirculation switchover point is reached. This increase in primary system inventory and cooling results in decreasing the secondary side temperature and pressure. Since the primary system pressure is continually decreasing after unsuccessful recirculation switchover, the UHI continues to inject past 0.37 hours. This continued injection cools the primary and secondary side until a minimum pressure of about 1000 lb/in^2a is reached in the primary system. At this point, the primary side pressure begins to increase due to secondary side heating. The primary side pressure increase results in termination of UHI injection. Since heat removal through the break is less than the decay heat, both primary and secondary pressurize to the secondary side relief valve set point of approximately 1100 lb/in^2a. With no more water available for injection, reactor coolant inventory starts decreasing within the primary system. The primary system pressure remains somewhat constant until about 1.3 hours. At this time, the reactor vessel water level falls below the top of the core and superheated steam begins to exit the core. As the water level in the core continues to decrease, the cladding temperature increases. Approximately 0.2 hours after core uncovery, the cladding metal-water reaction initiates significant hydrogen generation. The increasing void in the primary system coupled with the increased flow out of the break causes a depressurization at a relatively constant rate until 1.5 hours. At this time, the pressure has decreased enough for UHI initiation. UHI continues to inject until depletion occurs at about 2.3 hours, after which the injected water is quickly heated to reactor vessel conditions. During the period 1.5-2.0 hours, the UHI is insufficient to quench the fuel resulting in continued hydrogen production.

At approximately 2.45 hours, the primary system pressure has decreased to the cold leg accumulator set point (415 lb/in^2a) and bottom-to-top reflood is initiated. This results in providing additional water for steam production and further oxidation of the cladding as indicated by the re-initiation of hydrogen production. Continued accumulator discharge causes the vessel water level and mass to increase as the pressure decreases to approximately 350 lb/in^2a. As the core continues to heat up, the first node reaches the melting temperature of 5144°F at 1.9 hours. Increased heating and node melting results in the molten core collecting on the core support plate until about 110,000 pounds have accumulated at 3.30 hours. At this time, the lower core support plate fails and the molten core material falls into the lower plenum of the reactor vessel. Within one minute, the molten core material fails one of the penetrations in the bottom head of the vessel and the molten core material is discharged through the hole into the reactor cavity. Following the molten core, the remaining hydrogen, steam, and water is discharged into the cavity along with the remaining accumulator water. The core nodes remaining in the vessel continue heating adiabatically with each node draining into the reactor cavity when it reaches 5144°F. The corium discharge rate after vessel failure decreases, with the final core node reaching the melting temperature at 8.4 hours. A total hydrogen mass of 680 lbs is generated with an average hydrogen production rate of 0.09 lb/sec. This corresponds to an overall Zircaloy clad oxidation of 33 percent.

4.2.3 Containment Response

Immediately following the accident initiation, the lower compartment pressurizes as RCS inventory is discharged. At 65 seconds, the pressure set point for the containment spray is reached. The containment sprays take suction from the RWST until the recirculation alignment occurs at 0.37 hours. At this point the sprays recirculate water from the containment sump. At 3.31 hours when the vessel fails the lower compartment pressure increases to about 21.5 lb/in^2a. However, the air return fans, containment sprays, and available ice reduce this pressure to approximately 18 lb/in^2a. The water level in the lower compartment exceeds the necessary curb height required for spilling water into the cavity at approximately 0.8 hours. Therefore, by the time the reactor vessel failure occurs, the cavity is flooded. This flooded condition limits core-concrete ablation to the jet attack only resulting in a 0.15 ft penetration depth. The flooded cavity results in the immediate quenching of the corium.

The ice remaining at the time of vessel failure is approximately 5.75×10^5 lbs. At 4.55 hours all the ice has been melted and the containment pressure rapidly increases due to loss of the passive ice heat sink. The containment sprays continue to remove heat from the containment atmosphere, but lag the input decay heat energy until 7.0 hours, at which time the containment pressure of about 20 lb/in^2a is reached. Afterward, the containment spray heat removal rate exceeds that of decay heat and the containment pressure continues to decrease, thus precluding containment failure.

TABLE 4.2-1

PRELIMINARY

S2H U2MAAP

SEC	HR	EVENT DESCRIPTION	CODE
0.0	0.00	REACTOR SCRAM	13
0.0	0.00	LETDOWN FLOW OFF	46
0.0	0.00	AUX FEEDWATER ON	154
0.0	0.00	MSIV CLOSED	156
0.0	0.00	PS BREAK FAILED	209
0.0	0.00	MANUAL SCRAM	227
0.0	0.00	MAKEUP SWITCH OFF	242
0.0	0.00	LETDOWN SWITCH OFF	243
47.6	.01	CHARGING PUMPS ON	11
61.1	.02	MAIN COOLANT PUMPS OFF	4
61.1	.02	MCP SWITCH OFF OR HI-VIBR TRIP	215
64.9	.02	CONTMT SPRAYS ON	103
160.3	.04	HPI ON	5
1342.3	.37	HPI OFF	5
1342.3	.37	CHARGING PUMPS OFF	11
1342.3	.37	RECIRC SYSTEM IN OPERATION	181
1342.3	.37	HPI FORCED OFF	216
1342.3	.37	LPI FORCED OFF	217
1342.3	.37	RECIRC SWITCH: MAN ON	220
1342.3	.37	CHARGING PUMPS FORCED OFF	232
1354.9	.38	CH PUMPS INSUFF NPSH	183
1354.9	.38	HPI PUMPS INSUFF NPSH	185
4442.3	1.23	FP RELEASE ENABLED	14
5818.5	1.62	BURN IN PROGRESS IN I/C UPPER PLENUM	141
6294.7	1.75	BURN IN PROGRESS IN LOWER CMPT	75
6426.6	1.79	BURN IN PROGRESS IN UPPER CMPT	102
6493.3	1.80	BURN IN PROGRESS IN ANNULAR CMPT	122
6601.6	1.83	NO BURN IN LOWER CMPT	75
7213.5	2.00	BURN IN PROGRESS IN LOWER CMPT	75
7280.2	2.02	NO BURN IN LOWER CMPT	75
8400.1	2.33	UHI ACCUM EMPTY	190
9449.7	2.62	BURN IN PROGRESS IN LOWER CMPT	75
9895.2	2.75	NO BURN IN LOWER CMPT	75
10234.8	2.84	BURN IN PROGRESS IN LOWER CMPT	75
10458.2	2.91	NO BURN IN LOWER CMPT	75
11771.0	3.27	BURN IN PROGRESS IN LOWER CMPT	75

TABLE 4.2-1

PRELIMINARY

S2H U2MAAP CONT.

SEC	HR	EVENT DESCRIPTION	CODE
11868.9	3.30	SUPPORT PLATE FAILED	2
11915.4	3.31	NO BURN IN LOWER CMPT	75
11927.3	3.31	RV FAILED	3
11936.7	3.32	BURN IN PROGRESS IN LOWER CMPT	75
12021.4	3.34	ACCUMULATOR WATER DEPLETED	188
12051.6	3.35	NO BURN IN UPPER CMPT	102
12058.4	3.35	NO BURN IN LOWER CMPT	75
12062.9	3.35	NO BURN IN I/C UPPER PLENUM	141
12063.8	3.35	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12079.5	3.36	NO BURN IN I/C UPPER PLENUM	141
12084.9	3.36	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12105.7	3.36	BURN IN PROGRESS IN UPPER CMPT	102
13429.2	3.73	NO BURN IN UPPER CMPT	102
13523.7	3.76	BURN IN PROGRESS IN UPPER CMPT	102
13550.7	3.76	NO BURN IN UPPER CMPT	102
13581.0	3.77	BURN IN PROGRESS IN UPPER CMPT	102
13597.7	3.78	NO BURN IN UPPER CMPT	102
13599.0	3.78	BURN IN PROGRESS IN UPPER CMPT	102
13647.7	3.79	NO BURN IN UPPER CMPT	102
13685.1	3.80	NO BURN IN ANNULAR CMPT	122
13722.7	3.81	BURN IN PROGRESS IN ANNULAR CMPT	122
13784.0	3.83	NO BURN IN ANNULAR CMPT	122
13853.5	3.85	BURN IN PROGRESS IN ANNULAR CMPT	122
13943.6	3.87	NO BURN IN ANNULAR CMPT	122
13951.0	3.88	BURN IN PROGRESS IN ANNULAR CMPT	122
14097.5	3.92	NO BURN IN ANNULAR CMPT	122
14153.4	3.93	BURN IN PROGRESS IN ANNULAR CMPT	122
14165.3	3.93	NO BURN IN ANNULAR CMPT	122
14182.3	3.94	BURN IN PROGRESS IN ANNULAR CMPT	122
14260.0	3.96	NO BURN IN ANNULAR CMPT	122
14294.6	3.97	BURN IN PROGRESS IN ANNULAR CMPT	122
14301.6	3.97	NO BURN IN ANNULAR CMPT	122
14307.1	3.97	BURN IN PROGRESS IN ANNULAR CMPT	122
14380.4	3.99	NO BURN IN ANNULAR CMPT	122
14388.2	4.00	BURN IN PROGRESS IN ANNULAR CMPT	122
14488.5	4.02	NO BURN IN ANNULAR CMPT	122

TABLE 4.2-1 PRELIMINARY

S2H U2MAAP CONT.

SEC	HR	EVENT DESCRIPTION	CODE
14521.7	4.03	BURN IN PROGRESS IN ANNULAR CMPT	122
14638.4	4.07	BURN IN PROGRESS IN UPPER CMPT	102
14665.2	4.07	NO BURN IN UPPER CMPT	102
14703.1	4.08	NO BURN IN ANNULAR CMPT	122
14775.6	4.10	BURN IN PROGRESS IN ANNULAR CMPT	122
14783.8	4.11	NO BURN IN ANNULAR CMPT	122
14792.0	4.11	BURN IN PROGRESS IN ANNULAR CMPT	122
14808.4	4.11	NO BURN IN ANNULAR CMPT	122
14840.5	4.12	BURN IN PROGRESS IN ANNULAR CMPT	122
14892.9	4.14	NO BURN IN ANNULAR CMPT	122
14926.2	4.15	NO BURN IN I/C UPPER PLENUM	141
14939.6	4.15	BURN IN PROGRESS IN I/C UPPER PLENUM	141
14959.6	4.16	NO BURN IN I/C UPPER PLENUM	141
14981.1	4.16	BURN IN PROGRESS IN ANNULAR CMPT	122
14994.4	4.17	BURN IN PROGRESS IN I/C UPPER PLENUM	141
15075.8	4.19	NO BURN IN I/C UPPER PLENUM	141
15084.4	4.19	BURN IN PROGRESS IN I/C UPPER PLENUM	141
15133.8	4.20	NO BURN IN I/C UPPER PLENUM	141
15152.7	4.21	NO BURN IN ANNULAR CMPT	122
15200.3	4.22	BURN IN PROGRESS IN ANNULAR CMPT	122
15288.8	4.25	NO BURN IN ANNULAR CMPT	122
15324.8	4.26	BURN IN PROGRESS IN ANNULAR CMPT	122
15392.6	4.28	NO BURN IN ANNULAR CMPT	122
15481.1	4.30	BURN IN PROGRESS IN ANNULAR CMPT	122
15558.2	4.32	NO BURN IN ANNULAR CMPT	122
15575.6	4.33	BURN IN PROGRESS IN ANNULAR CMPT	122
15672.1	4.35	NO BURN IN ANNULAR CMPT	122
15680.5	4.36	BURN IN PROGRESS IN ANNULAR CMPT	122
15765.2	4.38	NO BURN IN ANNULAR CMPT	122
15779.4	4.38	BURN IN PROGRESS IN ANNULAR CMPT	122
15991.1	4.44	NO BURN IN ANNULAR CMPT	122
16007.5	4.45	BURN IN PROGRESS IN ANNULAR CMPT	122
16020.2	4.45	NO BURN IN ANNULAR CMPT	122
16032.8	4.45	BURN IN PROGRESS IN ANNULAR CMPT	122
16230.2	4.51	NO BURN IN ANNULAR CMPT	122
16241.9	4.51	BURN IN PROGRESS IN ANNULAR CMPT	122

TABLE 4.2-1

PRELIMINARY

S2H U2MAAP CONT.

SEC	HR	EVENT DESCRIPTION	CODE
16256.1	4.52	BURN IN PROGRESS IN UPPER CMPT	102
16276.2	4.52	NO BURN IN UPPER CMPT	102
16325.3	4.53	NO BURN IN ANNULAR CMPT	122
16329.2	4.54	BURN IN PROGRESS IN ANNULAR CMPT	122
16373.9	4.55	ICE DEPLETED	132
16387.7	4.55	BURN IN PROGRESS IN UPPER CMPT	102
16407.7	4.56	NO BURN IN UPPER CMPT	102
16440.1	4.57	NO BURN IN ANNULAR CMPT	122

PRELIMINARY

4.3 Sequence No. 3 - S_2HF

4.3.1 Accident Sequence Description

S_2HF consists of a small LOCA initiator with subsequent failure of the ECCS and containment spray system in the recirculation mode. Emergency core cooling and containment sprays are available during the injection phase only and the containment safeguards systems (ice condenser, air return fans, and igniters) are available throughout the accident.

The following sections will present two scenarios for this accident sequence. The first sequence (4.3.2, 4.3.3) postulates that the drains between the upper and lower compartments are either closed or blocked resulting in the spray water accumulating in the refueling pool thus preventing the normal flowback from the upper compartment to the lower compartment sump. The second sequence (4.3.4, 4.3.5) presented postulates an equipment failure preventing the accumulated water in the lower compartment sump from being recirculated back into the upper compartment.

4.3.2 Reactor Coolant System Response (Drains Blocked)

Upon initiation of a 0.0218 ft^2 cold leg break, the reactor is scrammed, followed by reactor pump coastdown and auxiliary feedwater startup at five seconds. Figures C.3-6 through C.3-10 illustrate the variables of interest. Immediately following break initiation, the primary system pressure drops to saturation pressure followed by the initiation of ECCS injection at 0.01 hours to replace the mass of primary coolant lost out of the break. The ECCS supplies water to the RCS between the time of 0.01 and 0.37 hours. During this time period, the RCS pressure decreases at a slower rate. The UHI begins to inject water when the primary system pressure drops below 1255 lb/in^2a. This addition of cool water depresses the primary system pressure to a minimum of about 1000 lb/in^2a at about 0.4 hours after which the reactor coolant pressure and temperature increases due to the heat transferred from the secondary side. Continued loss of primary system inventory leads to core uncovery at 1.2 hours accompanied by initiation of the cladding metal-water reaction producing hydrogen at a significant rate around 1.5 hours. Total hydrogen production is 680 lbs at an average rate of 0.10 lbs/sec. This corresponds to an average clad oxidation of 34 percent. At approximately 2.5 hours the primary system pressure decreases below 415 lb/in^2a and the cold leg accumulators begin to dump water into the reactor vessel. The core continues to heat up until sufficient molten fuel accumulates leading to failure of the core support plate. The molten corium fails the support plate at approximately 3.34 hours. At 3.35 hours, the vessel fails and the remaining water, hydrogen, accumulator water, and molten corium is discharged into the cavity region.

4.3.3 Containment Response (Drains Blocked)

Immediately following the accident initiation, the lower compartment pressurizes as the RCS inventory is discharged. At 65 seconds the pressure set point for the containment spray is reached. The containment spray takes suction from the RWST until recirculation switchover is attempted unsuccessfully at 0.38 hours. At 3.35 hours the vessel fails and the containment pressure increases to about 25 lb/in^2a. The forced circulation of the air return fans and remaining ice reduce the pressure to approximately 21 lb/in^2a. At the time of vessel failure, the water level in the lower compartment is approximately 9 feet, which is less than the 10 feet necessary for spillover into the cavity. Although the containment sprays have delivered all the RWST water prior to recirculation switchover at 0.38 hours, all of this inventory is trapped in the upper compartment due to the failure to remove upper to lower compartment drain plugs. Therefore, the molten corium is released into a dry cavity. Immediate concrete ablation occurs due to "jet" attack during the corium blowdown, resulting in an initial penetration depth of about 0.3 feet.

Following reactor vessel failure, the water level in the lower compartment increases due to accumulation from the melted ice but never reaches the necessary 10 foot spillover height. Therefore, once the water discharged during vessel blowdown (cold leg accumulators and remaining vessel inventory) is evaporated by decay heat, the corium in the reactor cavity reheats and thermally attacks the concrete basemat generating noncondensible gases. The mass of ice remaining at the time of vessel failure is approximately 5.75×10^5 lbm. The air return fans in conjunction with the remaining ice provide containment pressure suppression until 3.81 hours, at which time all the ice has melted. With no method of removing decay heat from the containment, and the continued generation of noncondensible gases from the core-concrete attack, the containment failure pressure of 65 lb/in^2a is reached at 25.93 hours. At this time, the containment depressurizes through the assumed 0.02 ft^2 containment failure hole.

4.3.4 Reactor Coolant System Response (Drains Open)

Upon initiation of a 0.0218 ft^2 cold leg break, the reactor is scrammed, followed by reactor pump coastdown and auxiliary feedwater startup at five seconds. Figures C.3-1 through C.3-5 illustrate the variables of interest. Immediately following break initiation, the primary system pressure drops to saturation pressure followed by the initiation of ECCS injection at 0.01 hours to replace the mass of primary coolant lost out of the break. The ECCS system supplies water to the RCS between the time of 0.01 and 0.38 hours. During this time period, the RCS pressure decreases at a slower rate. The UHI begins to inject water when the primary system pressure drops below 1255 lb/in^2a. This addition of cool water depresses the primary system pressure to a minimum of about 1000 lb/in^2a at about 0.4 hours after which the reactor coolant pressure and temperature increases due to the heat transferred from the secondary side. Continued loss of primary system inventory leads to core uncovery at 1.2 hours accompanied by initiation of the cladding metal-water reaction producing hydrogen at a significant rate around 1.5 hours. Total hydrogen production is 700 pounds with an average rate of 0.10 lbs/sec, which corresponds to an average clad oxidation of 35 percent. At approximately 2.5 hours the primary system pressure decreases below 415 lb/in^2a and the cold leg accumulators begin to dump water into the reactor vessel. The core continues to heat up until sufficient molten fuel accumulates to failure of the core support plate with molten corium flowing into the lower plenum at approximately 3.30 hours. Vessel failure occurs about one minute later and the remaining water, hydrogen, accumulator water, and molten corium is discharged into the reactor cavity region.

4.3.5 Containment Response (Drains Not Blocked)

Immediately following the accident initiation, the lower compartment pressurizes as the RCS inventory is discharged. At 65 seconds the pressure setpoint for the containment spray is reached. The containment spray takes suction from the RWST until recircualtion switchover is attempted unsuccessfully at 0.37 hours. At 3.31 hours the vessel fails causing a containment pressure increase to 28 lb/in^2a. The forced circulation of the air return fans and the remaining ice reduce the pressure to approximately 18 lb/in^2a. The water level in the lower compartment has equaled the height required for spillover into the cavity at 0.8 hours. Therefore, the molten corium is release into a flooded cavity. Immediate concrete ablation occurs due to "jet" attack during the corium blowdown, resulting in an initial penetration depth of 0.15 feet. However, the debris is immediately quenched, halting any more concrete attack and the containment pressure remains low until the ice melts at 4.36 hours. Subsequently, with no method for removing decay heat, the containment pressurizes due to steam formation and fails at 9.54 hours. At this time, the containment depressurizes through the assumed 0.02 ft^2 failure hole.

TABLE 4.3-1

PRELIMINARY

S2HF U7MAAP (DRAIN BLOCKED)

SEC	HR	EVENT DESCRIPTION	CODE
0.0	0.00	REACTOR SCRAM	13
0.0	0.00	LETDOWN FLOW OFF	46
0.0	0.00	AUX FEEDWATER ON	154
0.0	0.00	MSIV CLOSED	156
0.0	0.00	PS BREAK FAILED	209
0.0	0.00	MANUAL SCRAM	227
0.0	0.00	MAKEUP SWITCH OFF	242
0.0	0.00	LETDOWN SWITCH OFF	243
47.6	.01	CHARGING PUMPS ON	11
61.1	.02	MAIN COOLANT PUMPS OFF	4
61.1	.02	MCP SWITCH OFF OR HI-VIBR TRIP	215
64.9	.02	CONTMT SPRAYS ON	103
160.3	.04	HPI ON	5
1356.8	.38	HPI OFF	5
1356.8	.38	CHARGING PUMPS OFF	11
1356.8	.38	CONTMT SPRAYS OFF	103
1356.8	.38	HPI FORCED OFF	216
1356.8	.38	LPI FORCED OFF	217
1356.8	.38	SPRAYS FORCED OFF	222
1356.8	.38	CHARGING PUMPS FORCED OFF	232
4435.5	1.23	FP RELEASE ENABLED	14
5916.7	1.64	BURN IN PROGRESS IN I/C UPPER PLENUM	141
6312.1	1.75	BURN IN PROGRESS IN LOWER CMPT	75
6430.8	1.79	BURN IN PROGRESS IN UPPER CMPT	102
6491.2	1.80	BURN IN PROGRESS IN ANNULAR CMPT	122
6592.4	1.83	NO BURN IN LOWER CMPT	75
8442.7	2.35	UHI ACCUM EMPTY	190
9250.4	2.57	BURN IN PROGRESS IN LOWER CMPT	75
9858.8	2.74	NO BURN IN LOWER CMPT	75
11413.3	3.17	BURN IN PROGRESS IN LOWER CMPT	75
11697.7	3.25	NO BURN IN LOWER CMPT	75
11805.4	3.28	BURN IN PROGRESS IN LOWER CMPT	75
11970.6	3.33	NO BURN IN LOWER CMPT	75
12014.3	3.34	SUPPORT PLATE FAILED	2
12077.0	3.35	RV FAILED	3
12129.4	3.37	BURN IN PROGRESS IN LOWER CMPT	75

PRELIMINARY

TABLE 4.3-1

S2HF U7MAAP (DRAIN BLOCKED) CONT.

SEC	HR	EVENT DESCRIPTION	CODE
12169.8	3.38	ACCUMULATOR WATER DEPLETED	188
12261.4	3.41	NO BURN IN I/C UPPER PLENUM	141
12272.7	3.41	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12366.3	3.44	NO BURN IN LOWER CMPT	75
13730.4	3.81	ICE DEPLETED	132
13739.1	3.82	NO BURN IN I/C UPPER PLENUM	141
13762.0	3.82	NO BURN IN UPPER CMPT	102
13790.1	3.83	NO BURN IN ANNULAR CMPT	122
31512.0	8.75	BURN IN PROGRESS IN LOWER CMPT	75
31594.5	8.78	BURN IN PROGRESS IN I/C UPPER PLENUM	141
31996.0	8.89	BURN IN PROGRESS IN UPPER CMPT	102
32079.5	8.91	BURN IN PROGRESS IN ANNULAR CMPT	122
34034.8	9.47	NO BURN IN LOWER CMPT	75
34104.8	9.47	BURN IN PROGRESS IN LOWER CMPT	75
34124.8	9.48	NO BURN IN LOWER CMPT	75
34164.8	9.49	BURN IN PROGRESS IN LOWER CMPT	75
34164.8	9.49	NO BURN IN I/C UPPER PLENUM	141
34184.8	9.50	NO BURN IN LOWER CMPT	75
34184.8	9.50	BURN IN PROGRESS IN I/C UPPER PLENUM	141
34204.8	9.50	NO BURN IN I/C UPPER PLENUM	141
34244.8	9.51	NO BURN IN UPPER CMPT	102
34244.8	9.51	NO BURN IN ANNULAR CMPT	122
93364.4	25.93	CONTMT FAILED	104

TABLE 4.3-1

PRELIMINARY

S2HF U3MAAP (DRAIN OPEN)

SEC	HR	EVENT DESCRIPTION	CODE
0.0	0.00	REACTOR SCRAM	13
0.0	0.00	LETDOWN FLOW OFF	46
0.0	0.00	AUX FEEDWATER ON	154
0.0	0.00	MSIV CLOSED	156
0.0	0.00	PS BREAK FAILED	209
0.0	0.00	MANUAL SCRAM	227
0.0	0.00	MAKEUP SWITCH OFF	242
0.0	0.00	LETDOWN SWITCH OFF	243
47.6	.01	CHARGING PUMPS ON	11
61.1	.02	MAIN COOLANT PUMPS OFF	4
61.1	.02	MCP SWITCH OFF OR HI-VIBR TRIP	215
64.9	.02	CONTMT SPRAYS ON	103
160.3	.04	HPI ON	5
1342.3	.37	HPI OFF	5
1342.3	.37	CHARGING PUMPS OFF	11
1342.3	.37	CONTMT SPRAYS OFF	103
1342.3	.37	HPI FORCED OFF	216
1342.3	.37	LPI FORCED OFF	217
1342.3	.37	SPRAYS FORCED OFF	222
1342.3	.37	CHARGING PUMPS FORCED OFF	232
4441.5	1.23	FP RELEASE ENABLED	14
5798.9	1.61	BURN IN PROGRESS IN I/C UPPER PLENUM	141
6281.4	1.74	BURN IN PROGRESS IN LOWER CMPT	75
6420.4	1.78	BURN IN PROGRESS IN UPPER CMPT	102
6486.4	1.80	BURN IN PROGRESS IN ANNULAR CMPT	122
6601.9	1.83	NO BURN IN LOWER CMPT	75
8316.7	2.31	UHI ACCUM EMPTY	190
9346.3	2.60	BURN IN PROGRESS IN LOWER CMPT	75
9819.3	2.73	NO BURN IN LOWER CMPT	75
9925.4	2.76	BURN IN PROGRESS IN LOWER CMPT	75
10112.0	2.81	NO BURN IN LOWER CMPT	75
11764.7	3.27	BURN IN PROGRESS IN LOWER CMPT	75
11868.8	3.30	SUPPORT PLATE FAILED	2
11923.9	3.31	NO BURN IN LOWER CMPT	75
11932.7	3.31	RV FAILED	3
11942.1	3.32	BURN IN PROGRESS IN LOWER CMPT	75

TABLE 4.3-1

PRELIMINARY

S2HF U3MAAP (DRAIN OPEN) CONT.

SEC	HR	EVENT DESCRIPTION	CODE
11951.6	3.32	NO BURN IN LOWER CMPT	75
11965.7	3.32	BURN IN PROGRESS IN LOWER CMPT	75
11989.9	3.33	NO BURN IN I/C UPPER PLENUM	141
11991.9	3.33	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12028.0	3.34	ACCUMULATOR WATER DEPLETED	188
12073.1	3.35	NO BURN IN LOWER CMPT	75
12077.9	3.35	NO BURN IN UPPER CMPT	102
12123.2	3.37	NO BURN IN ANNULAR CMPT	122
12148.2	3.37	NO BURN IN I/C UPPER PLENUM	141
12158.8	3.38	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12230.0	3.40	BURN IN PROGRESS IN UPPER CMPT	102
12286.5	3.41	BURN IN PROGRESS IN ANNULAR CMPT	122
13694.1	3.80	NO BURN IN ANNULAR CMPT	122
13761.5	3.82	NO BURN IN UPPER CMPT	102
13801.5	3.83	BURN IN PROGRESS IN UPPER CMPT	102
13821.0	3.84	NO BURN IN UPPER CMPT	102
13849.8	3.85	BURN IN PROGRESS IN UPPER CMPT	102
13864.8	3.85	NO BURN IN UPPER CMPT	102
13903.9	3.86	BURN IN PROGRESS IN UPPER CMPT	102
13923.9	3.87	NO BURN IN UPPER CMPT	102
14006.0	3.89	BURN IN PROGRESS IN UPPER CMPT	102
14022.1	3.90	NO BURN IN UPPER CMPT	102
14132.4	3.93	NO BURN IN I/C UPPER PLENUM	141
14183.9	3.94	BURN IN PROGRESS IN UPPER CMPT	102
14206.6	3.95	NO BURN IN UPPER CMPT	102
15707.8	4.36	ICE DEPLETED	132
34346.5	9.54	CONTMT FAILED	104

PRELIMINARY

4.4 Sequence No. 4 - TMLB'

4.4.1 Accident Sequence Description

TMLB' consists of a transient sequence initiated by loss of off-site AC power with subsequent loss of on-site AC power. Due to lack of cooling, the reactor coolant pump seals fail resulting in a small LOCA (50 gpm/pump). In this sequence, several potential sequences are lumped together. These include immediate failure of main and auxiliary feedwater as well as sequences involving no interruption of main feedwater but subsequent failure of the power conversion system and failure of the auxiliary feedwater. For the base case analysis, both main and auxiliary feedwater are both assumed lost at the time of the initiating event. Emergency core cooling, containment sprays, air return fans, and hydrogen igniters are not available due to loss of all AC power.

4.4.2 Reactor Coolant System Response

This sequence is initiated by loss of off-site AC power with subsequent loss of on-site AC power, reactor trip, reactor pump coastdown, and loss of both main and auxiliary feedwater. Figures C.4-1 through C.4-5 illustrate the variables of interest. Due to lack of injection and cooling, the reactor coolant pump seals fail at 0.75 hours resulting in a total 200 gal/min leak. The RCS water mass continues to decrease as RCS inventory is depleted through the pump seals. The primary system maintains a relatively constant pressure of 2000 lb/in^2a as the steam generators provides a heat sink. However, the steam generators are losing mass through the secondary side relief valves with no make-up from feedwater.

PRELIMINARY

The primary system pressure starts to rapidly increase between 1.4 and 1.7 hours due to the loss of the secondary side steam generator heat sink. The pressure continues to increase to the set point of the pressurizer relief valves. Continued blowdown to the quench tank results in failure of the tank rupture disk at 1.66 hours. Steam generator dryout also occurs at 1.66 hours. During this time of high pressure RCS blowdown, the water level in the reactor vessel rapidly decreases with core uncovery around 2.10 hours and initiation of hydrogen production occurring at approximately 2.2 hours. The total hydrogen production is 590 lbs. at an average rate of 0.14 lbs/sec. This corresponds to an overall oxidation of 30 percent. The primary system continues to remain at high pressure and sufficient molten corium is accumulated to fail the core support plate at approximately 3.33 hours as evidenced in the vessel pressure spike and slight level swell in the vessel. About one minute later, the vessel fails and the remaining water, hydrogen, and corium are discharged from the vessel into the cavity at high pressure. Due to the elevated RCS pressure, no water is injected by either UHI or cold leg accumulators until the time of vessel failure.

4.4.3 Containment Response

The containment pressure increases to 17 $lb/in^2{}_a$ following failure of the pump seals and then increases further to approximately 21 $lb/in^2{}_a$ following quench tank rupture disk failure. At 3.35 hours the vessel fails, increasing the containment pressure to approximately 30 $lb/in^2{}_a$. At the time of vessel failure the water level in the lower compartment is approximately 2.8 feet which is less than the 10 feet necessary for spillover into the cavity. Therefore, the molten corium is released into a dry cavity. Immediate concrete ablation occurs due to "jet" attack during the corium blowdown, resulting in an initial penetration depth of about 0.20 feet.

Following reactor vessel failure, the water level in the lower compartment never reaches the necessary 10 foot spillover height. Therefore, once the water discharged during vessel blowdown (cold leg accumulators and UHI) is evaporated by decay heat, the corium in the reactor cavity reheats and decomposes the concrete, thus generating noncondensible gases. The mass of ice remaining at time of vessel failure is approximately 1.25×10^6 lbs., but this has melted by 5.84 hours. With no method of removing decay heat from the containment, and the continued generation of noncondensible gases from the corium-concrete attack, the containment failure pressure of 65 $lb/in^2 a$ is reached at approximately 27.1 hours. At this time, the containment depressurizes through the assumed 0.001 ft^2 containment failure hole.

TABLE 4.4-1

PRELIMINARY

TMLB' U4MAAP

SEC	HR	EVENT DESCRIPTION	CODE
0.0	0.00	MAIN COOLANT PUMPS OFF	4
0.0	0.00	REACTOR SCRAM	13
0.0	0.00	LETDOWN FLOW OFF	46
0.0	0.00	MSIV CLOSED	156
0.0	0.00	POWER NOT AVAILABLE	205
0.0	0.00	MAKEUP SWITCH OFF	242
0.0	0.00	LETDOWN SWITCH OFF	243
2717.1	.75	PS BREAK FAILED	209
5970.3	1.66	Q/T RUPTURE DISK FAILED	92
5991.3	1.66	UNBKN S/G DRY	161
5992.3	1.66	BROKEN S/G DRY	151
6789.9	1.89	MCP SWITCH OFF OR HI-VIBR TRIP	215
7546.8	2.10	FP RELEASE ENABLED	14
11984.2	3.33	SUPPORT PLATE FAILED	2
12046.4	3.35	RV FAILED	3
12064.2	3.35	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12071.9	3.35	NO BURN IN I/C UPPER PLENUM	141
12080.5	3.36	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12177.0	3.38	ACCUMULATOR WATER DEPLETED	188
12190.8	3.39	NO BURN IN I/C UPPER PLENUM	141
12192.2	3.39	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12208.1	3.39	NO BURN IN I/C UPPER PLENUM	141
12215.9	3.39	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12218.0	3.39	NO BURN IN I/C UPPER PLENUM	141
12219.6	3.39	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12235.9	3.40	NO BURN IN I/C UPPER PLENUM	141
12237.0	3.40	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12252.7	3.40	NO BURN IN I/C UPPER PLENUM	141
12259.5	3.41	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12262.9	3.41	NO BURN IN I/C UPPER PLENUM	141
12269.4	3.41	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12271.5	3.41	NO BURN IN I/C UPPER PLENUM	141
12280.2	3.41	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12281.4	3.41	NO BURN IN I/C UPPER PLENUM	141
12284.7	3.41	UHI ACCUM EMPTY	190
12286.5	3.41	BURN IN PROGRESS IN I/C UPPER PLENUM	141

TABLE 4.4-1

TMLB' U4MAAP CONT.

SEC	HR	EVENT DESCRIPTION	CODE
12293.9	3.41	NO BURN IN I/C UPPER PLENUM	141
12300.7	3.42	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12302.8	3.42	NO BURN IN I/C UPPER PLENUM	141
12310.6	3.42	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12312.3	3.42	NO BURN IN I/C UPPER PLENUM	141
12319.5	3.42	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12321.0	3.42	NO BURN IN I/C UPPER PLENUM	141
12329.3	3.42	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12330.6	3.43	NO BURN IN I/C UPPER PLENUM	141
12341.2	3.43	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12342.6	3.43	NO BURN IN I/C UPPER PLENUM	141
12352.9	3.43	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12354.4	3.43	NO BURN IN I/C UPPER PLENUM	141
12361.1	3.43	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12363.0	3.43	NO BURN IN I/C UPPER PLENUM	141
12370.7	3.44	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12372.5	3.44	NO BURN IN I/C UPPER PLENUM	141
12379.0	3.44	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12381.1	3.44	NO BURN IN I/C UPPER PLENUM	141
12388.2	3.44	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12390.4	3.44	NO BURN IN I/C UPPER PLENUM	141
12399.1	3.44	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12401.8	3.44	NO BURN IN I/C UPPER PLENUM	141
12410.0	3.45	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12413.6	3.45	NO BURN IN I/C UPPER PLENUM	141
12420.2	3.45	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12424.8	3.45	NO BURN IN I/C UPPER PLENUM	141
12433.0	3.45	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12448.6	3.46	NO BURN IN I/C UPPER PLENUM	141
12453.2	3.46	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12469.4	3.46	NO BURN IN I/C UPPER PLENUM	141
12473.6	3.46	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12489.2	3.47	NO BURN IN I/C UPPER PLENUM	141
12492.0	3.47	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12507.5	3.47	NO BURN IN I/C UPPER PLENUM	141
12511.9	3.48	BURN IN PROGRESS IN I/C UPPER PLENUM	141

TABLE 4.4-1 PRELIMINARY

TMLB' U4MAAP CONT.

SEC	HR	EVENT DESCRIPTION	CODE
12527.3	3.48	NO BURN IN I/C UPPER PLENUM	141
12530.3	3.48	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12545.9	3.48	NO BURN IN I/C UPPER PLENUM	141
12549.7	3.49	BURN IN PROGRESS IN I/C UPPER PLENUM	141
12565.6	3.49	NO BURN IN I/C UPPER PLENUM	141
12571.4	3.49	BURN IN PROGRESS IN I/C UPPER PLENUM	141
13258.9	3.68	NO BURN IN I/C UPPER PLENUM	141
21018.1	5.84	ICE DEPLETED	132
38157.3	10.60	BURN IN PROGRESS IN LOWER CMPT	75
38183.7	10.61	NO BURN IN LOWER CMPT	75
38528.8	10.70	BURN IN PROGRESS IN LOWER CMPT	75
38555.2	10.71	NO BURN IN LOWER CMPT	75
39111.6	10.86	BURN IN PROGRESS IN LOWER CMPT	75
39137.5	10.87	NO BURN IN LOWER CMPT	75
41372.8	11.49	BURN IN PROGRESS IN LOWER CMPT	75
41378.9	11.49	BURN IN PROGRESS IN UPPER CMPT	102
41378.9	11.49	BURN IN PROGRESS IN I/C UPPER PLENUM	141
41394.9	11.50	NO BURN IN I/C UPPER PLENUM	141
41398.7	11.50	NO BURN IN LOWER CMPT	75
41400.1	11.50	NO BURN IN UPPER CMPT	102
42362.9	11.77	BURN IN PROGRESS IN LOWER CMPT	75
42389.4	11.77	NO BURN IN LOWER CMPT	75
97695.6	27.14	CONTMT FAILED	104

PRELIMINARY

4.5 Sequence No. 5 - $T_{23}ML$

4.5.1 Accident Sequence Description

$T_{23}ML$ consists of a transient initiator other than loss of off-site power with automatic reactor trip and loss of main and auxiliary feedwater. AC power is available and, therefore, emergency core cooling and containment safeguards are available throughout the accident. Although suffi ient time exists for operator action, the base case assumes human or equipment failures prevent proper charging and safety system operation. It, therefore, is a very low probability event. Higher probability sequences are discussed in section 5.0.

4.5.2 Reactor Coolant System Response

This sequence is initiated by loss of both main and auxiliary feedwater, followed by reactor trip and reactor pump coastdown. Figures C.5-1 through C.5-5 illustrate the variables of interest. Following loss of all feedwater and reactor scram, the primary system pressure decreases momentarily followed by the actuation of the pressurizer heaters which maintain the pressure at approximately 2250 lb/in^2. The water level in the pressurizer increases during heat up and volumetric expansion causing the pressurizer to go solid around 1.0 hour after accident initiation.

The primary system pressure starts to increase after 0.95 hours due to the loss of the secondary side steam generator heat sink. The pressure continues to rise to the set point of the presssurizer safety valves. However, blowdown through these valves decreases primary system inventory and with no makeup available, both the primary system pressure and level begin to decrease. Therefore, the primary system pressure stablizes at the PORV set point of 2350 lb/in^{2}a with continued inventory depletion and core uncovery occurring at 1.7 hours. As the water level in the core continues to drop, the cladding temperature begins to increase. At approximately 1.9 hours, the metal-water reaction initiates significant hydrogen generation and further core melting. Total hydrogen production from in-vessel Zircaloy oxidation is 520 lbs. The average production rate is 0.14 lbm/sec and the reaction is equivalent to a total core average clad oxidation of 26 percent. The primary system continues to remain at high pressure and sufficient molten corium is accumulated to fail the core support plate at 2.90 hours. At 2.91 hours the vessel fails and the remaining water, hydrogen, and corium core discharged from the vessel into the cavity at high pressure.

4.5.3 Containment Response

The containment pressure remains at about 15 lb/in^{2}a until quench tank rupture disk failure at 1.20 hours. The containment pressure rapidly increases to 19.5 lb/in^{2}a but is suppresssed as the containment sprays (actuated at 1.21 hours), air return fans, and ice are available. The containment sprays take suction from the RWST until successful recirculation realignment occurs at 1.60 hours. This pressure suppression reduces the pressure to about 17.0 lb/in^{2}a until vessel failure occurs at 2.91 hours with a corresponding pressure increase to 23 lb/in^{2}a which is quickly suppressed. As the ice continues to melt and RCS inventory is lost from the pressurizer relief valves, the water level in the lower compartment exceeds the necessary curb height required for spilling water into the cavity at approximately 1.2 hours. Therefore, when the vessel fails the cavity is flooded. This flooded condition

PRELIMINARY

limits core-concrete ablation to the "jet" attack resulting in a 0.14 foot penetration depth. The flooded cavity results in immediate quenching of the corium.

The remaining ice at time of vessel failure is approximately $1.3x10^6$ lbm. At 5.36 hours, all of the ice has melted and containment pressurization begins. Following ice depletion, the containment pressure rapidly rises to about 20 lb/in^2a. However, the containment sprays continue to remove heat from the containment atmosphere. This heat removal rate matches the heat decay at approximately 7.5 hours. Therefore, the containment spray heat removal rate is more than adequate to remove decay heat and the containment pressure continues to decrease, thus precluding containment failure.

TABLE 4.5-1

PRELIMINARY

T23ML U5MAAP

SEC	HR	EVENT DESCRIPTION	CODE
0.0	0.00	REACTOR SCRAM	13
0.0	0.00	LETDOWN FLOW OFF	46
0.0	0.00	MSIV CLOSED	156
0.0	0.00	HPI FORCED OFF	216
0.0	0.00	LPI FORCED OFF	217
0.0	0.00	AUX FEED WATER FORCED OFF	224
0.0	0.00	MANUAL SCRAM	227
0.0	0.00	MAIN FW SHUT OFF	228
0.0	0.00	CHARGING PUMPS FORCED OFF	232
0.0	0.00	MAKEUP SWITCH OFF	242
0.0	0.00	LETDOWN SWITCH OFF	243
3404.4	.95	BROKEN S/G DRY	151
3404.4	.95	UNBKN S/G DRY	161
4310.3	1.20	Q/T RUPTURE DISK FAILED	92
4348.8	1.21	MAIN COOLANT PUMPS OFF	4
4348.8	1.21	MCP SWITCH OFF OR HI-VIBR TRIP	215
4350.9	1.21	CONTMT SPRAYS ON	103
5753.7	1.60	RECIRC SYSTEM IN OPERATION	181
5753.7	1.60	RECIRC SWITCH: MAN ON	220
5765.8	1.60	CH PUMPS INSUFF NPSH	183
5765.8	1.60	HPI PUMPS INSUFF NPSH	185
6163.6	1.71	FP RELEASE ENABLED	14
10429.2	2.90	SUPPORT PLATE FAILED	2
10457.2	2.90	BURN IN PROGRESS IN LOWER CMPT	75
10489.6	2.91	RV FAILED	3
10490.5	2.91	BURN IN PROGRESS IN I/C UPPER PLENUM	141
10493.0	2.91	NO BURN IN LOWER CMPT	75
10538.5	2.93	BURN IN PROGRESS IN LOWER CMPT	75
10615.0	2.95	ACCUMULATOR WATER DEPLETED	188
10636.8	2.95	NO BURN IN LOWER CMPT	75
10702.3	2.97	NO BURN IN I/C UPPER PLENUM	141
10709.0	2.97	BURN IN PROGRESS IN I/C UPPER PLENUM	141
10727.5	2.98	UHI ACCUM EMPTY	190
10922.4	3.03	NO BURN IN I/C UPPER PLENUM	141
19284.8	5.36	ICE DEPLETED	132

PRELIMINARY

4.6 Sequence No. 6 - AD

4.6.1 Accident Sequence Description

AD consists of a large LOCA (10" diameter) initiator with subsequent failure of the ECCS in the injection mode. The ECCS continues to be unavailable in the recirculation mode. Containment safeguards systems are available throughout the accident.

4.6.2 Reactor Coolant System Response

Upon initiation of a 0.5454 ft^2 cold leg break, the reactor is scrammed, followed by reactor pump coastdown and auxiliary feedwater startup at five seconds. Figures C.6-1 through C.6-5 illustrate the variables of interest. Immediately following break initiation, the primary system pressure rapidly decreases to containment pressure. The decrease in reactor vessel water level results in core uncovery about 0.5 hours and initiation of hydrogen production at 0.7 hours. Total hydrogen production from in-vessel Zircaloy oxidation is 840 lbs. at an average rate of 0.25 lbs/sec. This corresponds to an average clad oxidation of 42 percent. The core continues to heat up until fuel melting occurs leading to failure of the core support plate at 1.50 hours as evidenced in the vessel pressure increase and level swell in the vessel. The molten corium falls into the lower plenum and fails the reactor vessel at approximately 1.52 hours and the remaining water, hydrogen, and molten corium is discharged into the cavity region.

4.6.3 Containment Response

Immediately following break initiation, the lower compartment rapidly pressurizes as the RCS inventory is discharged. This immediate pressure increase leads to actuation of containment sprays. The containment spray takes suction from the RWST until 0.39 hours at which time successful spray recirculation switchover is achieved. At 1.52 hours, the reactor vessel fails and the containment pressure increases to about 22 lb/in^2. The air return fans, containment sprays, and remaining ice reduce the containment pressure. The water level in the lower compartment reaches the spillover curb height at approximately 0.25 hours. Therefore, at the time vessel failure occurs the cavity is flooded. This flooded condition limits core-concrete ablation to the "jet" attack only resulting in about 0.13 ft penetration depth. The flooded cavity results in the immediate quenching of the corium.

The ice remaining at time of vessel failure is approximately 9.5×10^5 lbs (about 60 percent melted). At 3.15 hours, all the ice has melted and containment pressurization begins. Following ice depletion, the containment sprays continue to remove heat from the containment atmosphere. This heat removal rate matches the decay heat at approximately 6 hours when the containment pressure reaches 21 lb/in^{2}a. Afterward, the containment spray heat removal rate exceeds that of decay heat and the containment pressure decreases, thus precluding containment failure.

TABLE 4.6-1

PRELIMINARY

AD U6MAAP

SEC	HR	EVENT DESCRIPTION	CODE
0.0	0.00	REACTOR SCRAM	13
0.0	0.00	LETDOWN FLOW OFF	46
0.0	0.00	AUX FEEDWATER ON	154
0.0	0.00	MSIV CLOSED	156
0.0	0.00	PS BREAK FAILED	209
0.0	0.00	HPI FORCED OFF	216
0.0	0.00	LPI FORCED OFF	217
0.0	0.00	MANUAL SCRAM	227
0.0	0.00	CHARGING PUMPS FORCED OFF	232
0.0	0.00	MAKEUP SWITCH OFF	242
0.0	0.00	LETDOWN SWITCH OFF	243
2.1	.00	CONTMT SPRAYS ON	103
60.3	.02	MAIN COOLANT PUMPS OFF	4
60.3	.02	MCP SWITCH OFF OR HI-VIBR TRIP	215
335.5	.09	UHI ACCUM EMPTY	190
791.9	.22	ACCUMULATOR WATER DEPLETED	188
1407.2	.39	RECIRC SYSTEM IN OPERATION	181
1407.2	.39	RECIRC SWITCH: MAN ON	220
1411.0	.39	CH PUMPS INSUFF NPSH	183
1411.0	.39	HPI PUMPS INSUFF NPSH	185
1743.9	.48	FP RELEASE ENABLED	14
2664.9	.74	BURN IN PROGRESS IN LOWER CMPT	75
2745.0	.76	BURN IN PROGRESS IN I/C UPPER PLENUM	141
3531.7	.98	BURN IN PROGRESS IN UPPER CMPT	102
3581.9	.99	BURN IN PROGRESS IN ANNULAR CMPT	122
4796.4	1.33	NO BURN IN LOWER CMPT	75
4916.4	1.37	BURN IN PROGRESS IN LOWER CMPT	75
5315.6	1.48	NO BURN IN LOWER CMPT	75
5415.5	1.50	SUPPORT PLATE FAILED	2
5424.1	1.51	BURN IN PROGRESS IN LOWER CMPT	75
5473.1	1.52	RV FAILED	3
5479.4	1.52	NO BURN IN LOWER CMPT	75
5484.6	1.52	BURN IN PROGRESS IN LOWER CMPT	75
5503.5	1.53	NO BURN IN LOWER CMPT	75
6782.9	1.88	NO BURN IN UPPER CMPT	102
6828.1	1.90	BURN IN PROGRESS IN UPPER CMPT	102

TABLE 4.6-1

AD U6MAAP PRELIMINARY CONT.

SEC	HR	EVENT DESCRIPTION	CODE
6909.5	1.92	NO BURN IN UPPER CMPT	102
6925.3	1.92	BURN IN PROGRESS IN UPPER CMPT	102
6945.8	1.93	NO BURN IN UPPER CMPT	102
6972.0	1.94	BURN IN PROGRESS IN UPPER CMPT	102
7001.6	1.94	NO BURN IN UPPER CMPT	102
7089.7	1.97	BURN IN PROGRESS IN UPPER CMPT	102
7132.4	1.98	NO BURN IN UPPER CMPT	102
7228.9	2.01	BURN IN PROGRESS IN UPPER CMPT	102
7274.1	2.02	NO BURN IN UPPEF CMPT	102
7517.9	2.09	BURN IN PROGRESS IN UPPER CMPT	102
7554.5	2.10	NO BURN IN UPPER CMPT	102
7684.3	2.13	BURN IN PROGRESS IN UPPER CMPT	102
7702.6	2.14	NO BURN IN UPPER CMPT	102
7800.6	2.17	BURN IN PROGRESS IN UPPER CMPT	102
7829.8	2.17	NO BURN IN UPPER CMPT	102
7921.2	2.20	NO BURN IN ANNULAR CMPT	122
7929.8	2.20	BURN IN PROGRESS IN ANNULAR CMPT	122
8024.9	2.23	BURN IN PROGRESS IN UPPER CMPT	102
8052.9	2.24	NO BURN IN UPPER CMPT	102
8291.6	2.30	BURN IN PROGRESS IN UPPER CMPT	102
8316.4	2.31	NO BURN IN UPPER CMPT	102
8687.3	2.41	BURN IN PROGRESS IN UPPER CMPT	102
8725.5	2.42	NO BURN IN UPPER CMPT	102
8931.8	2.48	BURN IN PROGRESS IN UPPER CMPT	102
8954.0	2.49	NO BURN IN UPPER CMPT	102
9075.7	2.52	BURN IN PROGRESS IN UPPER CMPT	102
9118.3	2.53	NO BURN IN UPPER CMPT	102
9184.5	2.55	NO BURN IN ANNULAR CMPT	122
9204.5	2.56	BURN IN PROGRESS IN ANNULAR CMPT	122
9219.0	2.56	NO BURN IN ANNULAR CMPT	122
9233.5	2.56	BURN IN PROGRESS IN ANNULAR CMPT	122
9395.8	2.61	BURN IN PROGRESS IN UPPER CMPT	102
9414.2	2.62	NO BURN IN UPPER CMPT	102
9740.5	2.71	BURN IN PROGRESS IN UPPER CMPT	102
9759.4	2.71	NO BURN IN UPPER CMPT	102
9827.2	2.73	BURN IN PROGRESS IN UPPER CMPT	102

TABLE 4.6-1

AD U6MAAP PRELIMINARY CONT.

SEC	HR	EVENT DESCRIPTION	CODE
9847.0	2.74	NO BURN IN UPPER CMPT	102
9891.6	2.75	NO BURN IN ANNULAR CMPT	122
9896.5	2.75	BURN IN PROGRESS IN ANNULAR CMPT	122
10084.0	2.80	BURN IN PROGRESS IN UPPER CMPT	102
10106.8	2.81	NO BURN IN UPPER CMPT	102
10167.3	2.82	NO BURN IN ANNULAR CMPT	122
10176.1	2.83	BURN IN PROGRESS IN ANNULAR CMPT	122
10274.5	2.85	BURN IN PROGRESS IN UPPER CMPT	102
10294.2	2.86	NO BURN IN UPPER CMPT	102
10339.4	2.87	NO BURN IN ANNULAR CMPT	122
10359.9	2.88	BURN IN PROGRESS IN ANNULAR CMPT	122
10379.0	2.88	NO BURN IN ANNULAR CMPT	122
10418.1	2.89	BURN IN PROGRESS IN ANNULAR CMPT	122
10527.3	2.92	BURN IN PROGRESS IN UPPER CMPT	102
10552.5	2.93	NO BURN IN UPPER CMPT	102
10685.8	2.97	NO BURN IN ANNULAR CMPT	122
10739.8	2.98	BURN IN PROGRESS IN ANNULAR CMPT	122
10834.3	3.01	NO BURN IN ANNULAR CMPT	122
10857.2	3.02	BURN IN PROGRESS IN ANNULAR CMPT	122
10867.0	3.02	NO BURN IN ANNULAR CMPT	122
10876.9	3.02	BURN IN PROGRESS IN ANNULAR CMPT	122
10941.7	3.04	BURN IN PROGRESS IN UPPER CMPT	102
10975.2	3.05	NO BURN IN UPPER CMPT	102
10994.3	3.05	NO BURN IN ANNULAR CMPT	122
11062.1	3.07	BURN IN PROGRESS IN ANNULAR CMPT	122
11116.6	3.09	NO BURN IN ANNULAR CMPT	122
11132.5	3.09	BURN IN PROGRESS IN ANNULAR CMPT	122
11144.3	3.10	NO BURN IN ANNULAR CMPT	122
11154.7	3.10	BURN IN PROGRESS IN ANNULAR CMPT	122
11314.3	3.14	NO BURN IN ANNULAR CMPT	122
11323.4	3.15	BURN IN PROGRESS IN ANNULAR CMPT	122
11348.7	3.15	ICE DEPLETED	132
11351.4	3.15	BURN IN PROGRESS IN UPPER CMPT	102
11356.0	3.15	NO BURN IN I/C UPPER PLENUM	141
11386.2	3.16	NO BURN IN UPPER CMPT	102
11422.7	3.17	NO BURN IN ANNULAR CMPT	122

5.0 Plant Response with Recovery Actions

A series of parametric studies was performed to determine the effects of the number or amount of emergency core cooling system options available and beneficial as well as possible detrimental operator actions. The following cases were selected for this study:

S_2D - Minimum safeguards
Full restoration of injection (pre-core melt)
Secondary side (steam generator) blowdown

S_2H - Minimum safeguards
Partial restoration of recirculation (pre-core melt)

TMLB' - Complete power restoration (pre-core melt)
Complete power restoration (post-vessel failure)

$T_{23}ML$ - Bleed and feed mode
Feed and bleed

AD - Minimum safeguards
Full restoration of injection (pre-core melt)

5.1 S_2D Sequences

5.1.1 Minimum Safeguards - S_2D

The minimum safeguards case assumes that only one air return fan and one containment spray pump are available during the accident. Since the ECCS is unavailable during the accident, the primary system response is identical for both cases.

The predicted lower compartment pressures for the base case and the minimum safeguards case are compared in Figure 5.1-1. Prior to ice melt, the somewhat higher (less than 1.0 lbf/in^{2}a) lower compartment pressure during the accident for the minimum safeguards case is due to the reduced air flow through the ice condenser and the reduced heat removal capability of the single containment spray. The rather rapid increase in pressure at approximately 5.2 hours (for the minimum safeguards case) is coincident with the depletion of the ice. At approximately 7.5 hours the heat removal capability of the single containment eeds the heat production rate of the quenched debris b er compartment pressure starts to decrease. The maximum ssure reached in the minimum safeguards case is 22.5 lbf/ ely 7.5 hours, as compared to 21.1 lbf/in^{2}a o both of which are well below the containme ure e of 65 lbf/in^{2}a.

5.1.2 Full Restoration of Injection - S_2D

The purpose of this modified base case is to determine the effect of regaining full ECCS injection capability prior to core support plate failure. Full ECCS injection is defined as regaining all charging pumps, all safety injection pumps, and all RHR pumps. Restoration of injection occurs at 1.5 hours. At the time of injection, the reactor vessel water level is approximately 10.0 feet (see Figure 5.1-2), corresponding to the bottom of the active fuel. The total hydrogen mass produced in the core is plotted in Figure 5.1-3 for the two cases. Note that the quenching of the core produces 975 lbm of hydrogen (about 325 lbm more hydrogen than produced in the base case). The greater hydrogen production is due to the ECCS injection water providing additional steam for the Zr, H_2O reaction.

Figures 5.1-4 and 5.1-5 show comparison of the two cases of the primary system corium temperature and upper compartment hydrogen mass, respectively. The maximum hydrogen mass in the upper compartment for the full restoration of injection case and for the base case (see Figure 5.1-5) is 225 lbm. The lower compartment pressure for the full restoration of injection case does not exceed 20.8 lbf/in^{2}a, well below the containment failure pressure of 65 lbf/in^{2}a (see Figure 5.1-6).

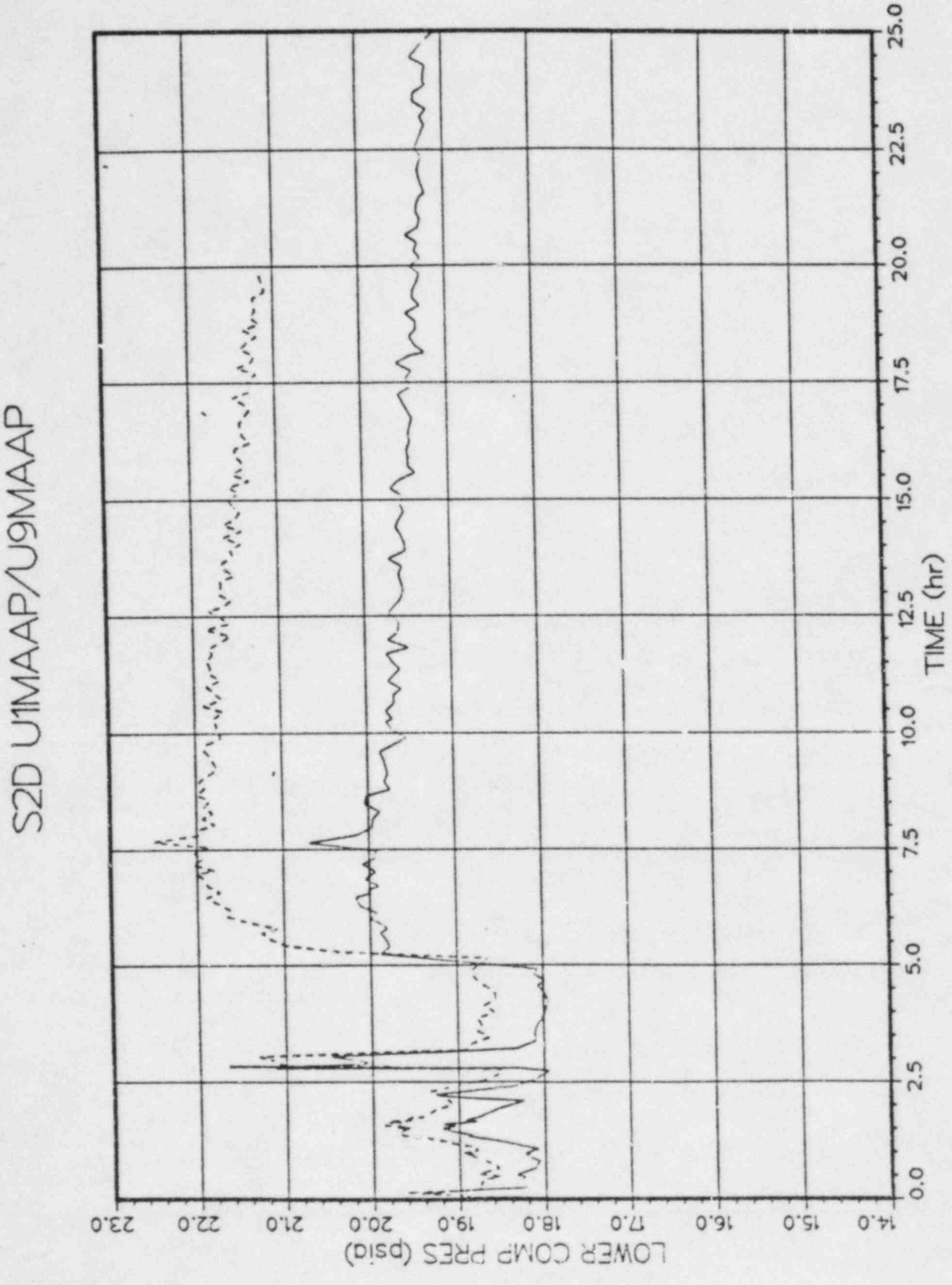
5.1.3 Secondary Side (Steam Generator) Depressurization - S_2D

The purpose of this case is to determine the effectiveness of depressurizing the steam generator to cool and reduce primary system pressure, given a small break scenario with no high pressure injection but with low pressure injection (RHR) available.

PRELIMINARY

The plots of the primary system pressure and core water temperature for the secondary side blowdown case are shown in Figures 5.1-7 and 5.1-8, respectively, where they are compared to the respective plots for the base case. Due to the rather rapid decrease in primary side pressure (i.e., the primary pressure decreases from 2250 lbf/in^{2}a at 0.0 hours to less than 200 bf/in^2 at 0.4 hours), it is possible for the RHR pumps to start injecting water into the primary system at 0.4 hours. Thus, the reactor vessel water level is maintained throughout the accident as shown in Figure 5.1-9. Since the core is never uncovered, there is no hydrogen production.

FIGURE 5.1-1


S2D U1MAAP/U9MAAP
LOWER COMP PRES (psia)
23.0
22.0
21.0
20.0
19.0
18.0
17.0
16.0
15.0
14.0
TIME (hr)
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0

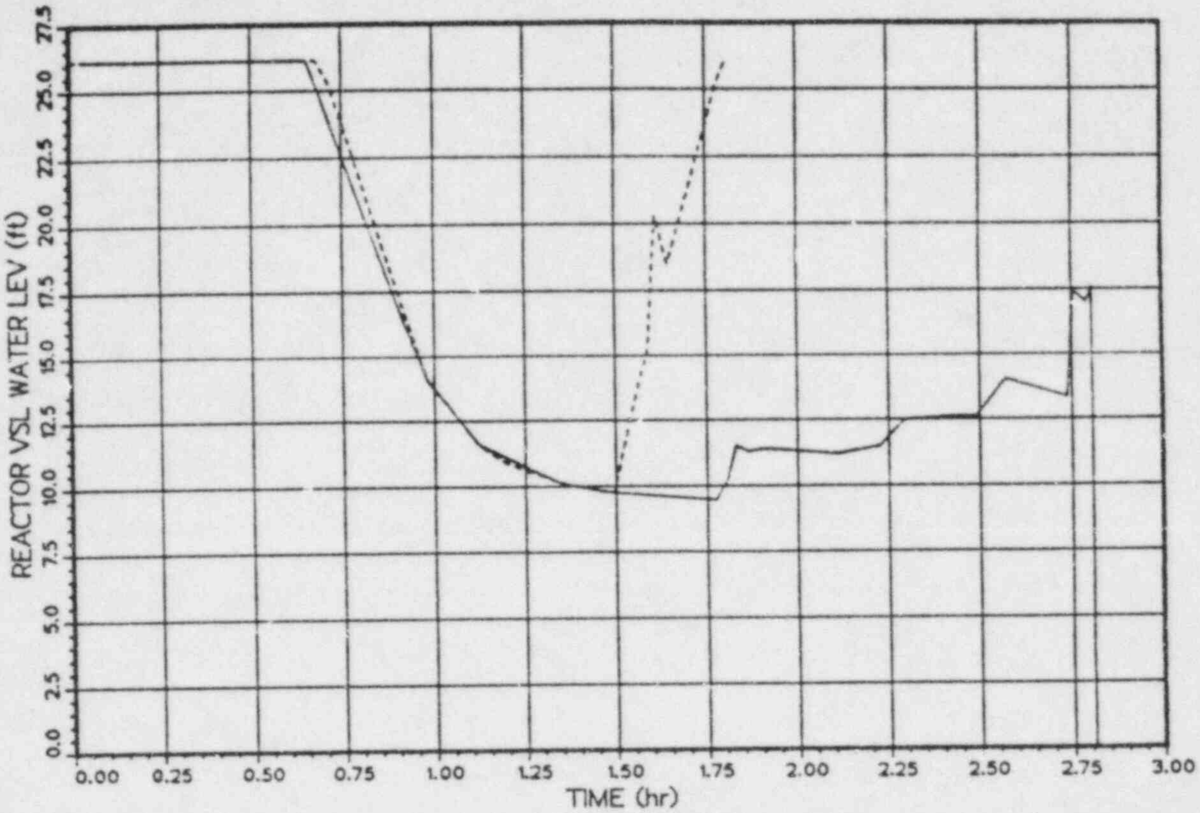


FIGURE 5.1-2

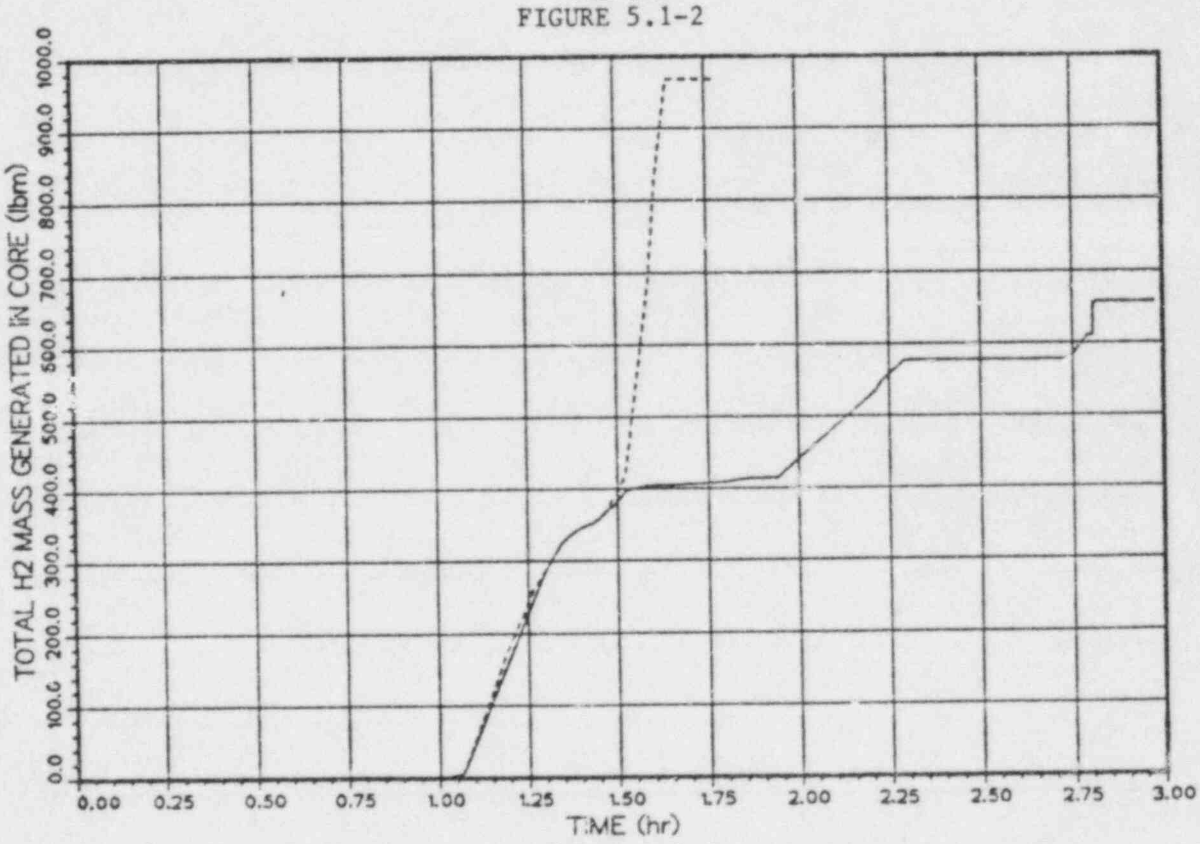


FIGURE 5.1-3

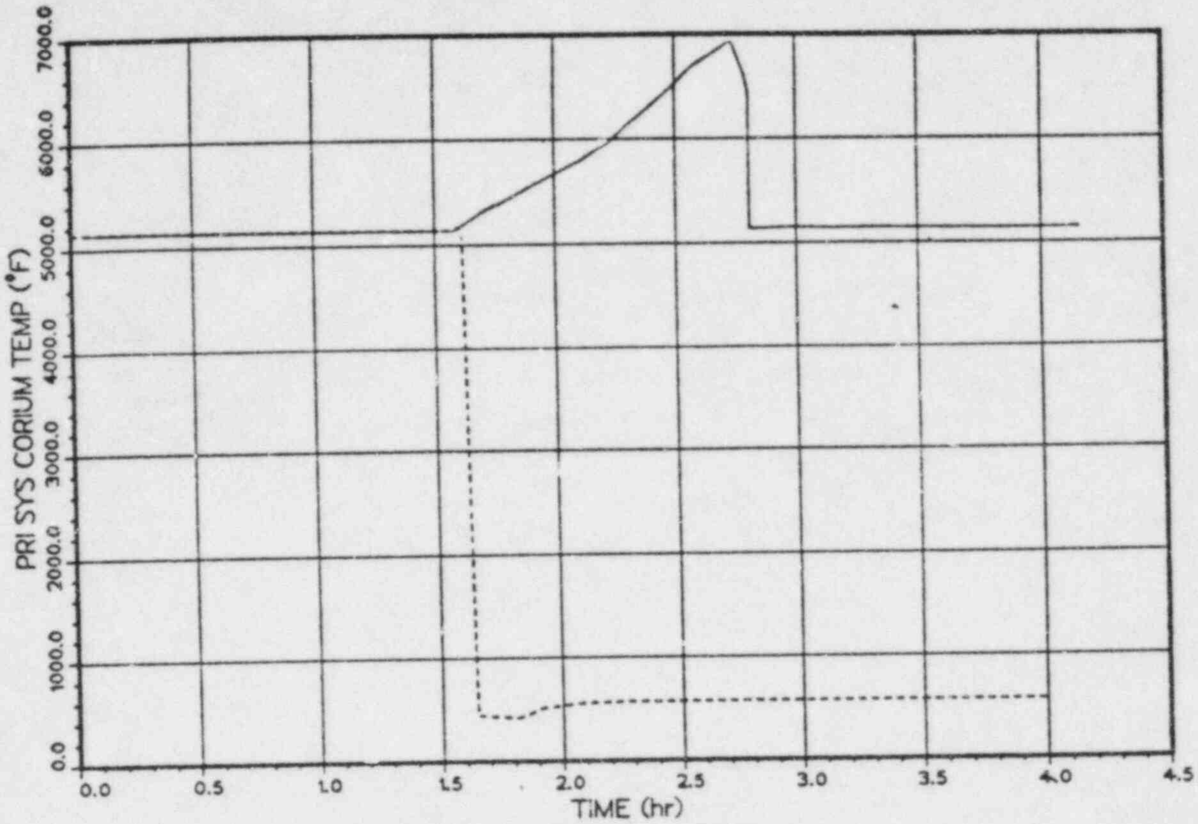


FIGURE 5.1-4

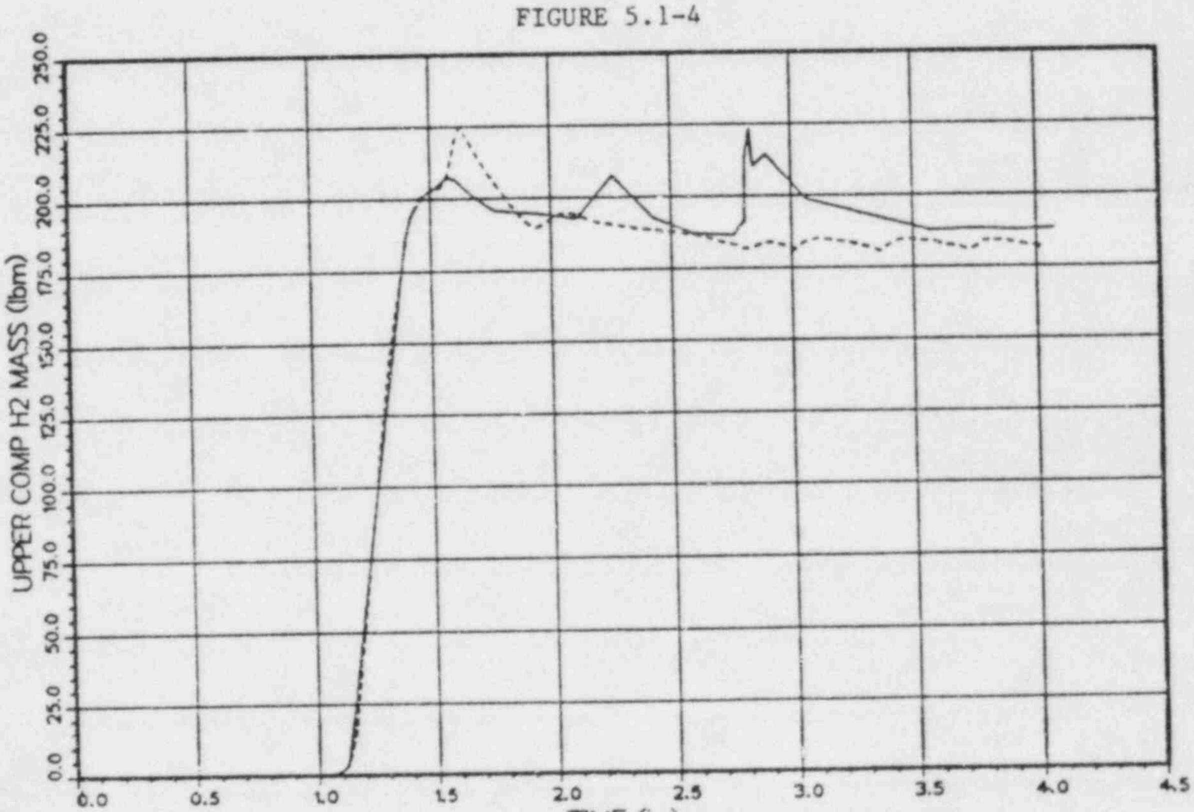


FIGURE 5.1-5

S2D U1MAAP/U8MAAP

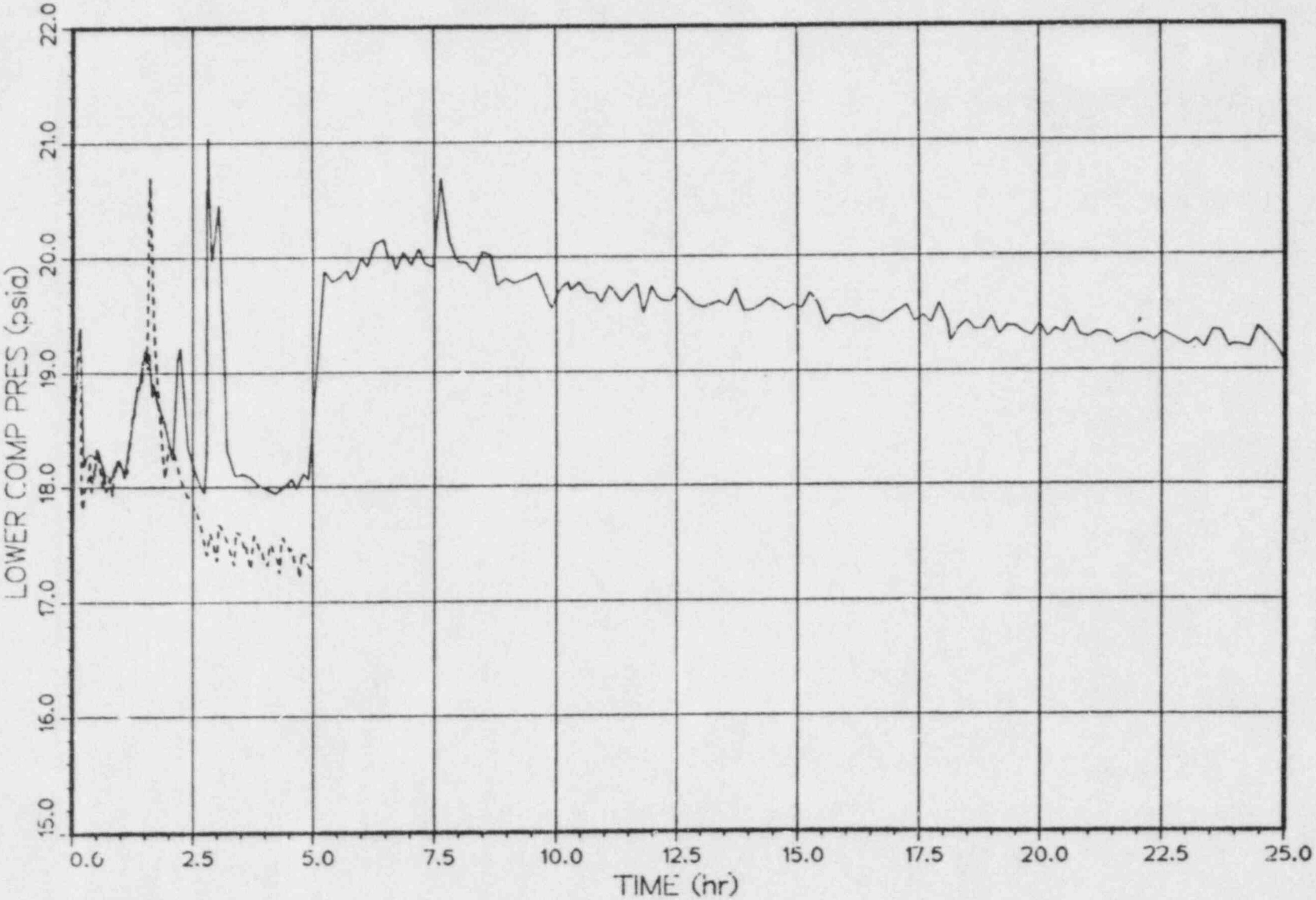


FIGURE 5.1-6

PRELIMINARY

S2D U1MAAP/U10MAAP

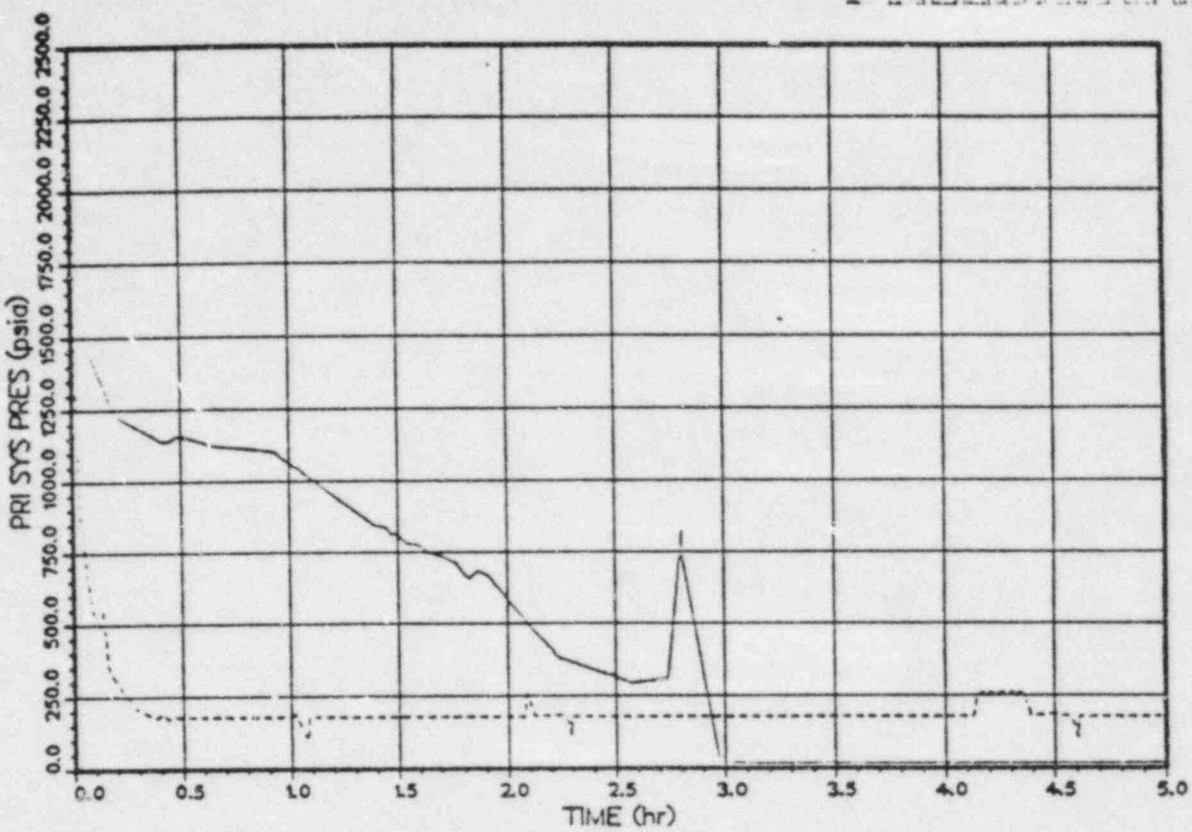


FIGURE 5.1-7

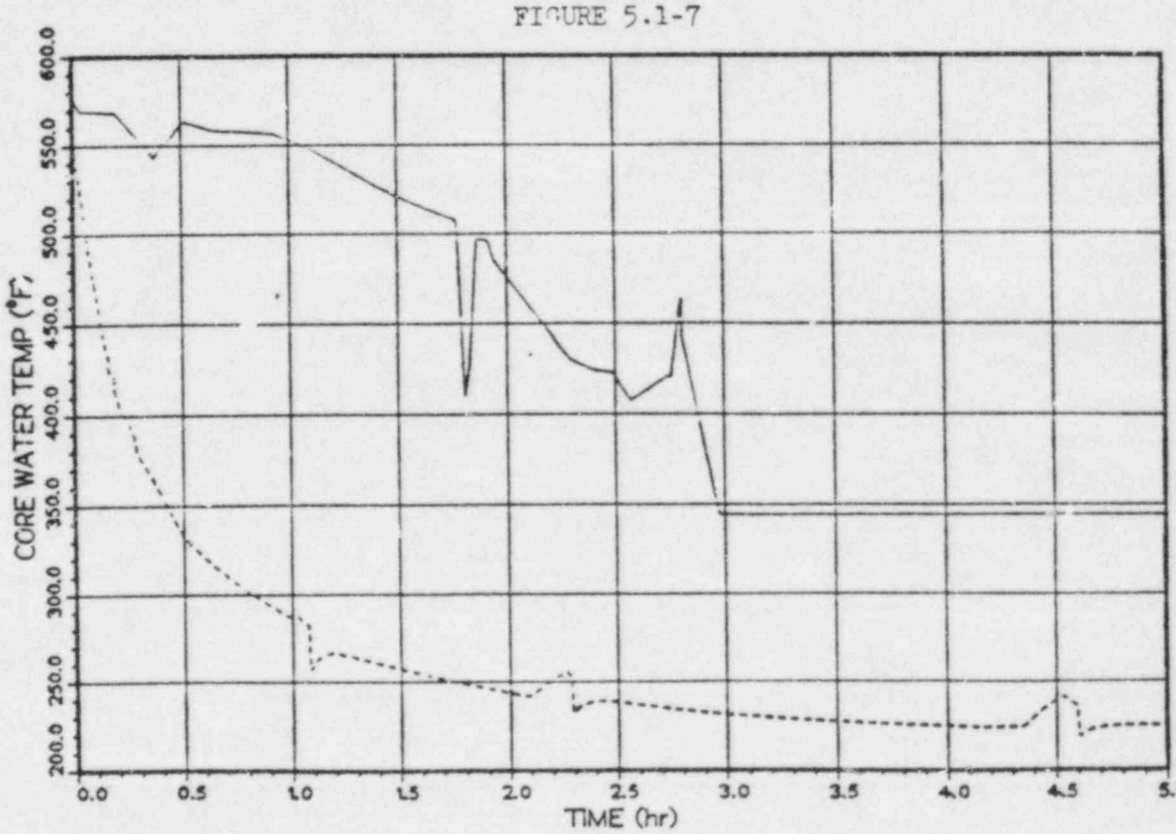


FIGURE 5.1-8

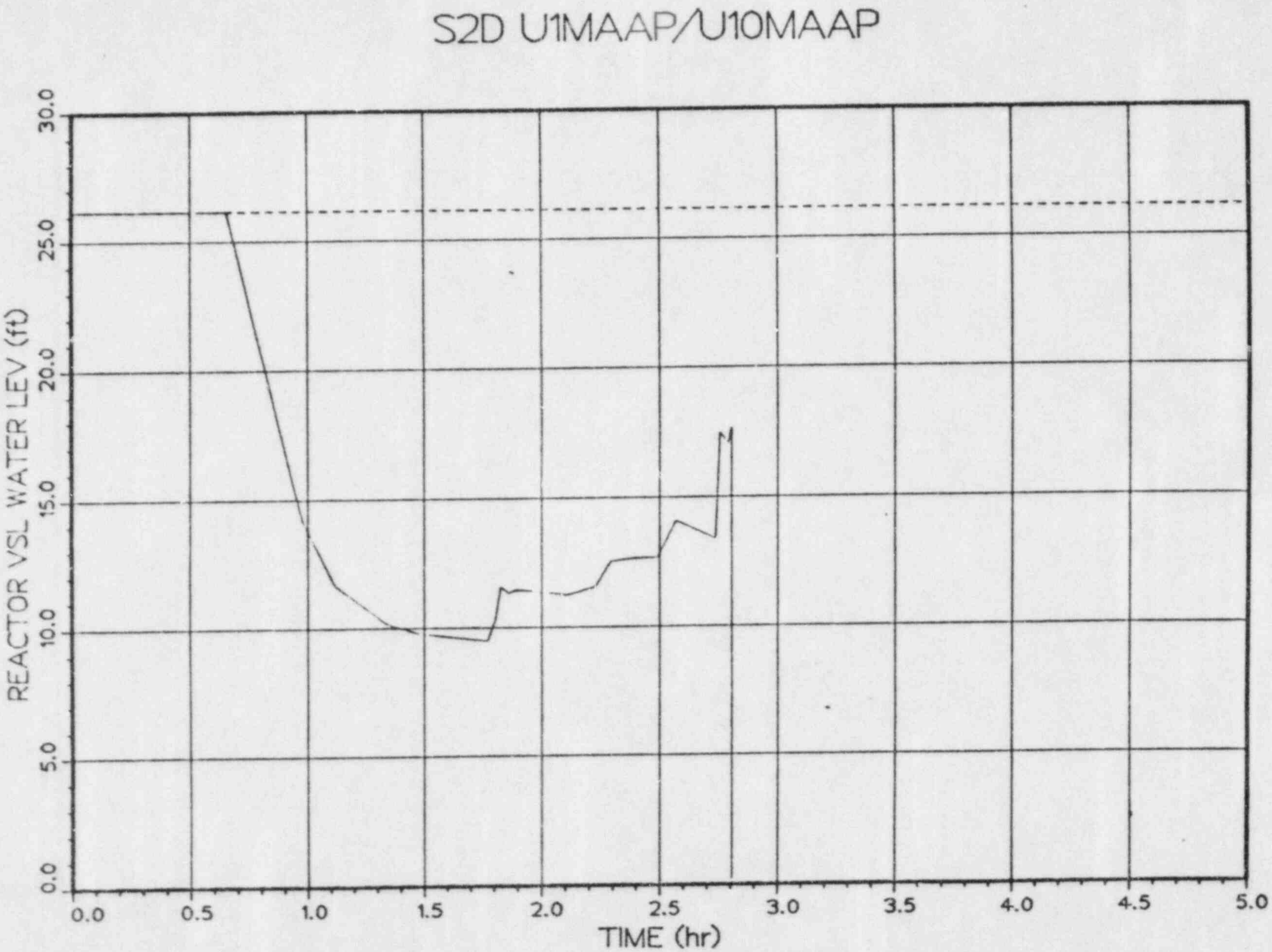

S2D U1MAAP/U10MAAP
REACTOR VSL WATER LEV (ft)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
TIME (hr)

FIGURE 5.1-9

5.2 S_2H Sequences

5.2.1 Minimum Safeguards - S_2H

The minimum safeguards case assumes that one air return fan, one safety injection pump, one charging pump, one RHR pump, and one containment spray pump are available. For this case, partial injection is available until the recirculation switchover point is reached, then only the one containment spray is available.

The reactor vessel fails at 3.57 hours for the minimum safeguards case which is 0.26 hour after the reactor vessel fails for the base case. This is due to the fact that only one spray spump is operating so the time to recirculation switchover is extended, thus delaying the time to vessel failure due to an increased mass of water available for injection.

The lower compartment pressure for the minimum safeguards case and the base (S_2H) case are plotted in Figure 5.2-1. Note the similarity in the pressure spike at vessel failure for both cases. Prior to ice melt, the somewhat higher (less than 1 lbf/in^2a) lower compartment pressure for the minimum safeguards case is due to the reduced air flow through the ice condenser and the reduced heat removal capability of the containment spray. The rapid increase in pressure at approximately 4.5 hours is nearly conincident with the depletion of the ice at 4.65 hours. At approximately 7.5 hours, the heat removal capability of the single containment spray exceeds the heat production rate of the quenched debris bed and the lower compartment pressure starts to decrease. The maximum containment pressure reached in the minimum safeguards case is 23.8 lbf/in^2a, which is well below the containment failure pressure of 65 lbf/in^2a.

5.2.2 Partial Restoration of Recirculation - S_2H

This case assumes minimum injection is available with one charging pump, one safety injection pump, and one RHR pump operating. Once the recirculation switchover point is reached, the ECCS fails as in the base case, and minimum ECCS injection capabilities are not restored until 2.5 hours.

The plot of the reactor vessel water level for the partial restoration of recirculation (at 2.5 hours) case is compared to the plot for the base case in Figure 5.2-2. The reactor vessel water level for the minimum ECCS injection case decreases at a slightly greater rate (see Figure 5.2-2) due to the reduced ECCS flow rate into the reactor vessel. When injection is restored at 2.5 hours, the water level in the reactor vessel recovers within 0.5 hours.

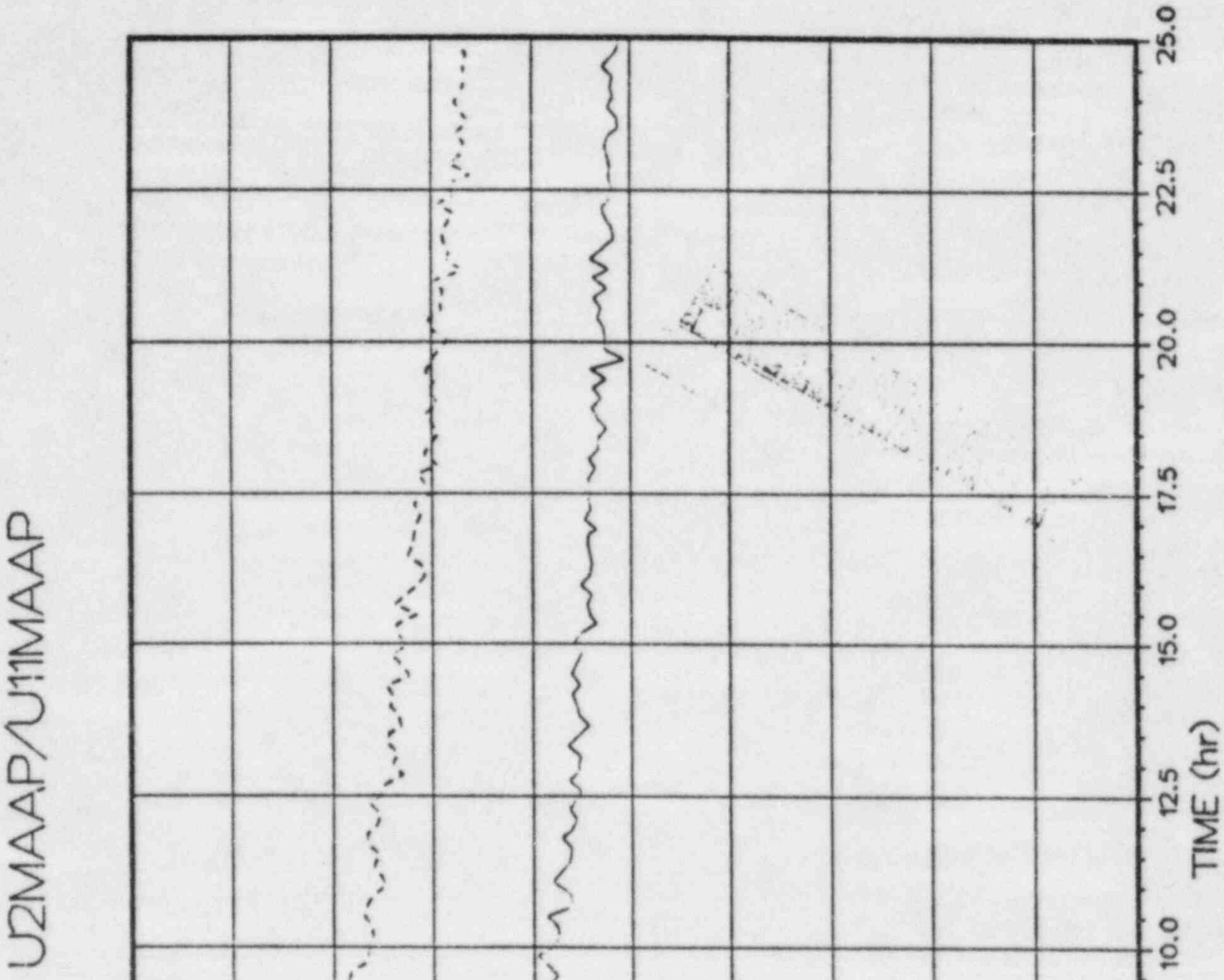
The plots of the total hydrogen generated in core for the partial injection case and base case are shown in Figure 5.2-3. Note that, as expected, the total hydrogen production for the partial injection case is greater than for the base case (by approximately 300 lbm). The greater hydrogen production is due to increased Zr, H_2O reactions due to the addition of ECCS injection water to the hot, semimolten core.

The plots of the primary system corium temperature for the two cases are shown in Figure 5.2-4. The rapid reduction in corium temperature for the partial injection case can be seen at 2.6 hours due to the quenching of the core.

Figure 5.2-5 shows the upper compartment hydrogen mass of the two cases. Note that the maximum amount of hydrogen in the upper compartment is nearly the same for both cases (at approximately 225 lbm). The containment pressure never exceeds 20.4 lbf/in^2a, which is well below the 65 lbf/in^2a containment failure pressure.

PRELIMINARY

FIGURE 5.2-1



S2H U2MAAP/U11MAAP
LOWER COMP PRES (psia)
TIME (hr)
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
24.0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0

S2H U2MAAP/U12MAAP

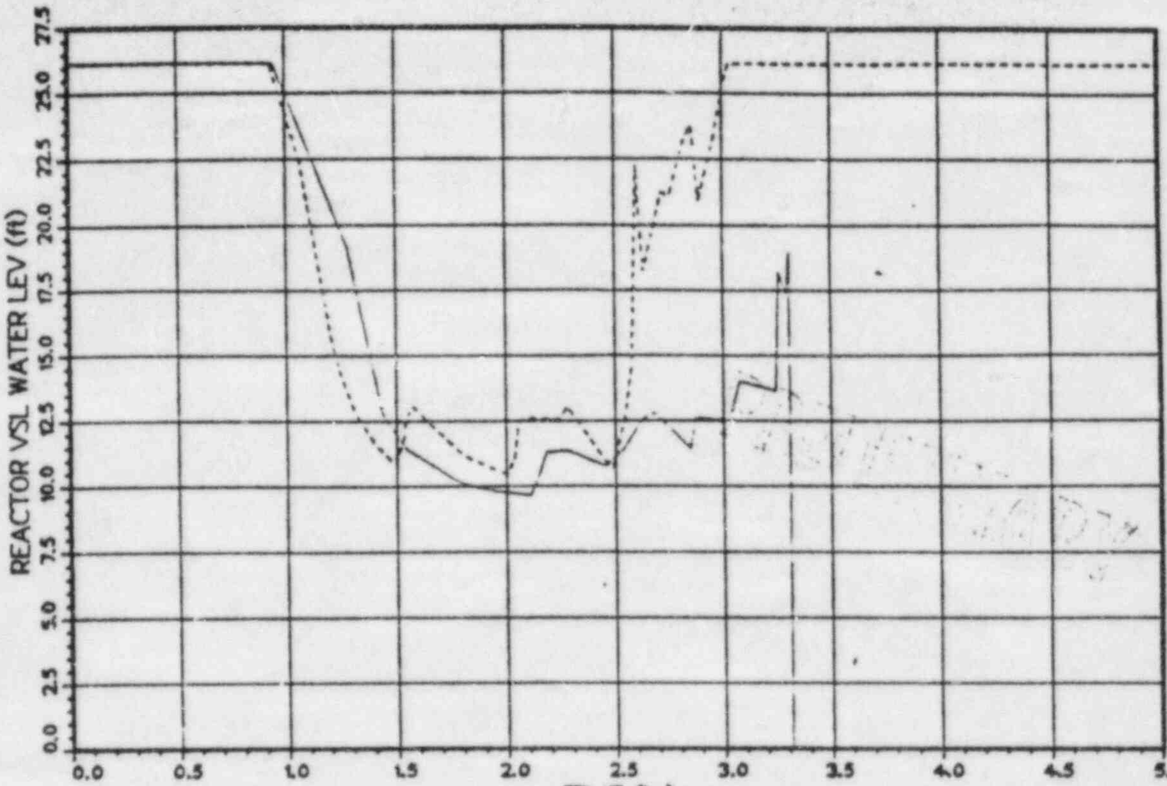


FIGURE 5.2-2

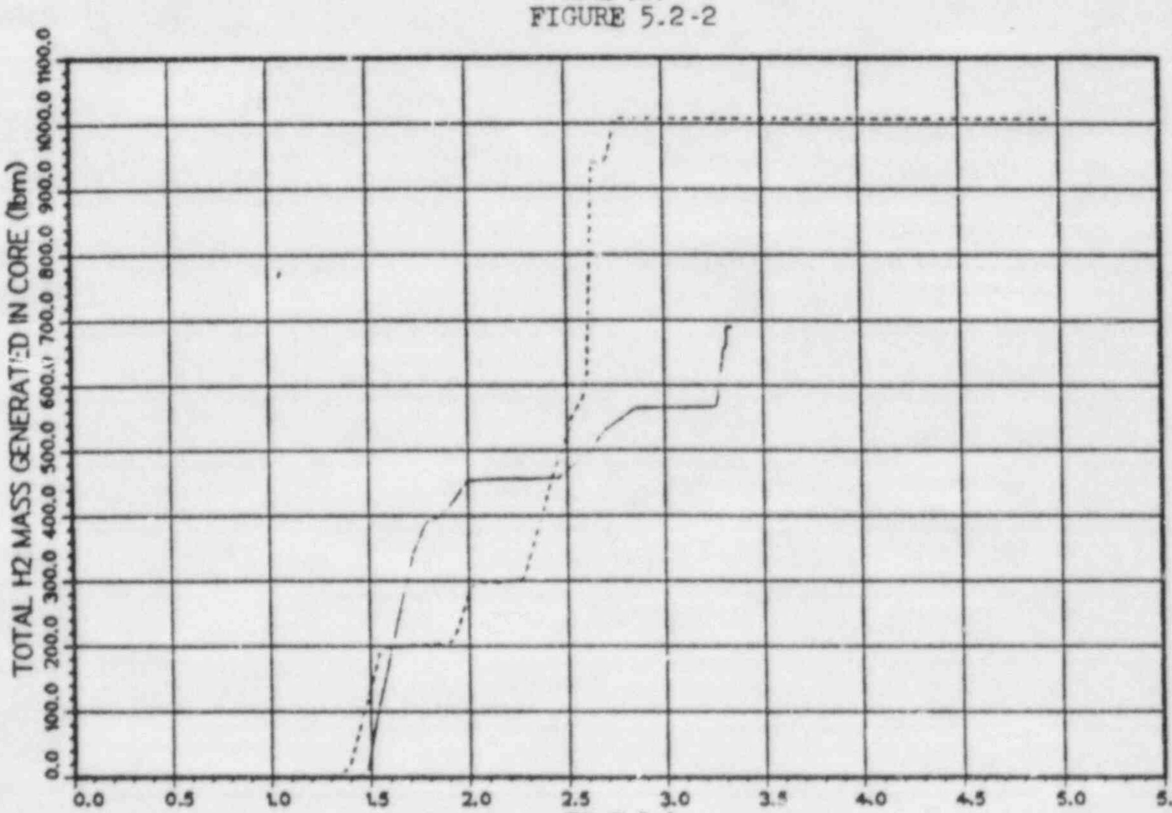


FIGURE 5.2-3

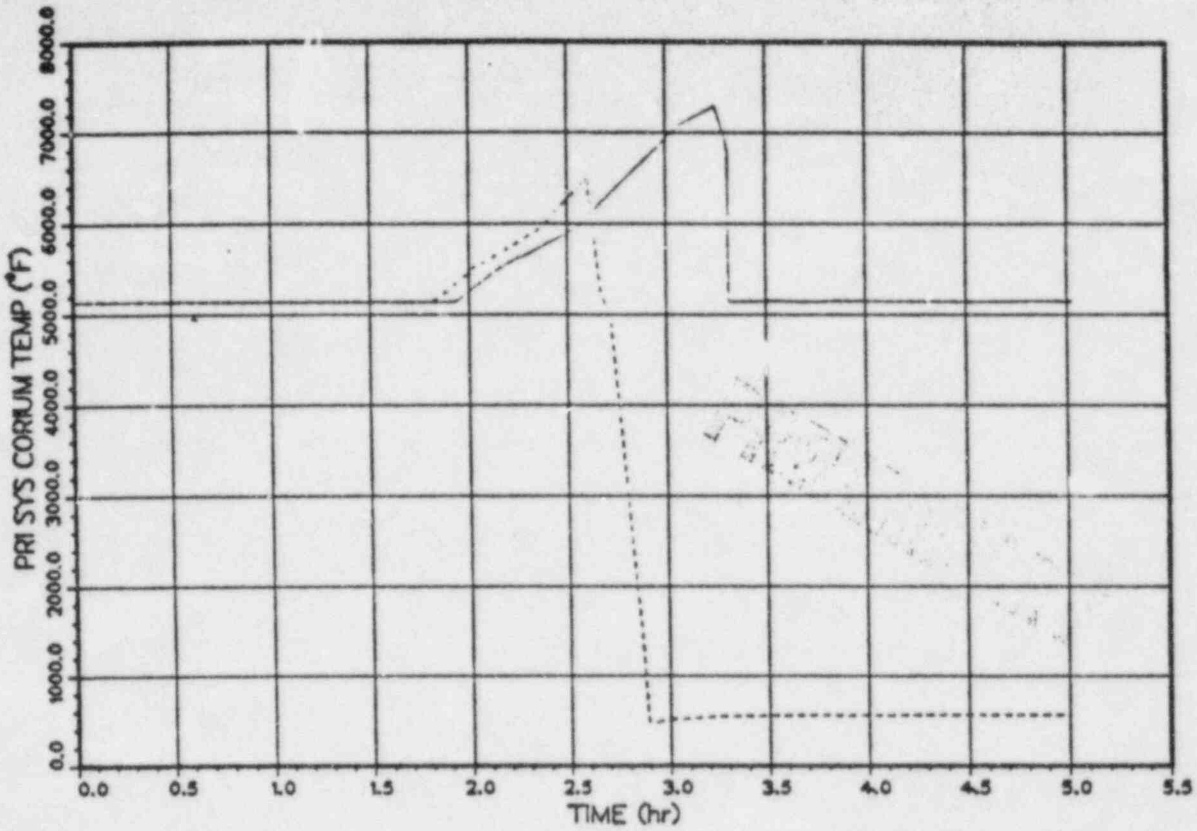


FIGURE 5.2-4

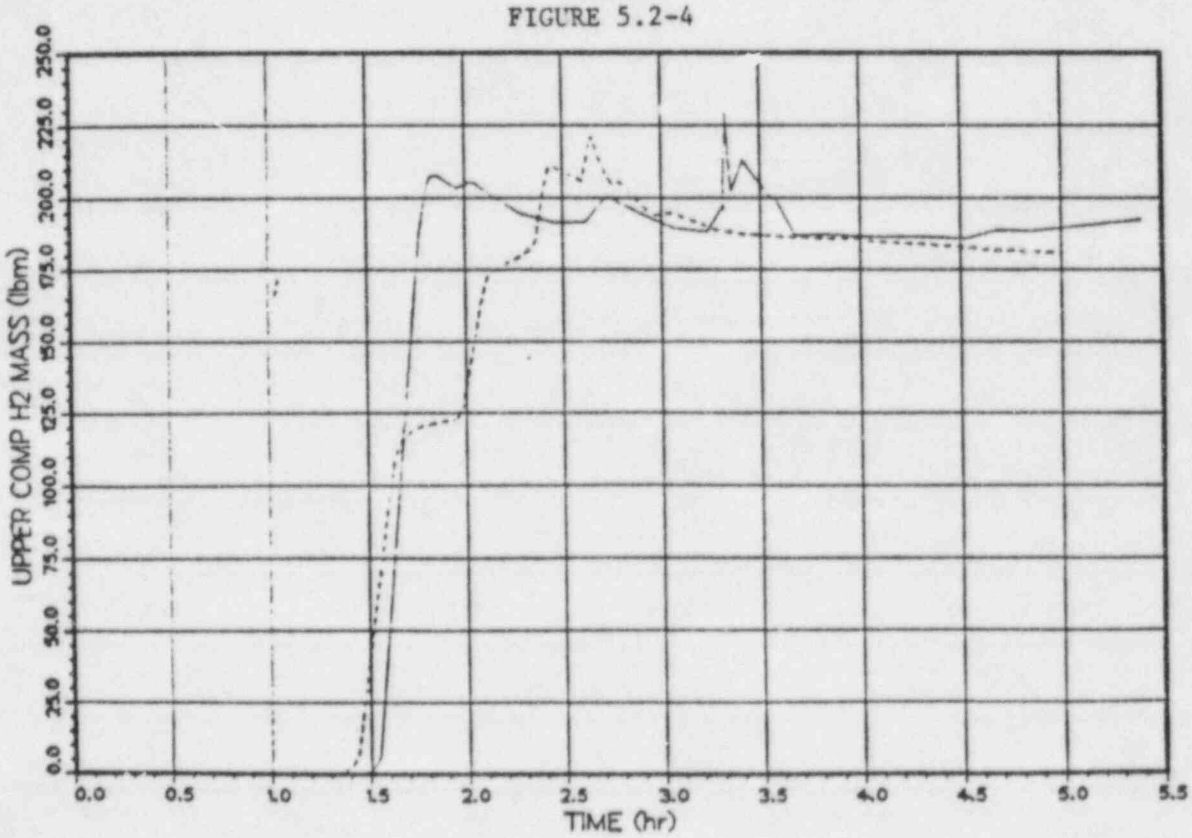


FIGURE 5.2-5

5.3 TMLB' Sequences

5.3.1 Complete Power Restoration at 2.5 Hours - TMLB'

This case compares the base case described in section 4.4 with the assumption of complete power restoration at 2.5 hours. The purpose of this modified base case is to determine the overall plant response to restoration of all plant functions before vessel failure. Just prior to power restoration, the pressurizer is empty, and the vessel water level is below the bottom of the active fuel. At 2.5 hours, all ECCS pumps, containment sprays, air return fans, igniters, and auxiliary feedwater pumps are restored. Referring to Figures 5.3-1 through 5.3-5 the primary system pressure shows an immediate decrease (at 2.5 hours) as feedwater refills the steam generators providing an effective heat sink. The primary system pressure reaches a minimum at about 20 minutes after power restoration. At this time, the ECCS pumps quickly refill the primary system, quench the fuel, and drive the pressure up to the shut off head of the charging pumps. The containment response shows a maximum pressure of 21 $lb/in^2{}_a$ corresponding to the failure of the quench tank rupture disk due to the pressurizer relief valves relieving the primary system pressure at approximately 1.66 hours. Containment pressure is rapidly suppressed to about 18 $lb/in^2{}_a$ after power restoration and remains relatively constant. With power restoration at 2.5 hours, the integrity of vessel and containment is never challenged.

5.3.2 Complete Power Restoration at 5.0 Hours - TML3'

This case compares the base case described in section 4.4 with the assumption of complete power restoration at 5.0 hours. The purpose of this modified base case is to determine the overall plant response to restoration of all plant functions after reactor vessel failure. Referring to Figures 5.3-6 through 5.3-11, at 5.0 hours the reactor vessel has already failed and all the invessel hydrogen has been released and the hydrogen mass in all the compartments is at a maximum. The containment experiences a maximum pressure of about 30 lb/in^2a at approximately 3.5 hours due to reactor vessel failure. The upper compartment gas temperature and hydrogen mass are 180°F and 140 lbm, respectively at 5.0 hours. Immediately after power restoration, the ECCS system and containment sprays rapidly add water to the containment resulting in flooding the cavity thus providing sufficient water to keep the corium quenched. Therefore, no concrete attack can occur and the vigorous concrete ablation rate with noncondensible gas generation as seen in the base case is precluded. When the containment sprays are actuated the temperature and pressure of the lower compartment are quickly suppressed. The containment pressure decreases to about 18.5 lb/in^2a. Once the injection phase is complete, successful realignment to recirculation is achieved. After about 6.5 hours, containment heat removal continues to decrease the containment temperature and pressure. Therefore, containment integrity is not challenged.

TMLB U4MAAP/U21HMAP

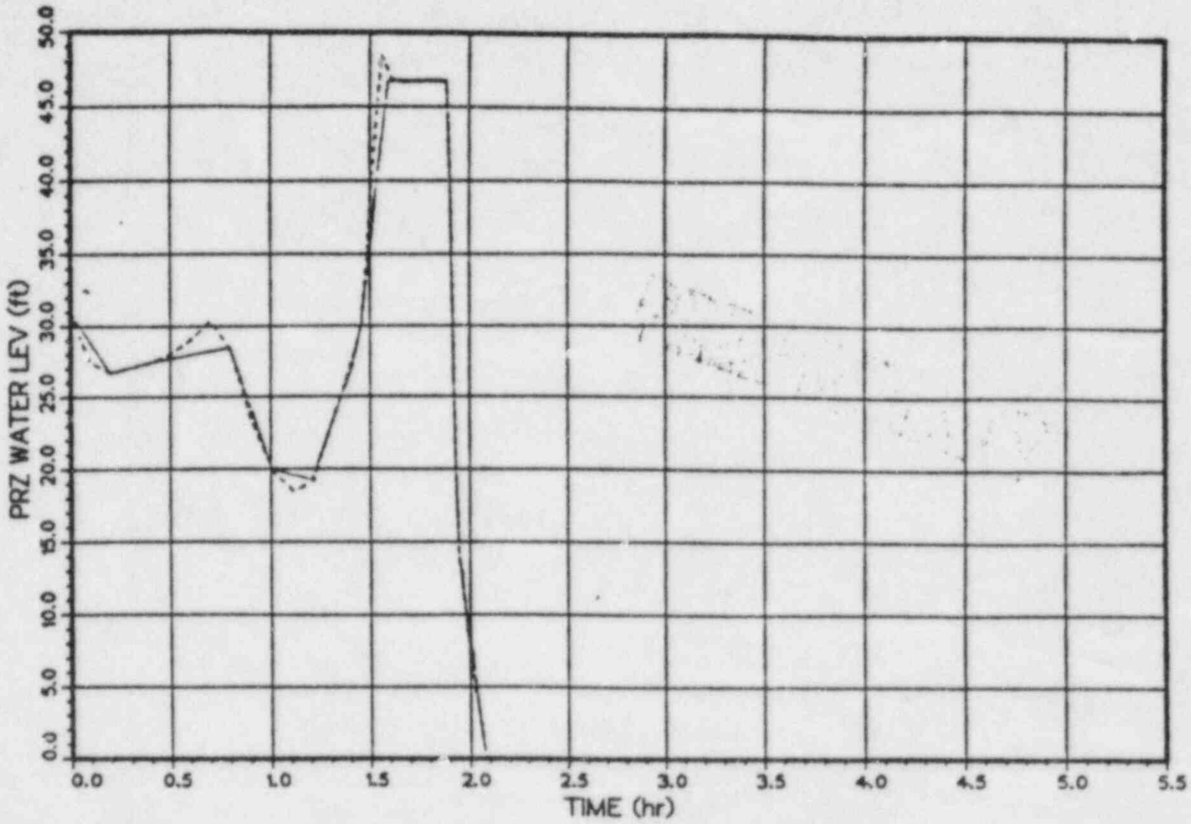


FIGURE 5.3-1

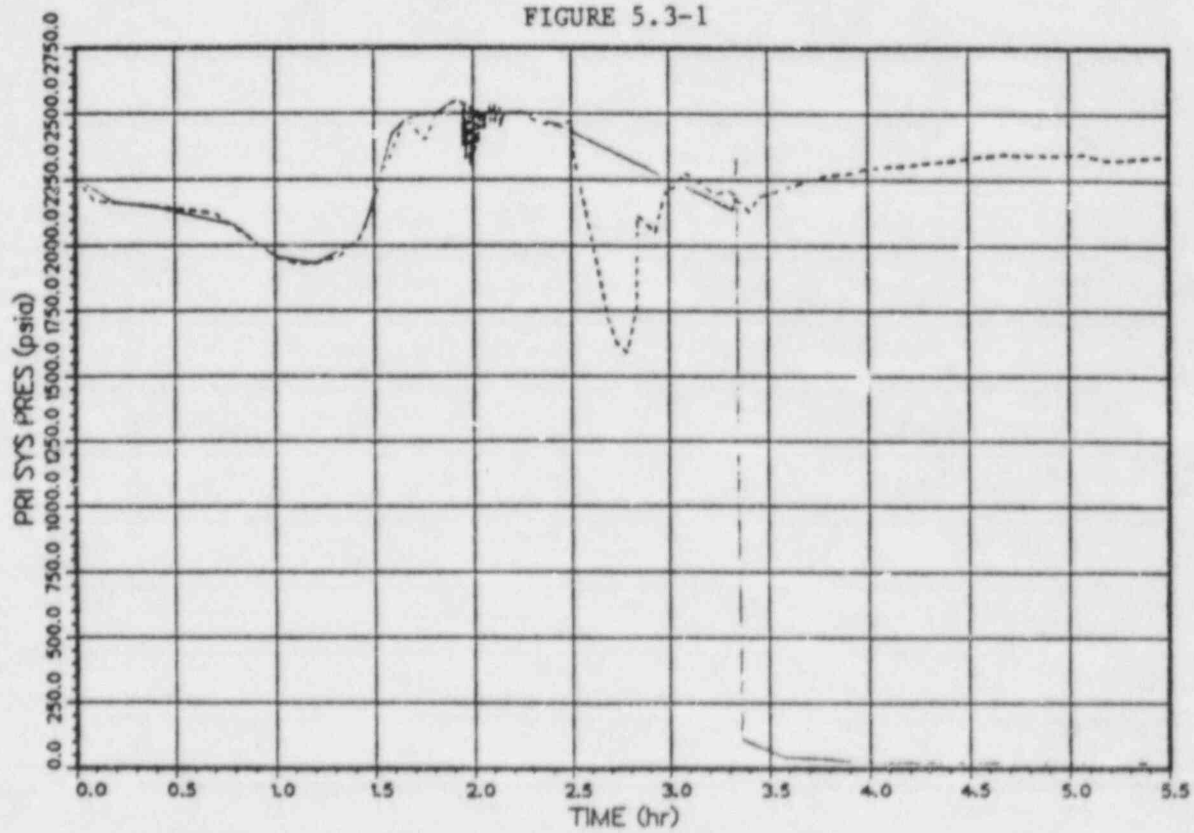


FIGURE 5.3-2

TMLB U4MAAP/U21HMAP

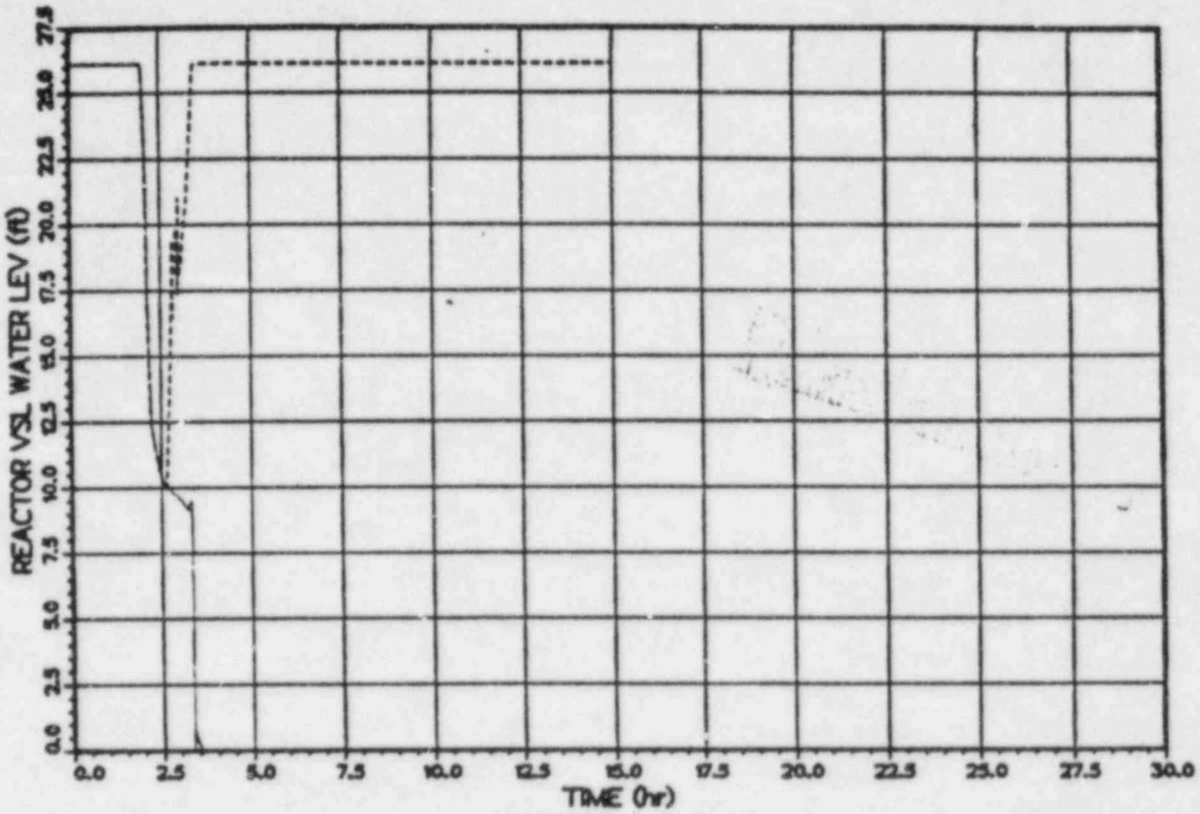


FIGURE 5.3-3

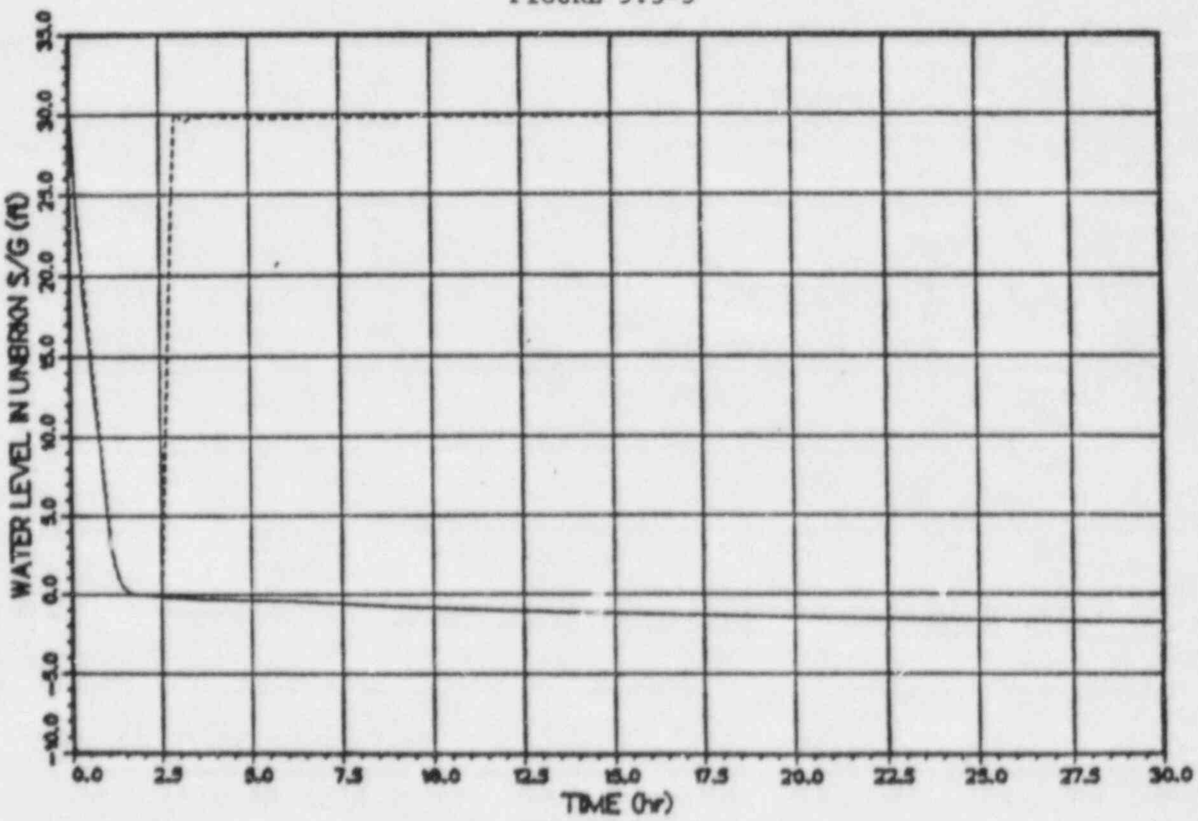
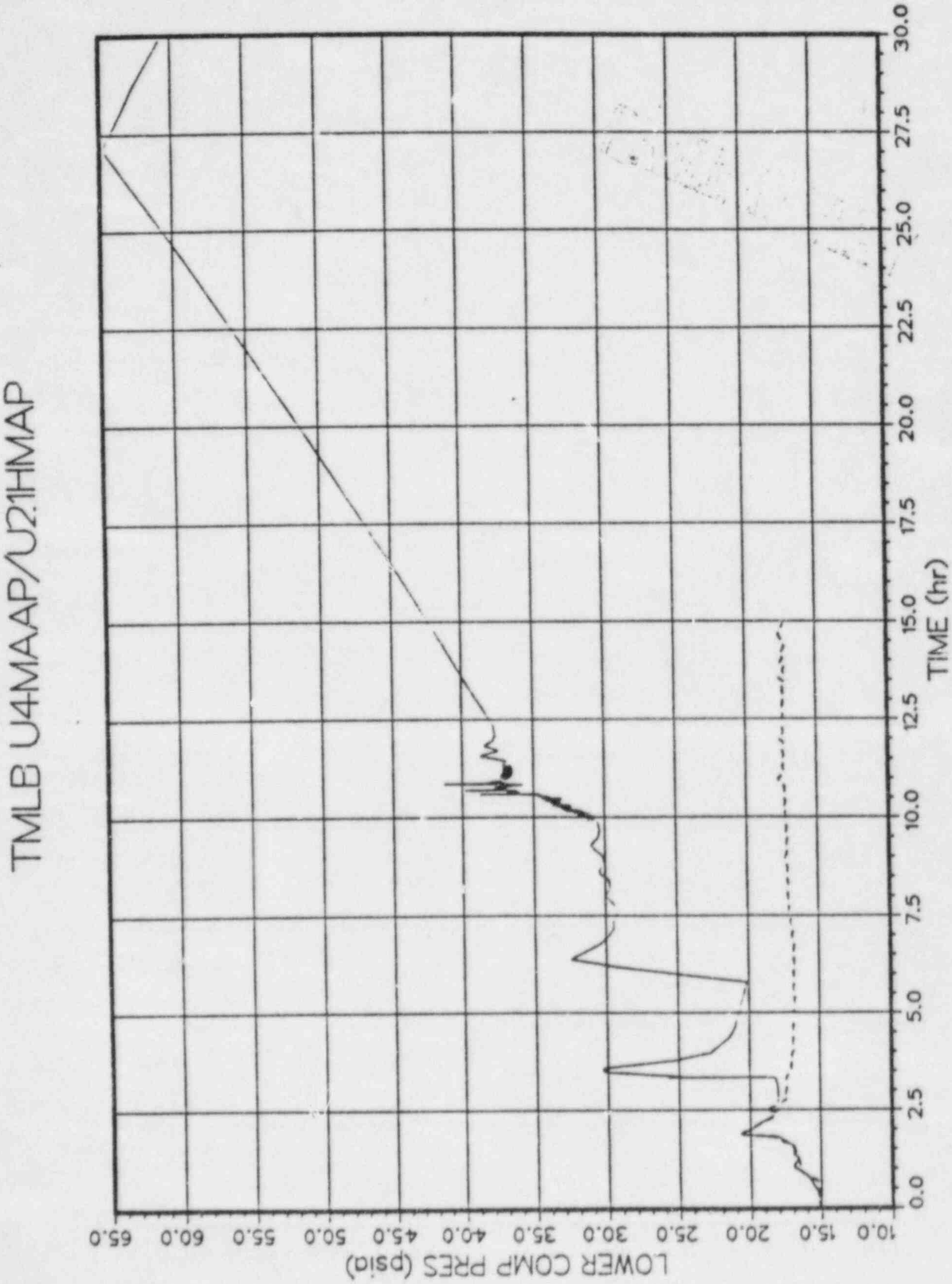


FIGURE 5.3-4

FIGURE 5.3-5



TMLB U4MAAP/U21HMAP
LOWER COMP PRES (psia)
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
65.0
TIME (hr)
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
30.0

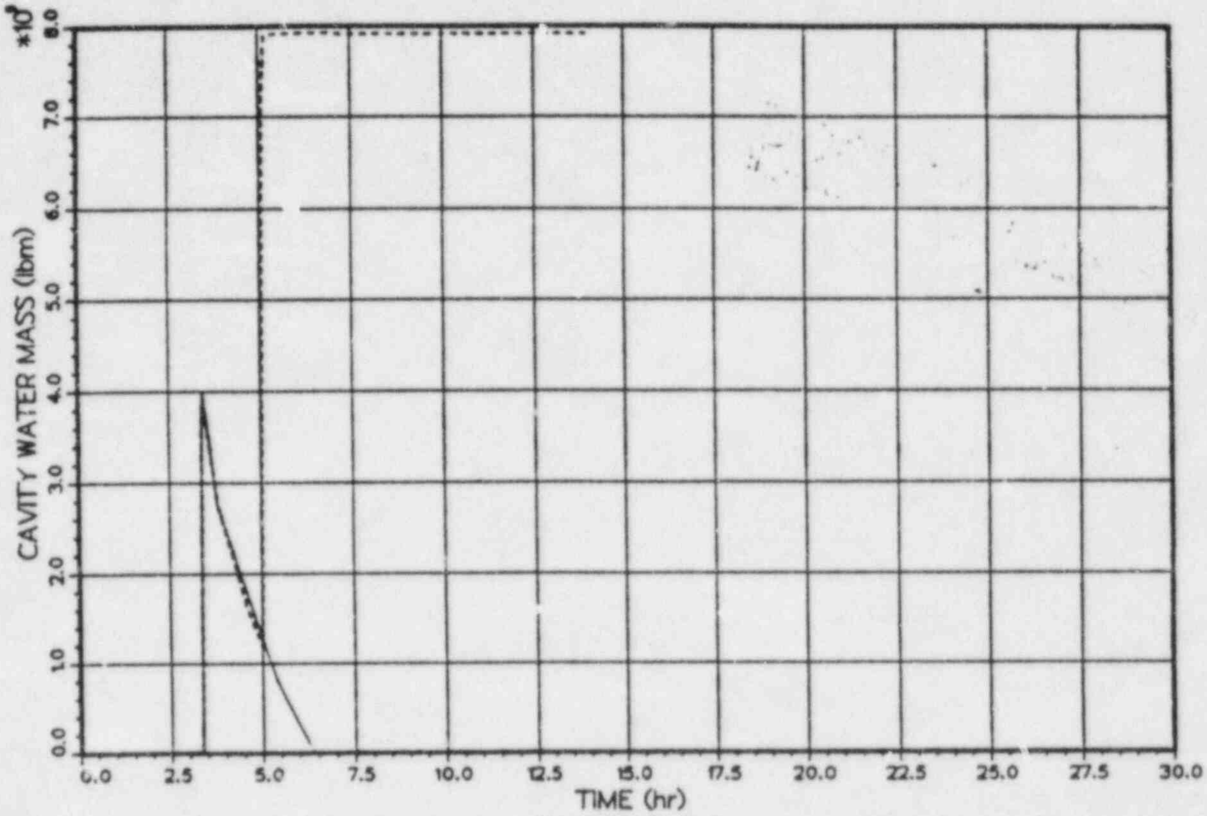


FIGURE 5.3-6

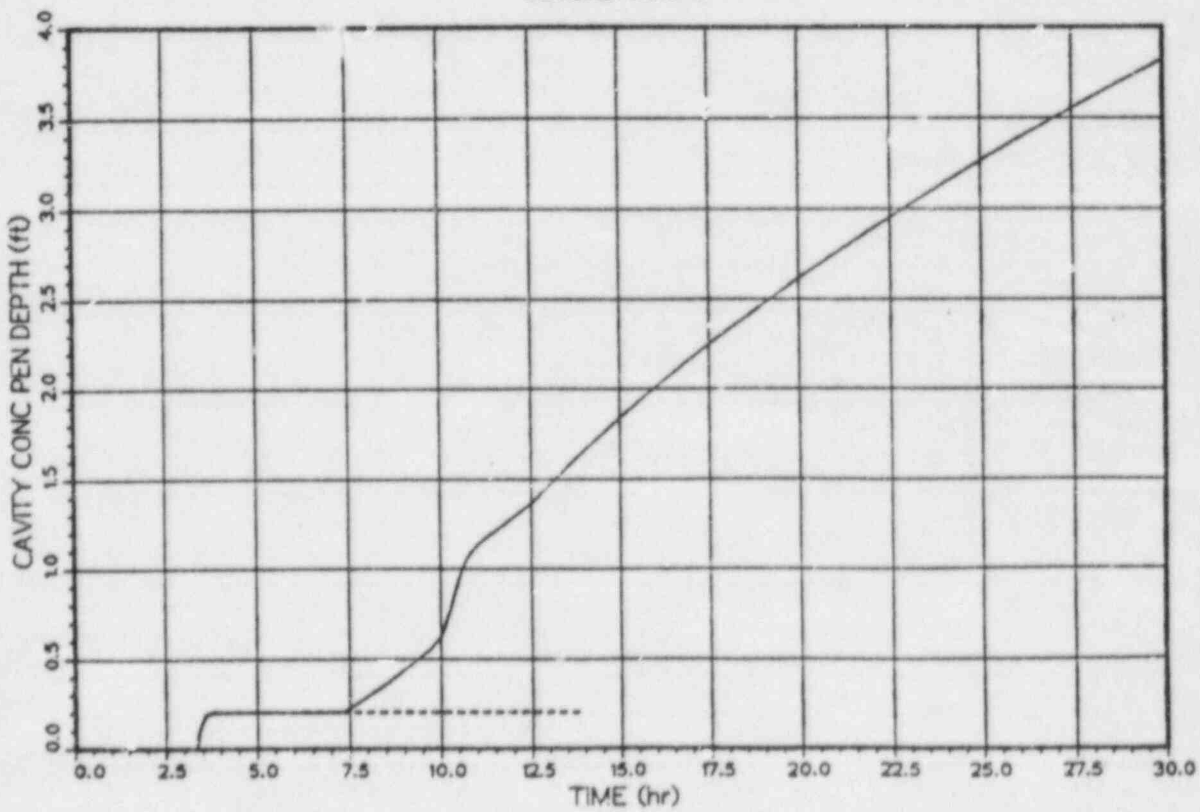


FIGURE 5.3-7

TMLB U4MAAP/U22HMAP

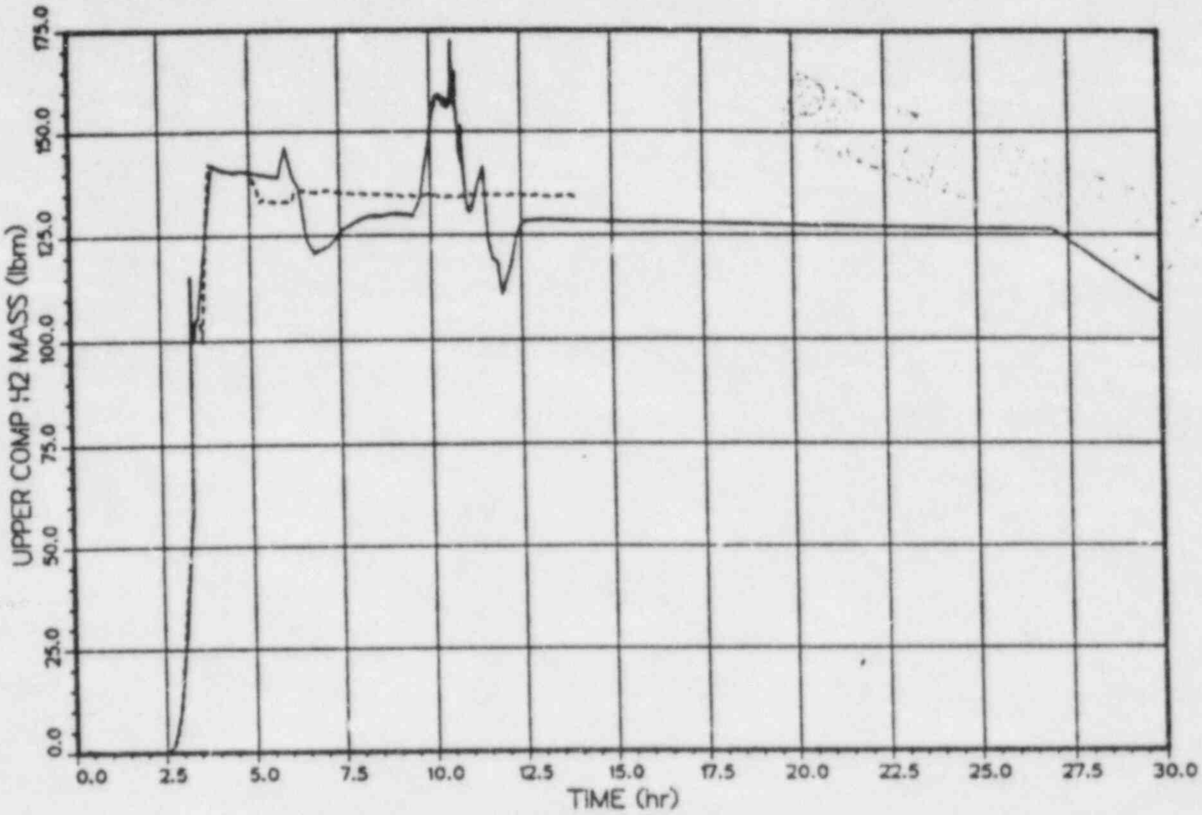


FIGURE 5.3-8

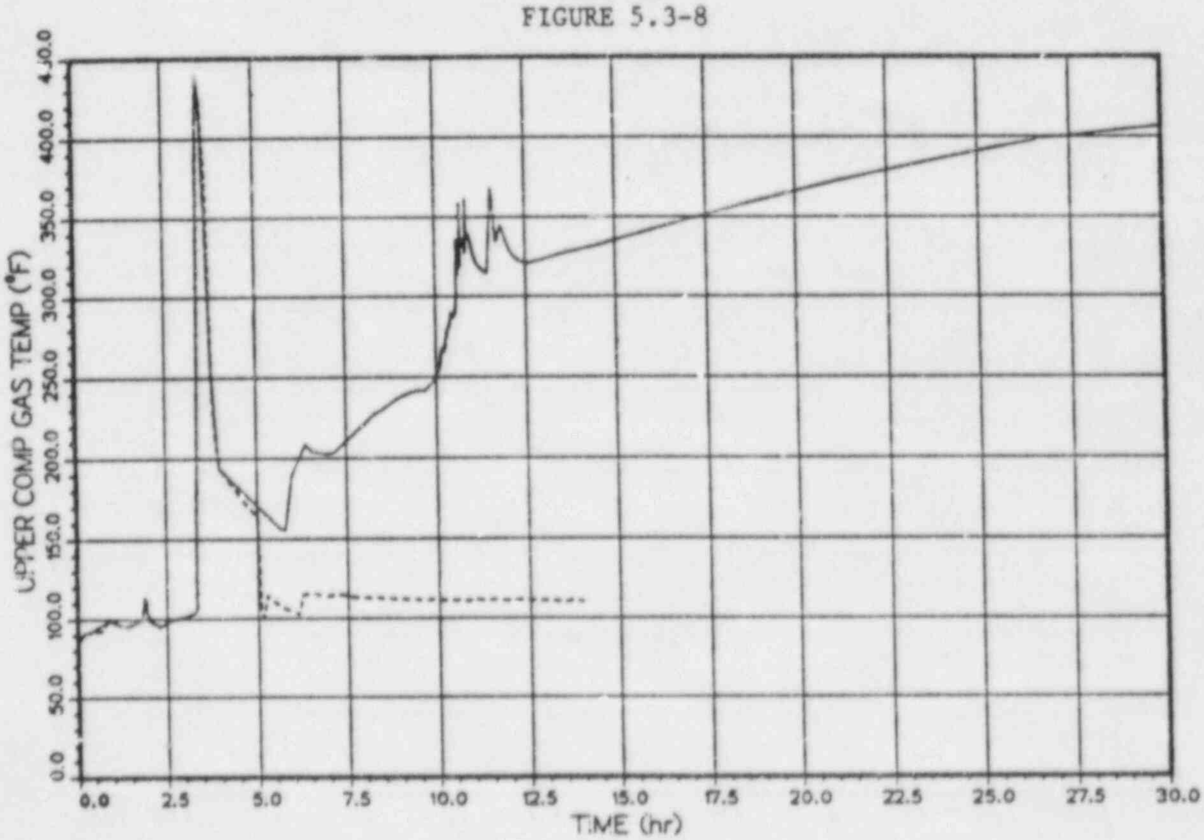
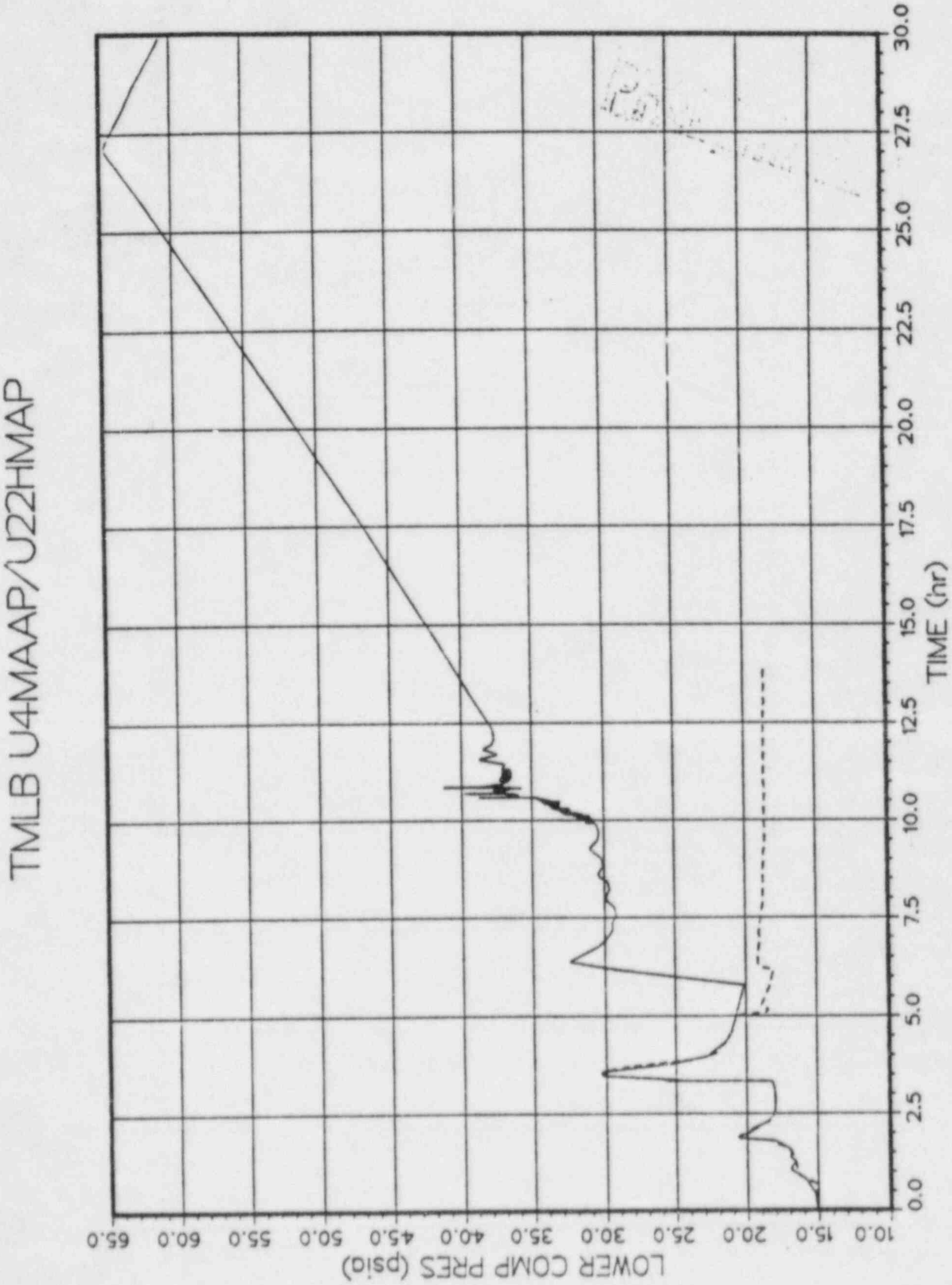


FIGURE 5.3-9

FIGURE 5.3-10


TMLB U4MAAP/U22HMAP
LOWER COMP PRES (psia)
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
65.0
TIME (hr)
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
30.0

PRELIMINARY

5.4 $T_{23}ML$ Sequences

5.4.1 Bleed and Feed - $T_{23}ML$

This case compares the base case described in section 4.5 with the bleed and feed sequence. The purpose of this case is to determine the plant response to an accident sequence in which the recovery actions require bleeding the primary system and using the ECCS pumps to remove energy via injection water. The assumptions are as follows (1) the PORV manually opened at 2500 seconds and (2) ECCS injection (two charging, two safety injection, two RHR pumps available at 2500 seconds). At time zero, the reactor is scrammed and no auxiliary feedwater is available. Referring to Figures 5.4-1 through 5.4-6, the pressurizer water level and pressure initially decrease but quickly stabilize themselves in response to the actuation of the pressurizer heaters. The steam generators pressurize to the relief valve set point and rapidly lose inventory due to the loss of auxiliary feedwater resulting in roughly 85 percent of the inventory being lost by 0.70 hours. At approximately the same time, 0.70 hours, the PORV is opened resulting in a rapid depressurization of the pressurizer (primary system) pressure to approximately 1150 lb/in^2a. At about 0.72 hours, the ECCS pumps start to refill the primary system. The injection of cool water immediately causes primary system pressure and temperature suppression. The ECCS injection and loss of secondary side cooling drives the pressurizer solid at 0.8 hours and the quench tank rupture disk fails at 0.82 hours. The PORV discharges liquid water as the charging pumps circulate cooling water into the cold leg.

Between about 1.5 and 3.0 hours, the pressurizer (primary system) pressure decreases from about 1550 to 1450 lb/in^2a. The core (primary system) water temperature decreases from about 565°F at 1.0 hour to about 400°F at 3.0 hours. Beyond 3.0 hours, the primary system pressure slowly decreases due to the equilibration between the pump injection rate and the flow out of the PORV. Although the pressure remains somewhat constant, the primary system water temperature continues to decrease as the ECCS heat exchangers and containment spray continue to remove decay heat from the primary system and the containment. Referring to Figure 5.4-6, the containment maximum pressure of approximately 18.6 lb/in^2a occurs around 6.0 hours due to the depletion of ice in the ice condenser, but it is suppressed as the decay heat relieved from the primary system is exceeded by the heat removal rate of the ECCS heat exchanger and containment sprays.

5.4.2 Feed and Bleed -$T_{23}ML$

This case compares the base case described in section 4.5 with the feed and bleed sequence. The purpose of this case is to determine the plant response to an accident sequence in which the recovery actions require using the ECCS pumps to remove energy via injection water. The assumptions are as follows: at 3000 seconds, the charging pumps, safety injection, and RHR pump are turned on forcing water into the primary system. At time zero, the reactor is scrammed and no auxiliary feedwater is available. Referring to Figures 5.4-7 through 5.4-12, the pressurizer water level and pressure initially decrease but quickly stabilize themselves in response to the actuation of the pressurizer heaters. The steam generators pressurize to the relief valve set point and rapidly lose inventory due to the loss of auxiliary feedwater resulting in steam generator dryout at 0.98 hours. At approximately 0.83 hours, the ECCS pumps are turned on forcing cool water into the primary system. The injection of cool water immediately causes primary system pressure and temperature suppression. Soon after initiation of the ECCS injection, the pressurizer is solid at approximately 1.0 hour and the quench tank rupture disk fails at 1.14 hours. The PORV discharges liquid water as the charging pumps circulate cooling water into the cold leg. After 1.0 hour the pressurizer safety relief valves are automatically opened to relieve excessive pressure of primary system, the pressurizer is maintained at approximately 2350 lb/in^{2}a. The primary system pressure remains constant due to the equilibration between the pump injection rate and the flow out of the PORV. Although the pressure remains constant, the primary system water temperature continues to decrease as the ECCS heat exchangers and containment spray continue to remove decay heat from the primary system and the containment. The containment pressure is maintained at about 17.4 lb/in^{2}a until the ice is depleted at 7.5 hours and then increases to about 19.5 lb/in^{2}a at 10 hours. After 10 hours, the decay heat relieved from the primary system is exceeded by the heat removal rate of the ECCS heat exchangers and containment sprays causing the containment pressure to decrease.

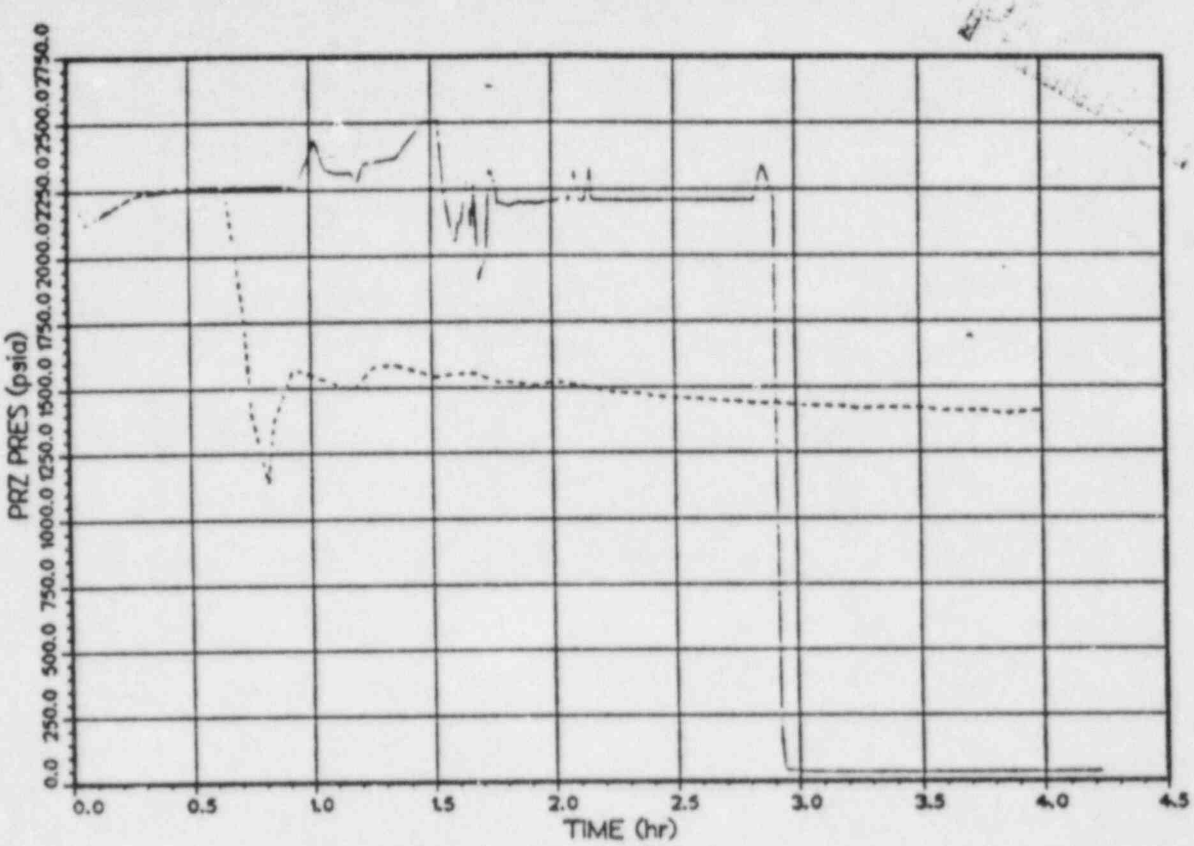


FIGURE 5.4-1

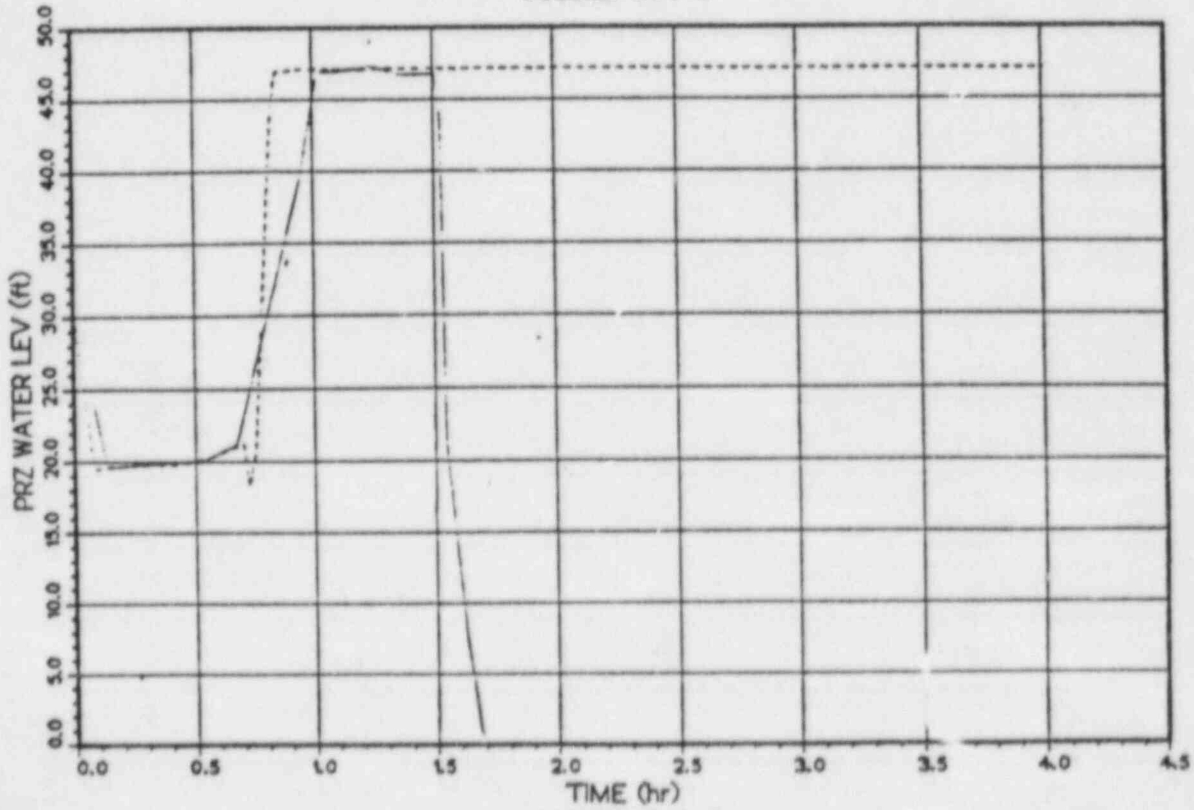


FIGURE 5.4-2

T23ML U5MAAP/U16MAAP

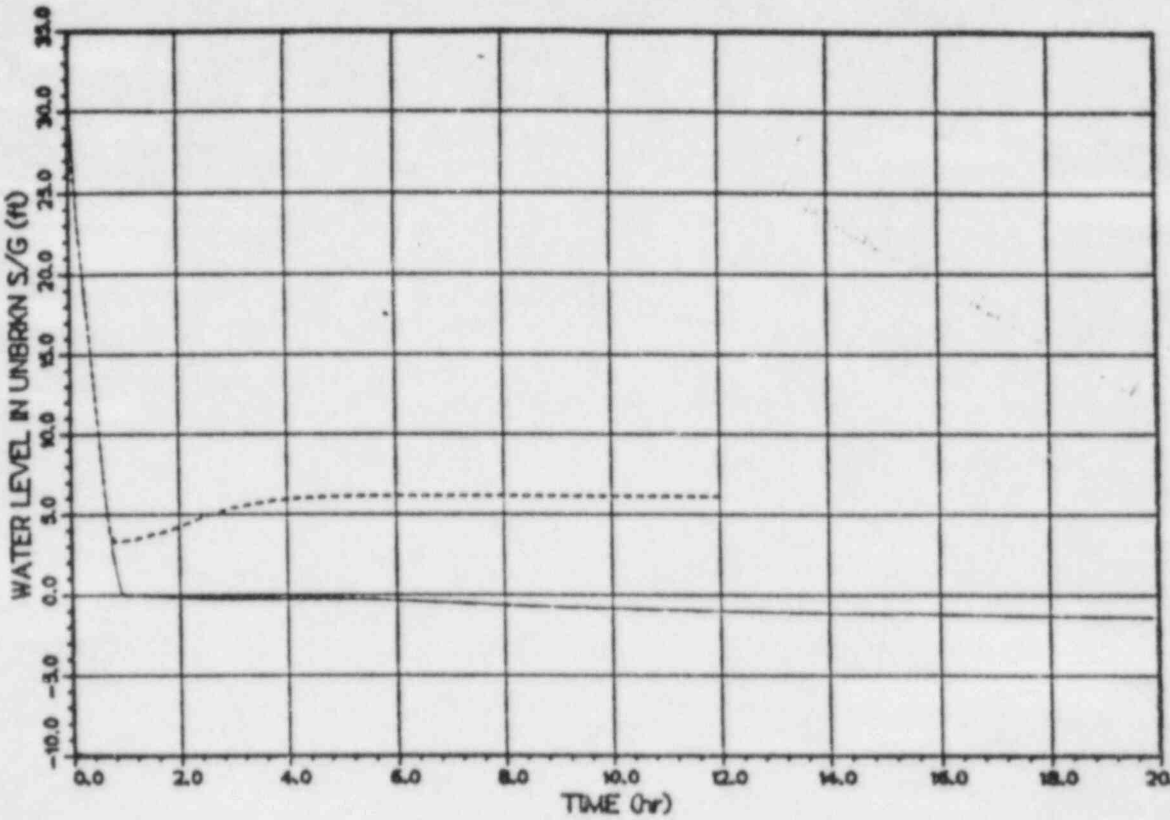


FIGURE 5.4-3

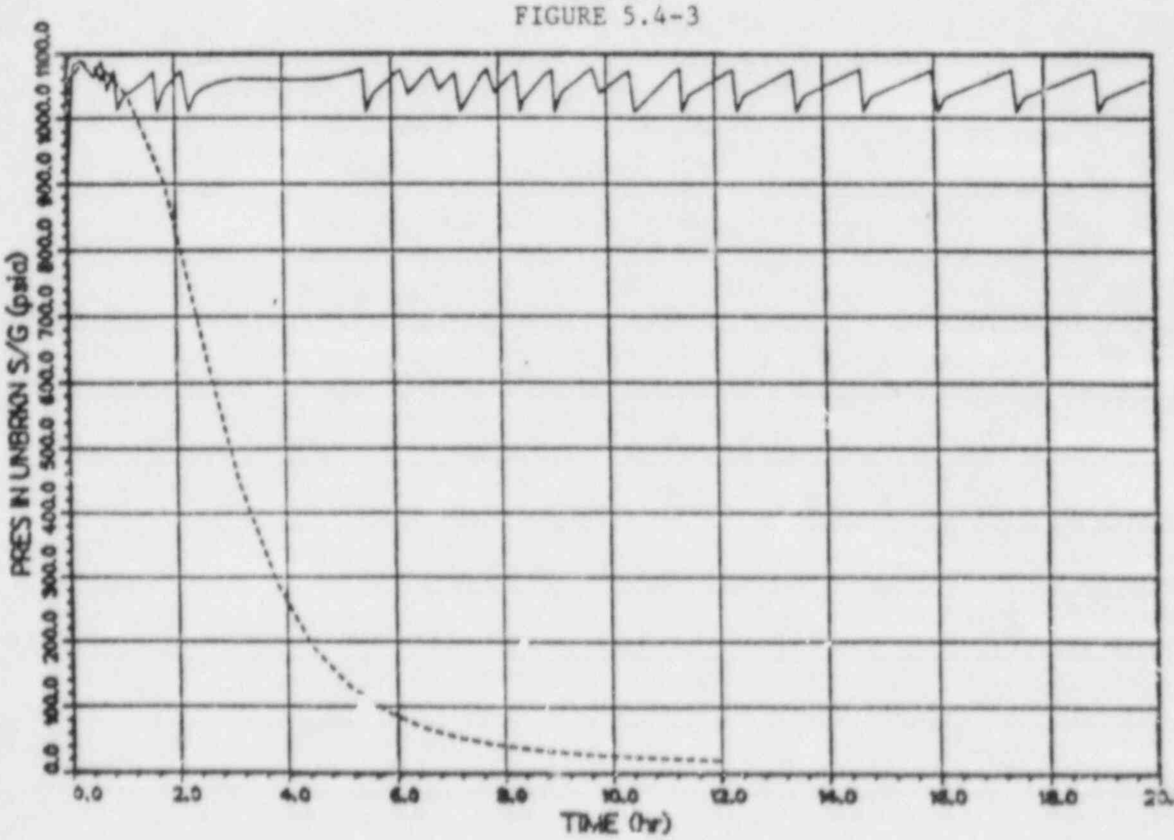


FIGURE 5.4-4

T23ML U5MAAP/U16MAAP

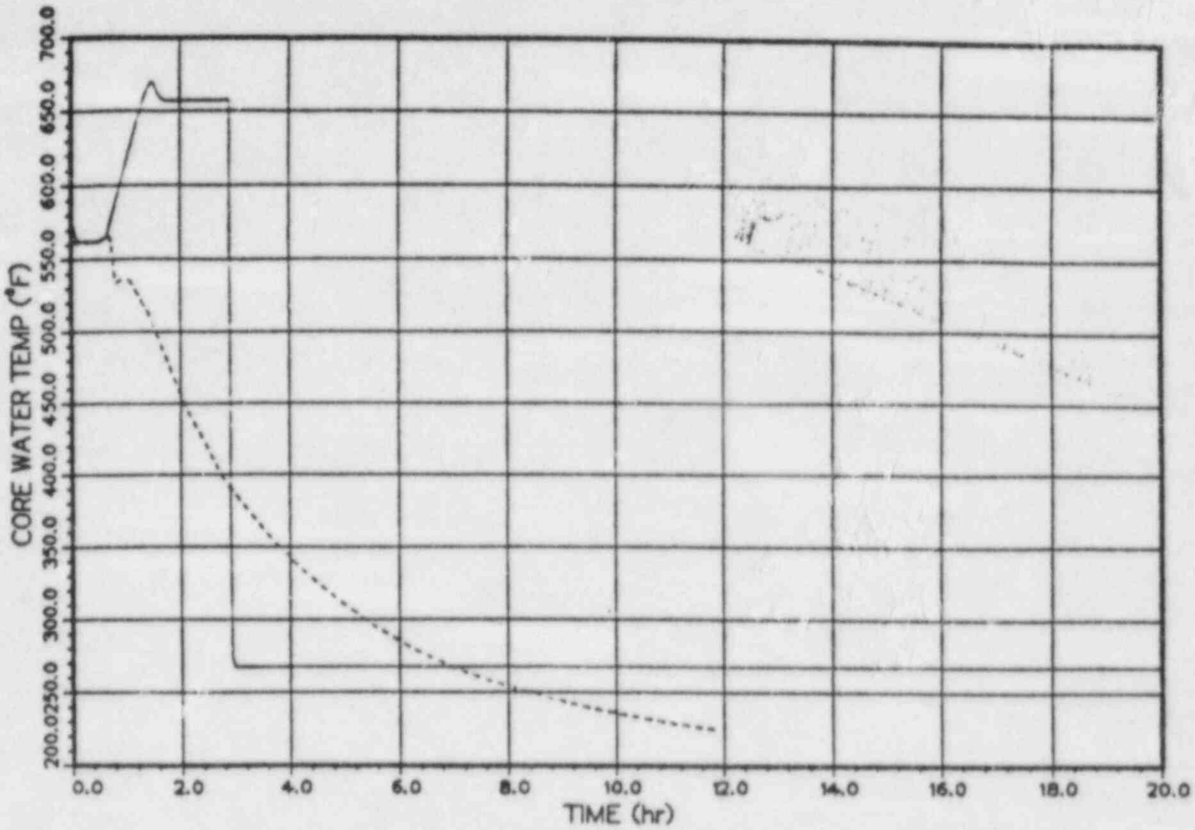


FIGURE 5.4-5

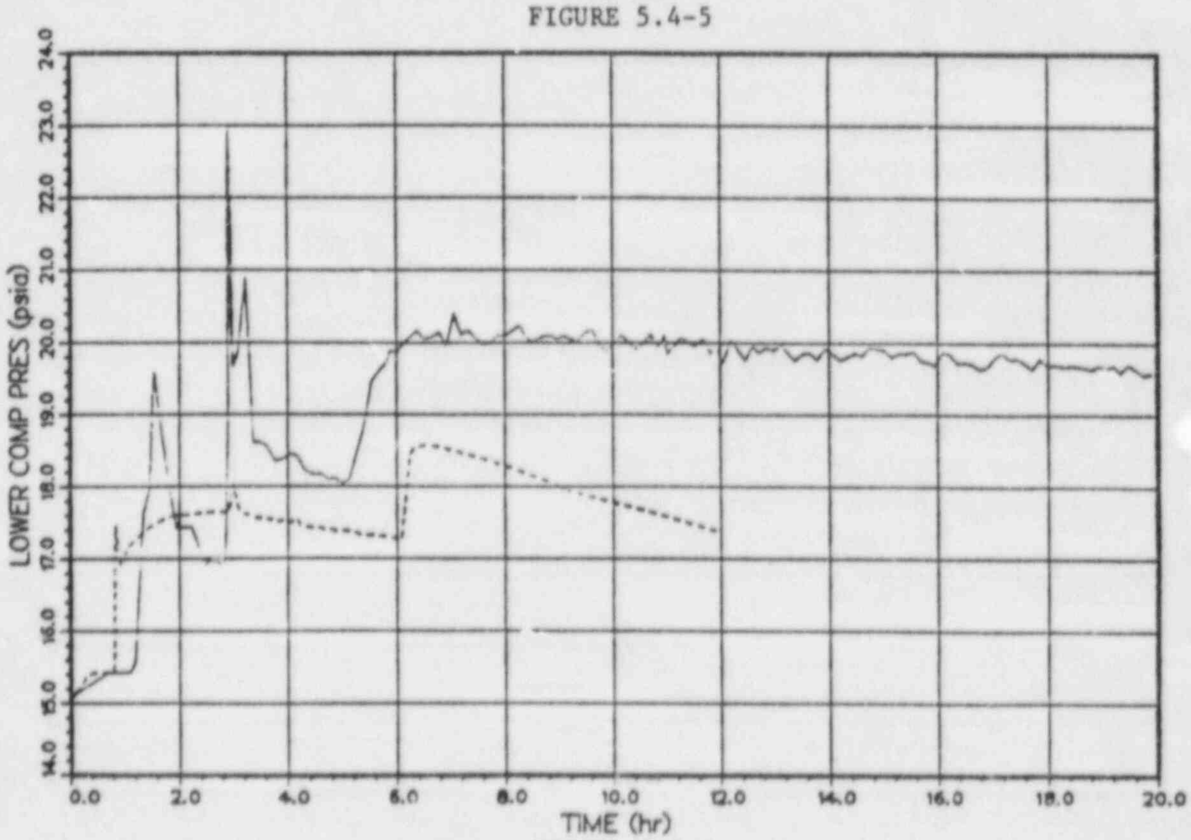


FIGURE 5.4-6

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

T23ML U5MAAP/U17MAAP

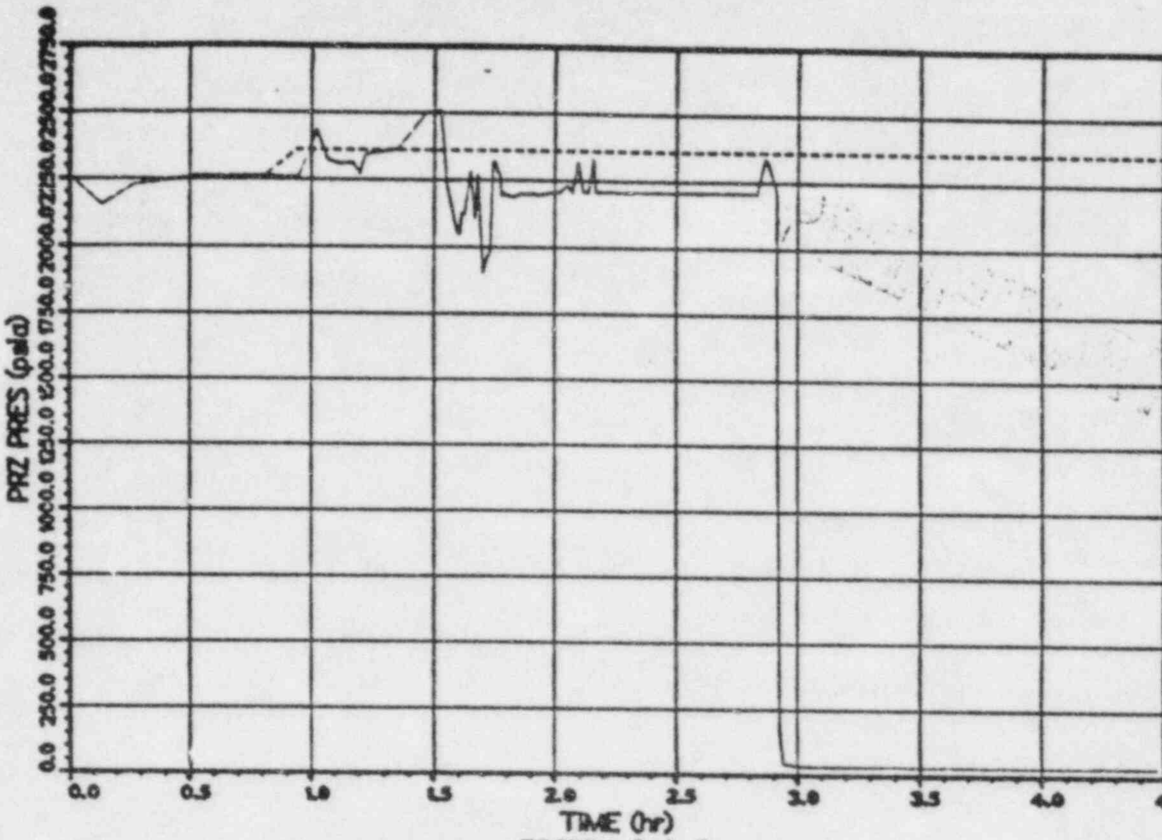


FIGURE 5.4-7

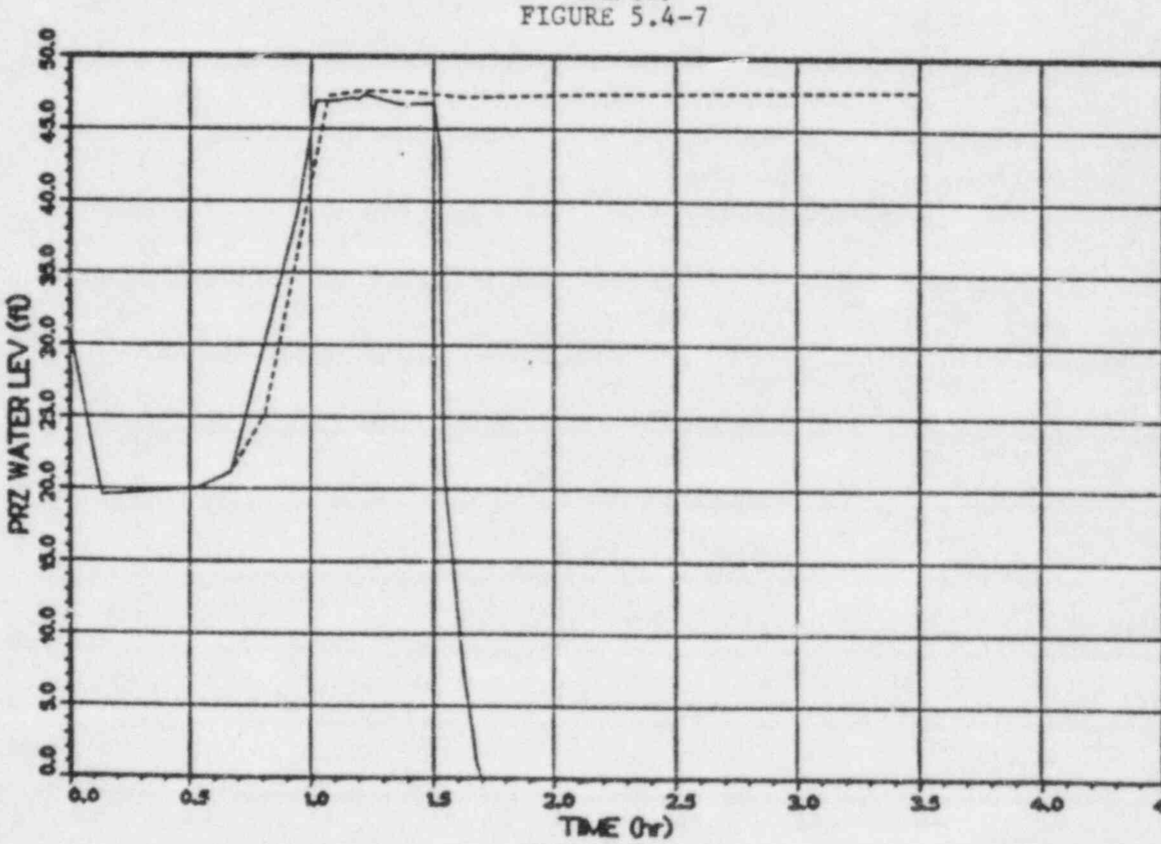


FIGURE 5.4-8

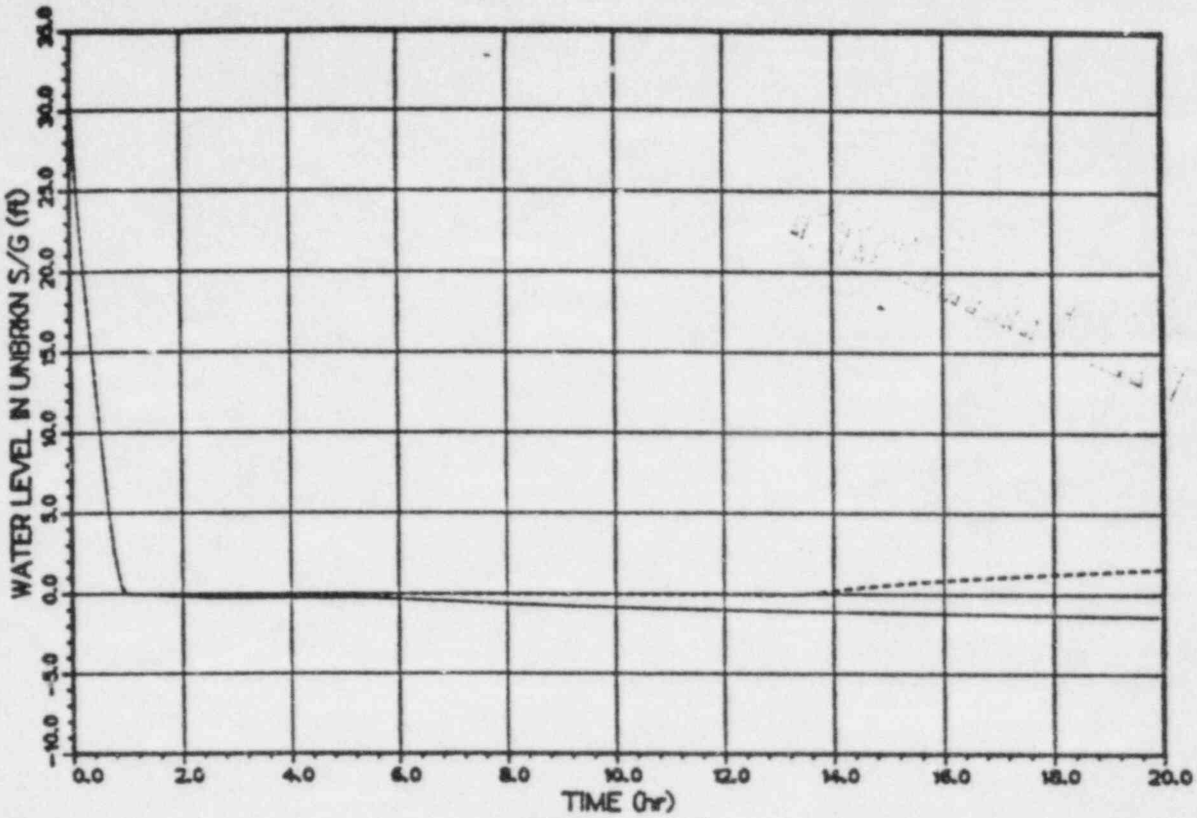


FIGURE 5.4-9

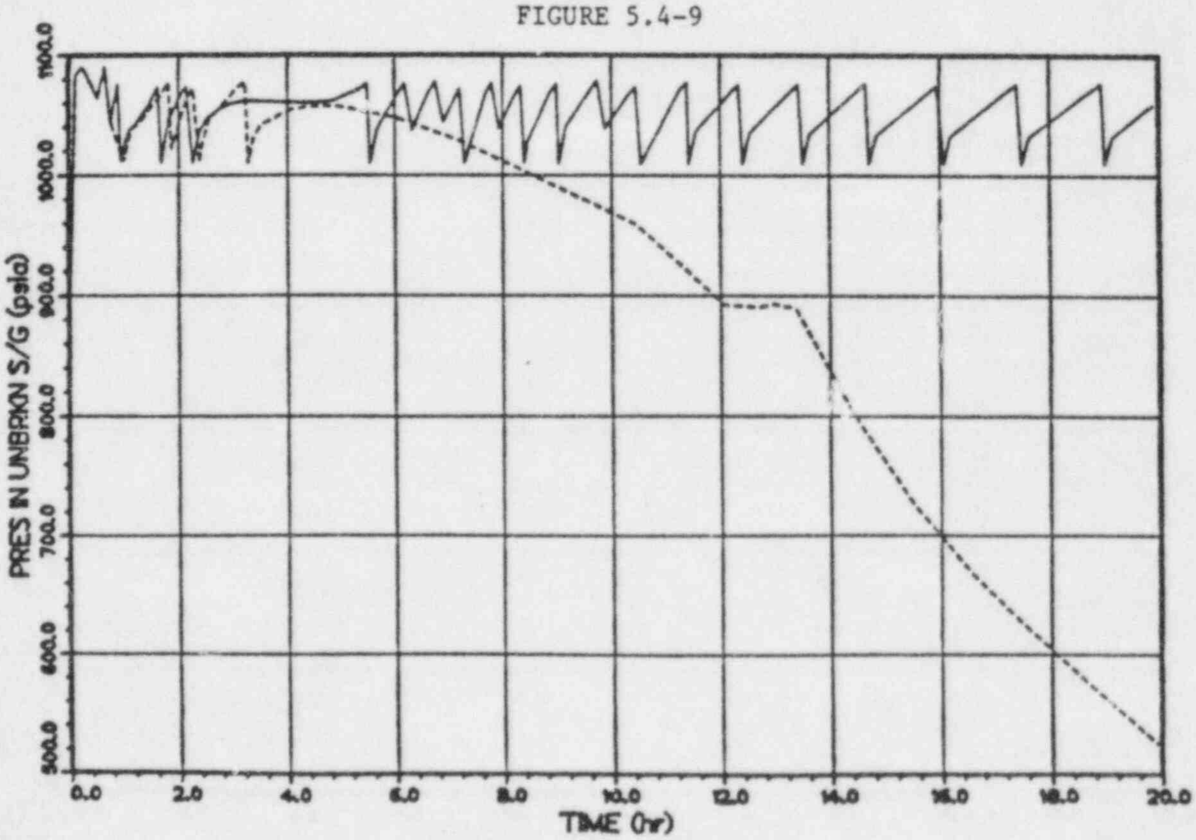


FIGURE 5.4-10

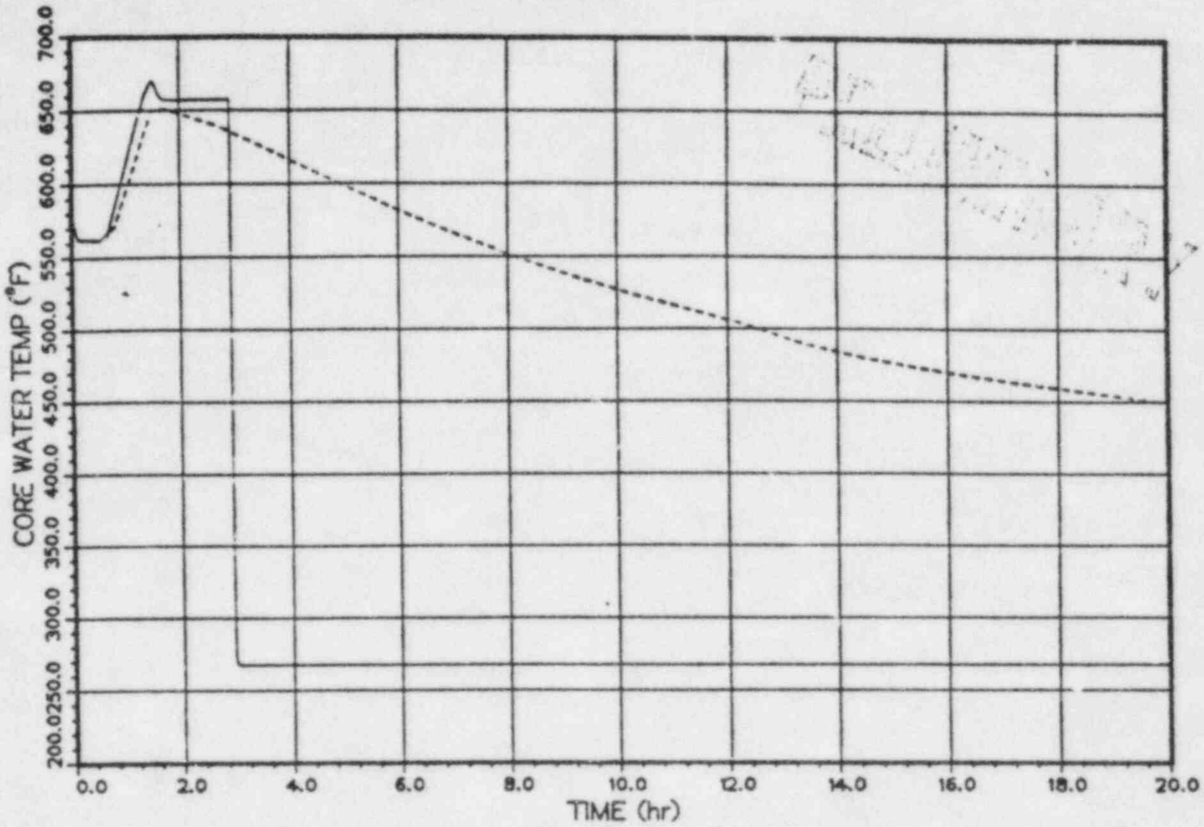


FIGURE 5.4-11

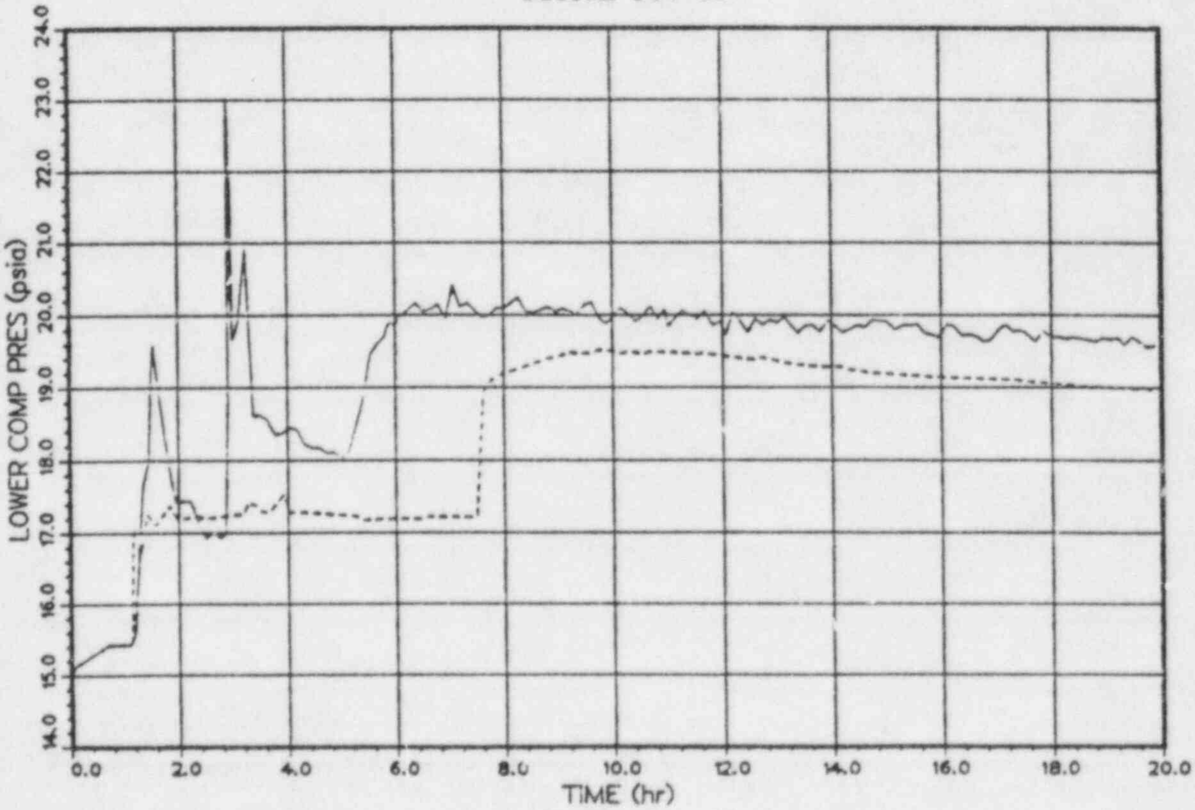


FIGURE 5.4-12

5.5 AD Sequences

5.5.1 Minimum Safeguards - AD

The minimum safeguards case assumes that only one air return fan and one containment spray pump are available for operation. Since both ECCS injection and recirculation are inoperable, the primary response is identical for both cases.

The predicted lower compartment pressure for the minimum safeguards case and the base case are compared in Figure 5.5-1. Prior to ice melt, the somewhat higher (less than 2.5 lbf/in^2a) lower compartment pressure during the accident for the minimum safeguards case is due to the reduced air flow through the ice condenser and the reduced heat removal capability of the single containment spray. The rather rapid increase in pressure at approximately 3.0 hours is nearly coincident with depletion of the ice in the ice condenser at 3.23 hours. At approximately 6.0 hours, the heat removal capability of the single containment spray exceeds the heat production rate of the quenched debris bed and the lower compartment pressure starts to decrease. The maximum containment pressure reached in the minimum safeguard case is 23.8 lbf/in^2a at approximately 6 hours, which is well below the containment failure pressure of 65 lbf/in^2a.

5.5.2 Full Restoration of Injection - AD

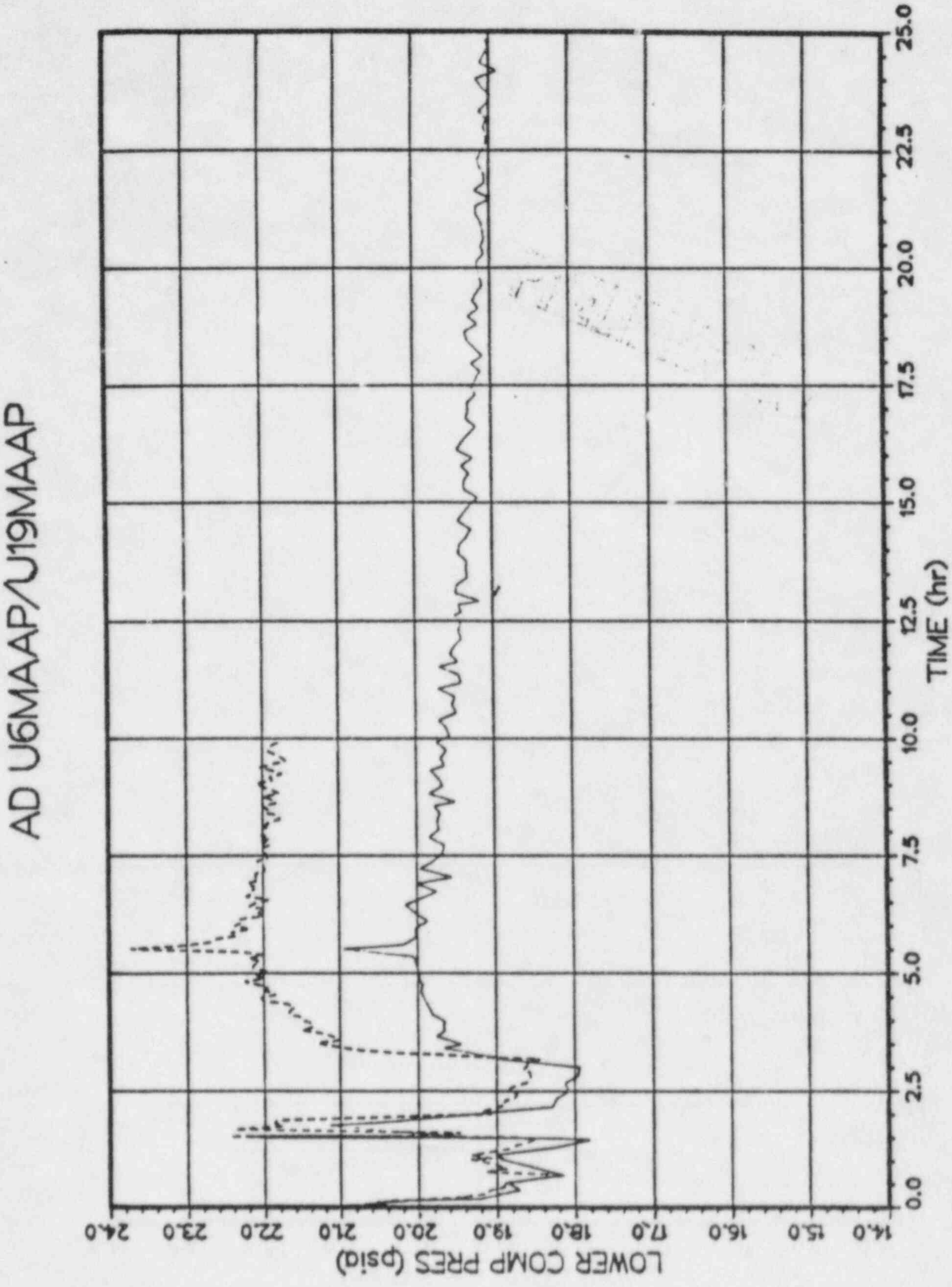
The purpose of this modified base case is to determine the system response to regaining full injection capability prior to core support plate failure. Complete restoration of injection is assumed to occur at 1.0 hour which is when the water level in the reactor vessel is at 10.5 feet (see Figure 5.5-2), which is approximately the bottom of the active fuel.

When ECCS operation is restored at 1.0 hour, the water level in the reactor vessel is restored to its normal height within 0.1 hours. As was noted in section 5.1.2, the quenching of the core produces more hydrogen than the base case (approximately 900 lbm) due to the additional steaming caused by the ECCS injection water reacting with the hot, semimolten fuel.

The primary system corium temperature and upper compartment hydrogen mass for the full restoration of injection case are plotted in Figures 5.5-4 and 5.5-5, respectively, where they are compared to the base case plots. Note that the maximum amount of hydrogen in the upper compartment for the full restoration of injection case is 280 lbm compared to 225 lbm of hydrogen base case (see Figure 5.5-5).

The containment pressure never exceeds 22.8 lbf/in^{2}a for this case, thus containment integrity is never challenged.

FIGURE 5.5-1


AD U6MAAP/U19MAAP
LOWER COMP PRES (psia)
24.0
23.0
22.0
21.0
20.0
19.0
18.0
17.0
16.0
15.0
14.0
TIME (hr)
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0

AD U6MAAP/U20MAAP

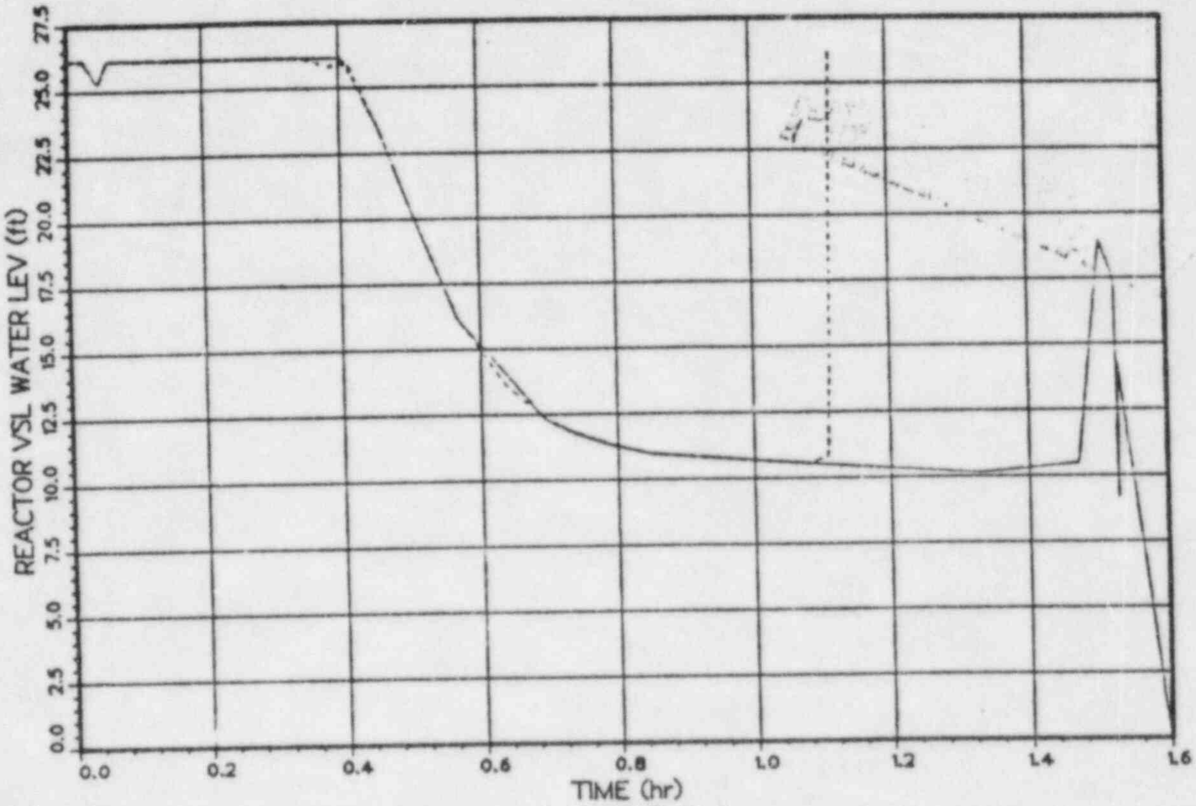


FIGURE 5.5-2

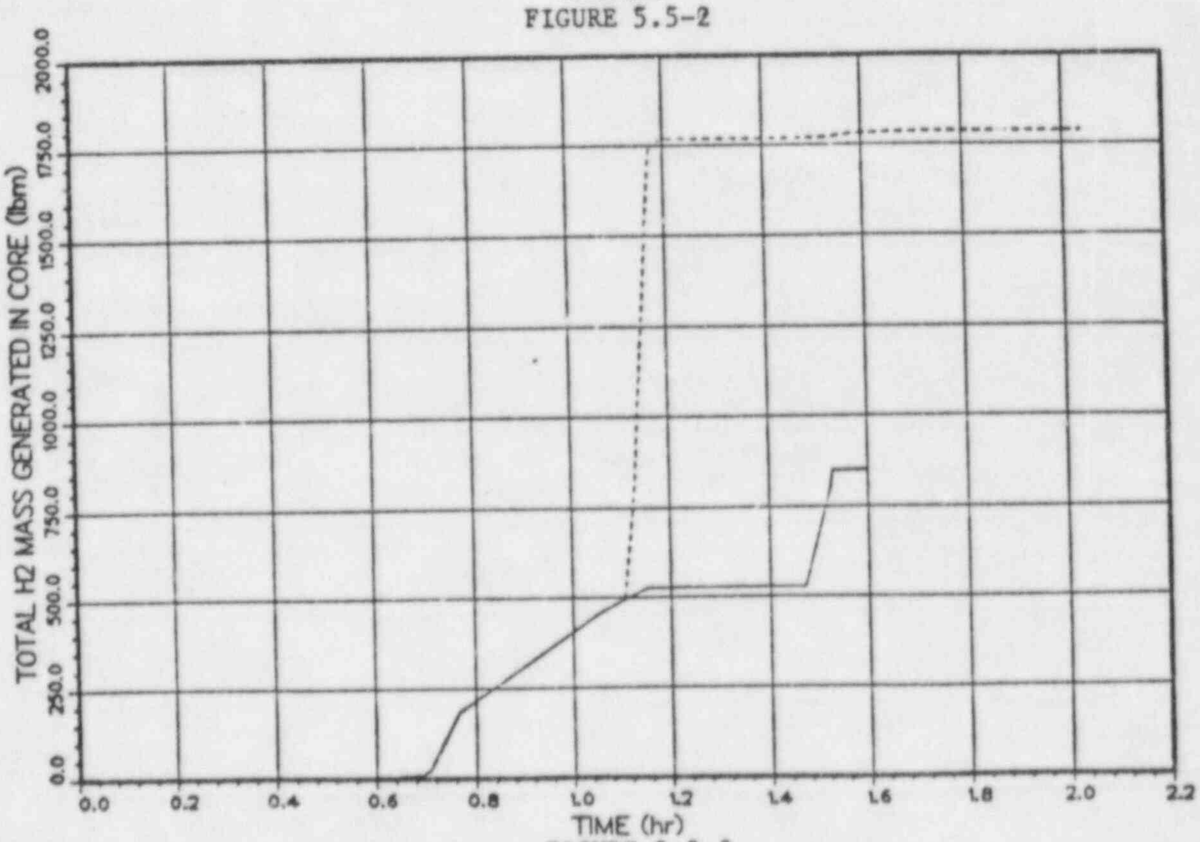


FIGURE 5.5-3

AD U6MAAP/U20MAAP

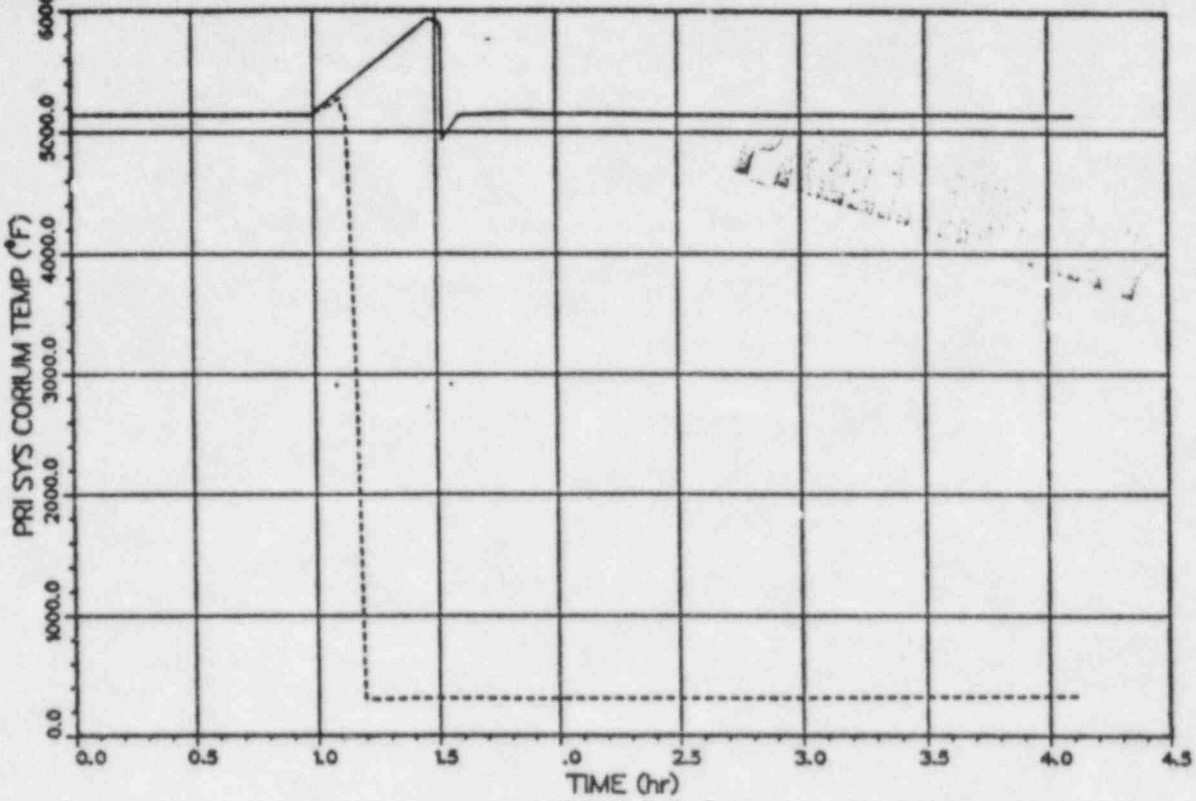


FIGURE 5.5-4

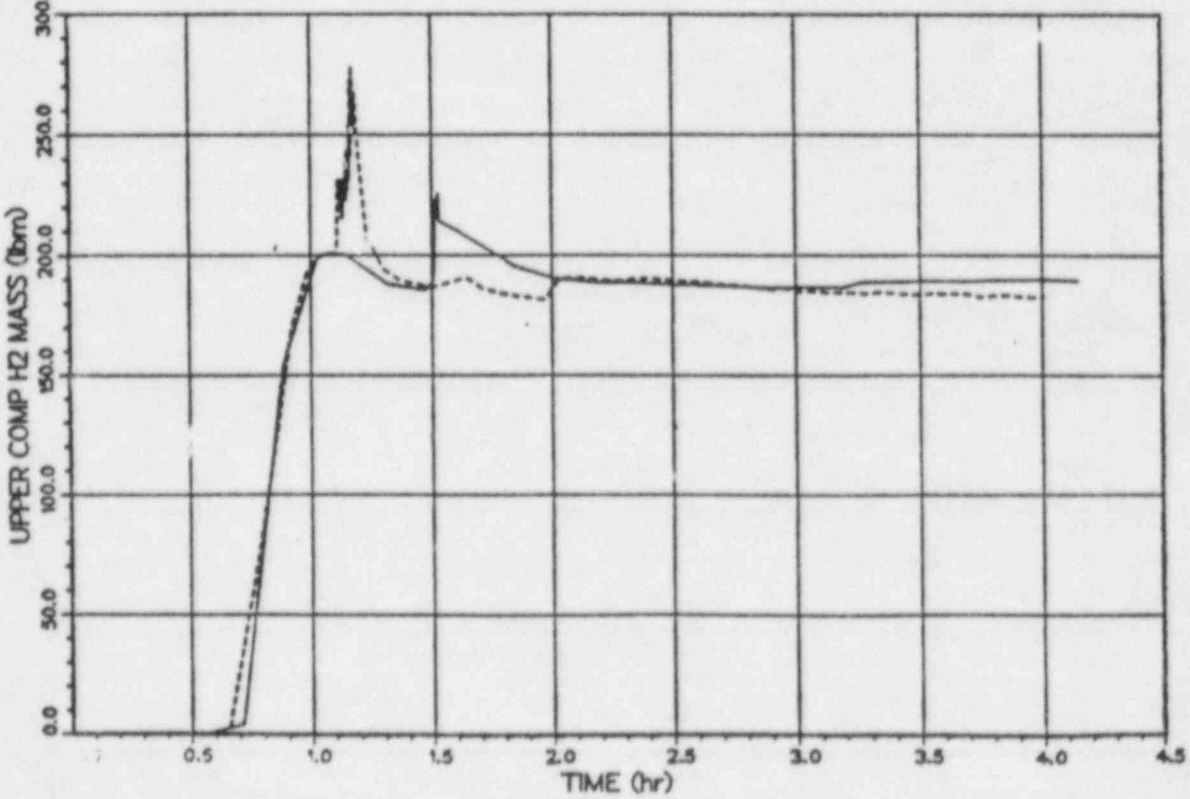


FIGURE 5.5-5

PRELIMINARY

C.0 Accident Signatures

Accident signatures are presented for each of the base cases analyzed in this report. These signatures are generated directly from the MAAP plot files using programs developed at TVA. Figures are arranged according to case number as described below. In all figures, the left axis is used in conjunction with the solid curve whereas the right axis, if present, is used with the dashed curve. An attempt has been made to group multiple plots on each plate to show transient interlationships between variables of interest. Cases are identified as described in the report body.

Case 1 —	S_2D	(U1MAAP)
Case 2 —	S_2H	(U2MAAP)
Case 3 --	S_2HF	(U3MAPP)*
	S_2HF	(U7MAAP)**
Case 4 --	TMLB'	(U4MAAP)
Case 5 --	$T_{23}ML$	(U5MAAP)
Case 6 --	AD	(U6MAAP)

*Drains open

**Drains blocked

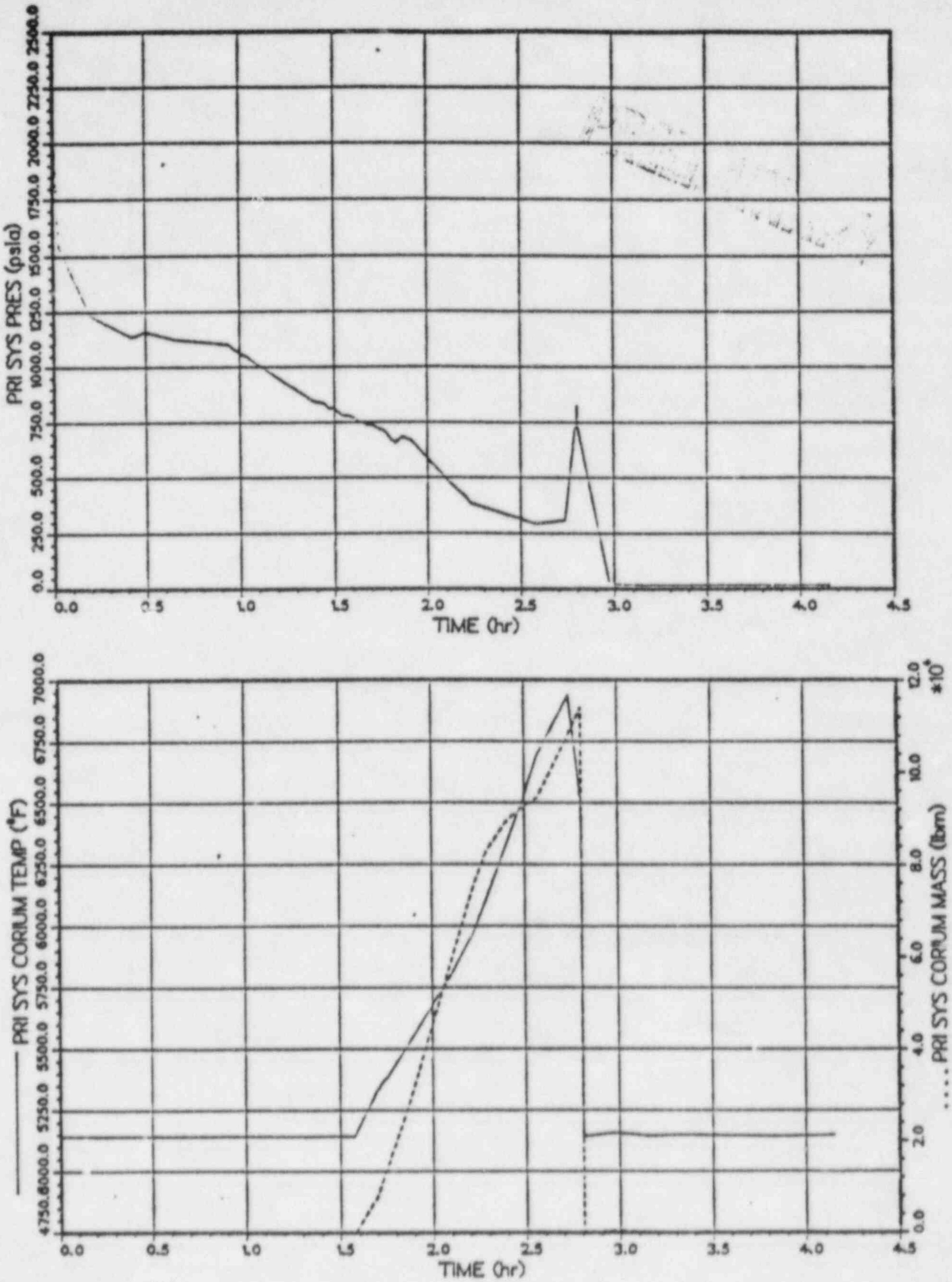
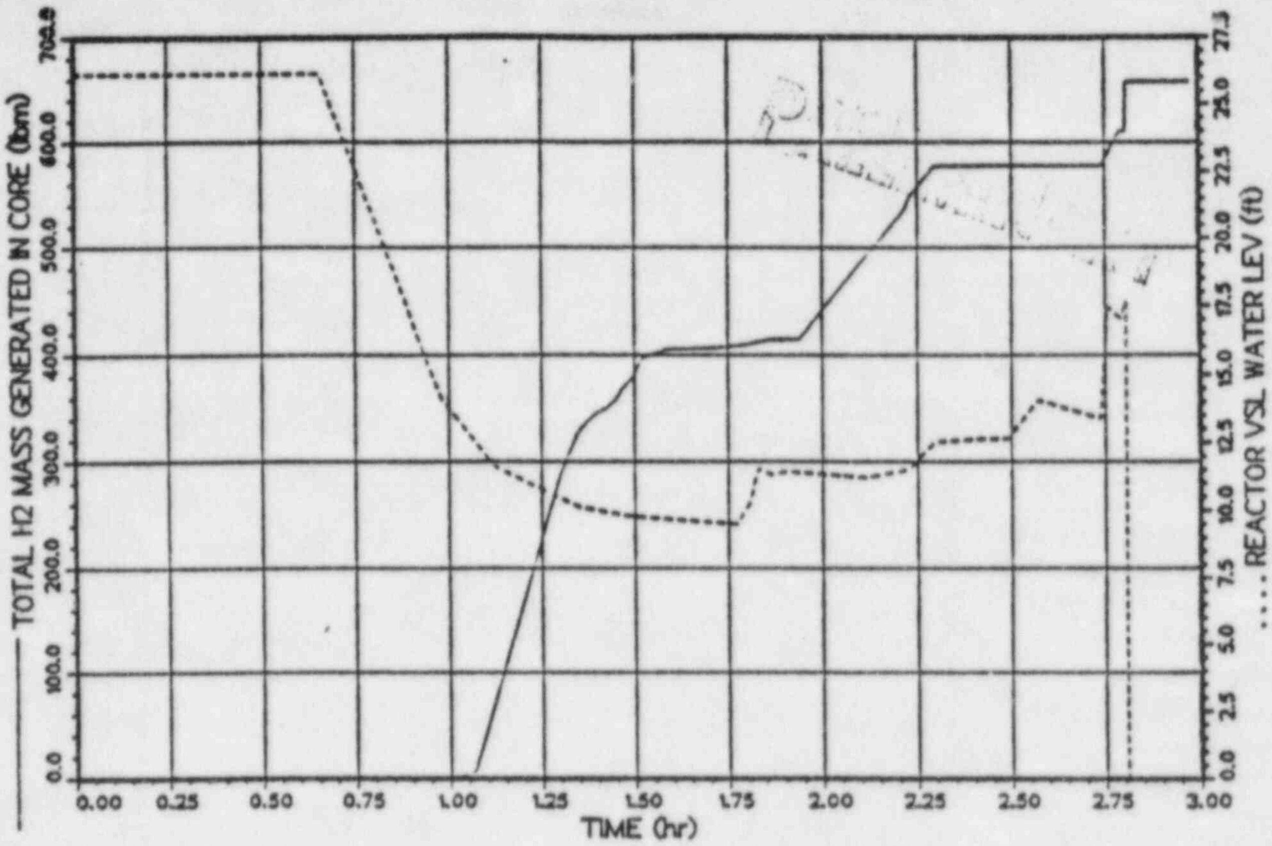

PRI SYS PRES (psia)
0.0
250.0
500.0
750.0
1000.0
1250.0
1500.0
1750.0
2000.0
2250.0
2500.0
TIME (hr)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
PRI SYS CORIUM TEMP (°F)
5250.0
5500.0
5750.0
6000.0
6250.0
6500.0
6750.0
7000.0
PRI SYS CORIUM MASS (lbm)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
TIME (hr)

Figure C.1-1


TOTAL H2 MASS GENERATED IN CORE (lbm)
REACTOR VSL WATER LEV (ft)
TIME (hr)

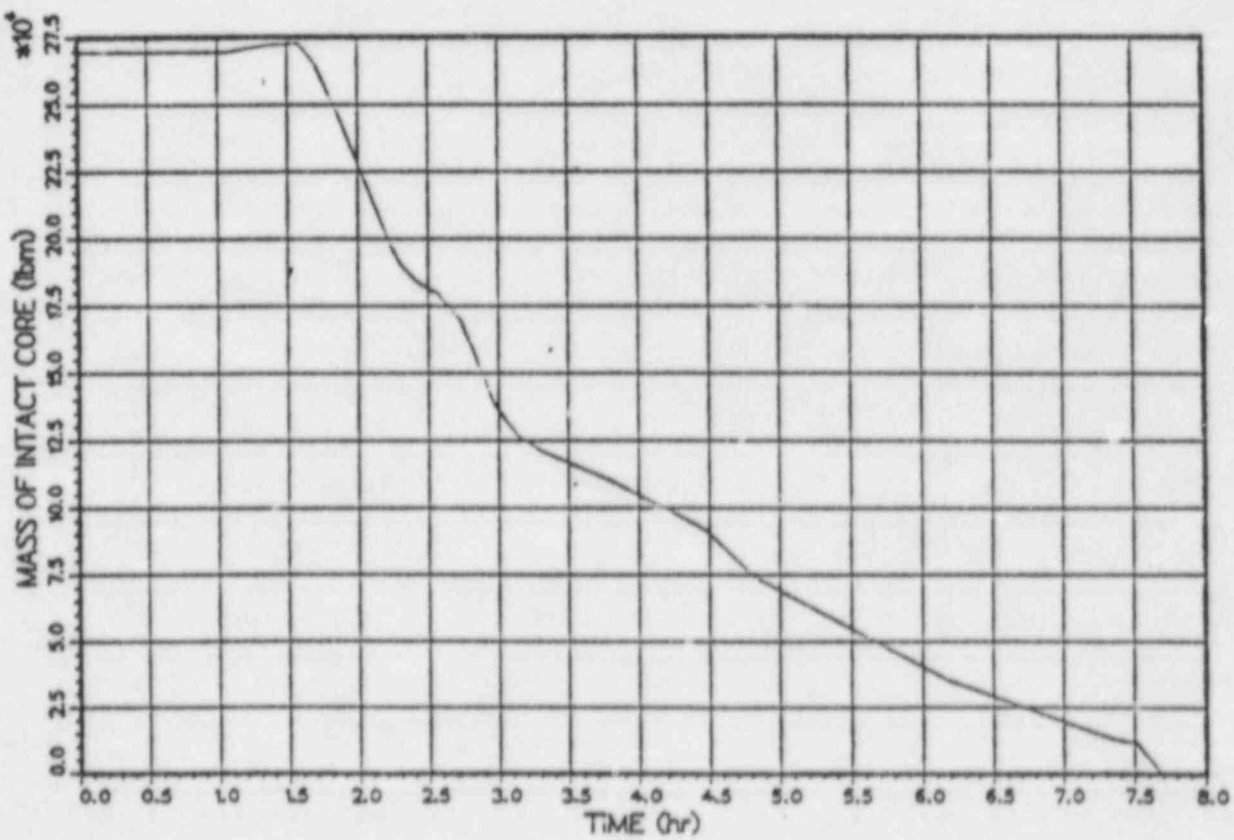

MASS OF INTACT CORE (lbm)
x10^4
TIME (hr)

Figure C.1-2

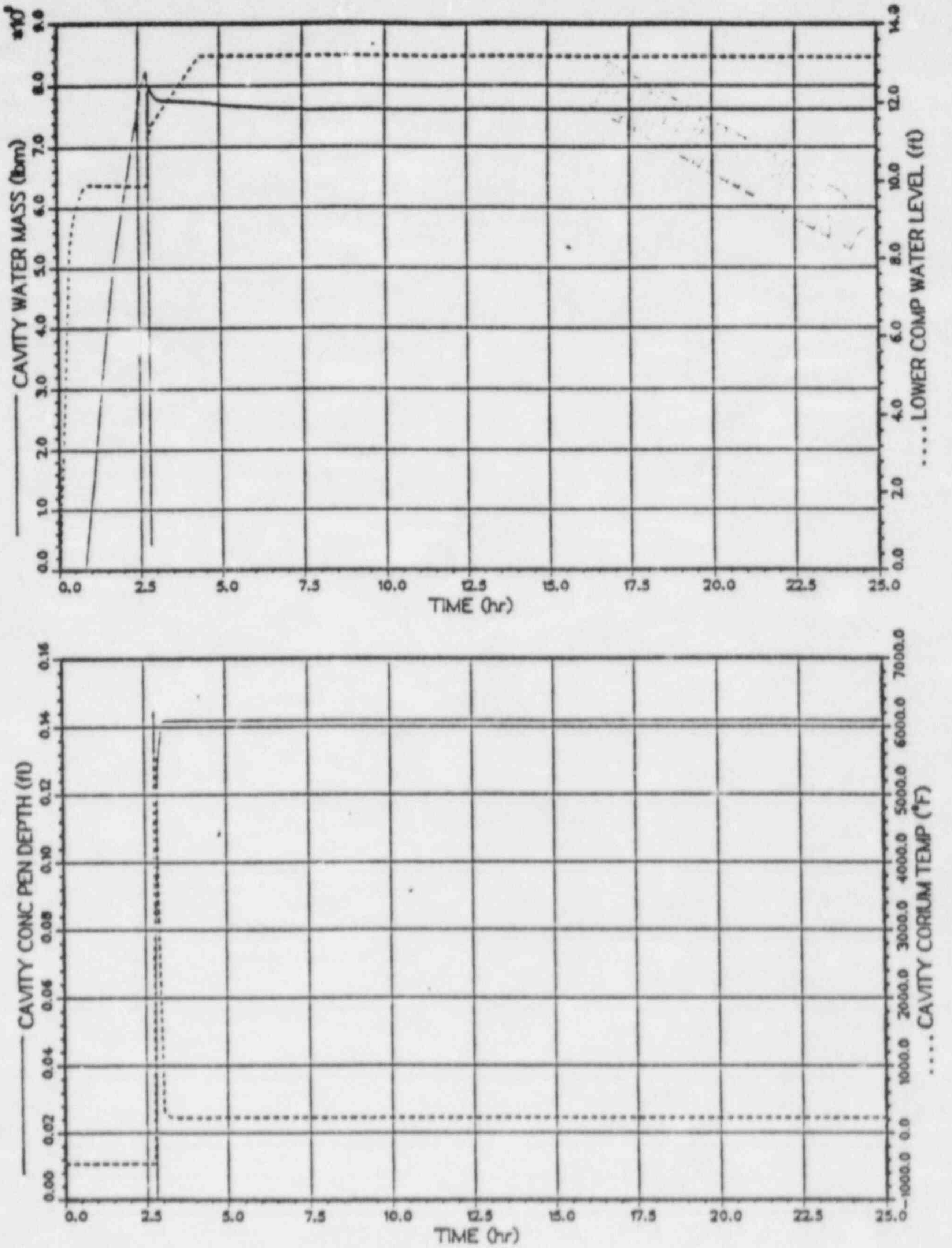
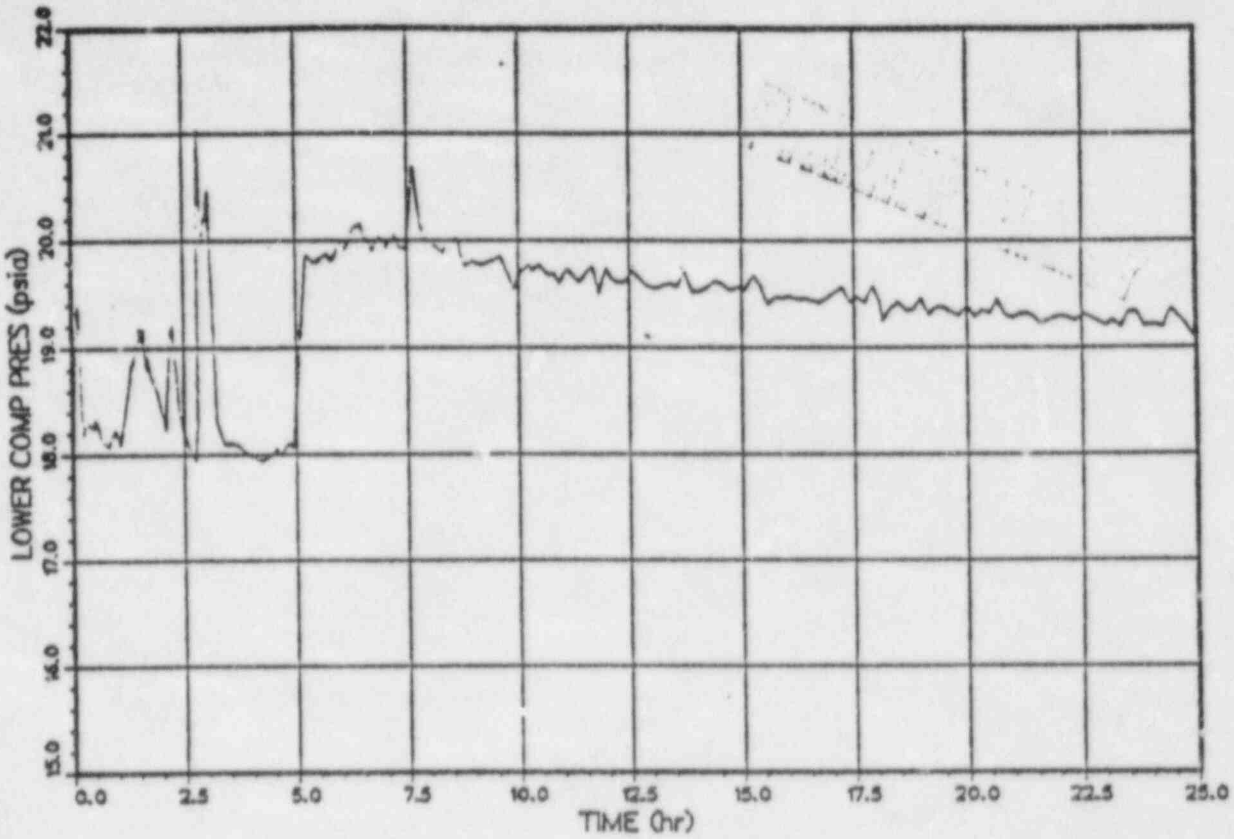

CAVITY WATER MASS (lbm)
x10^3
LOWER COMP WATER LEVEL (ft)
TIME (hr)
CAVITY CONC PEN DEPTH (ft)
CAVITY CORIUM TEMP (°F)
TIME (hr)

Figure C.1-3


LOWER COMP PRES (psia)
TIME (hr)
22.0
21.0
20.0
19.0
18.0
17.0
16.0
15.0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0

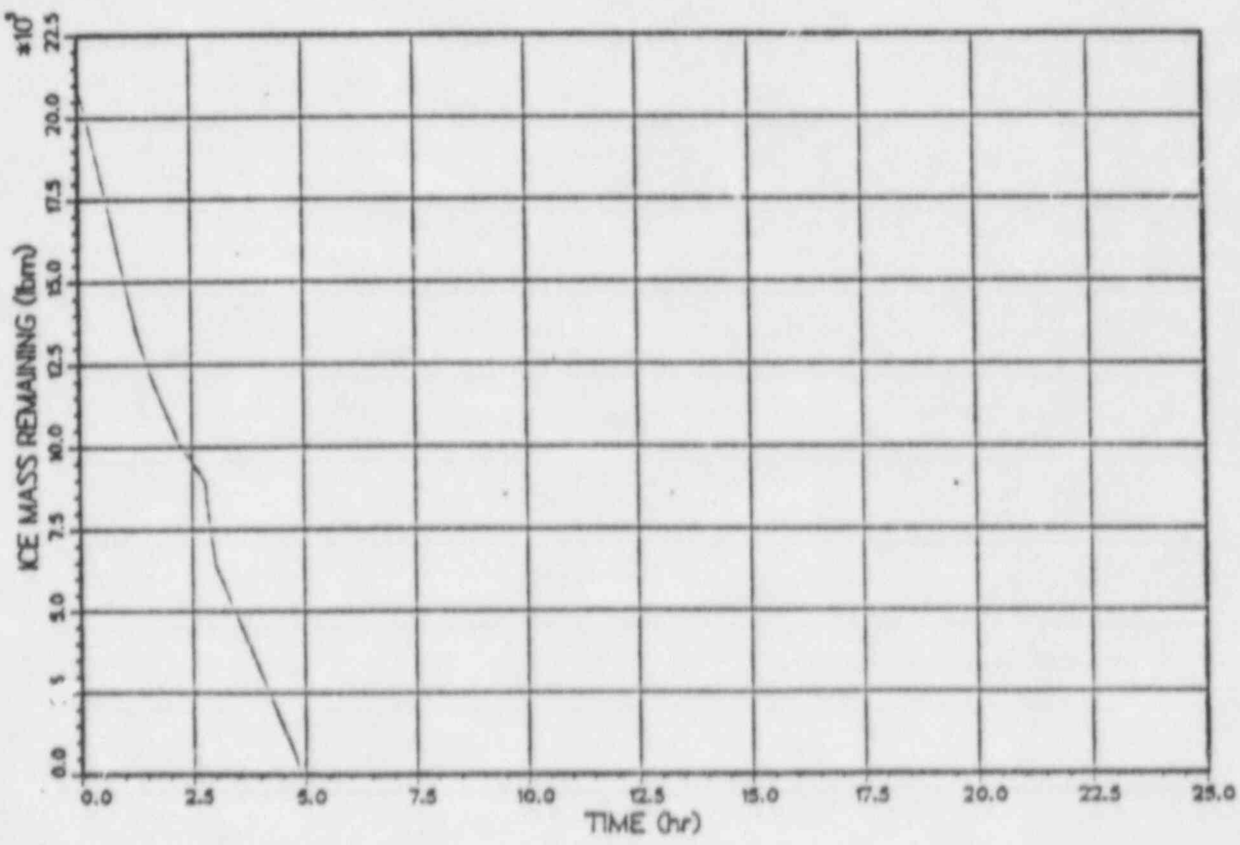

ICE MASS REMAINING (lbm)
TIME (hr)
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
0.0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0

Figure C.1-4

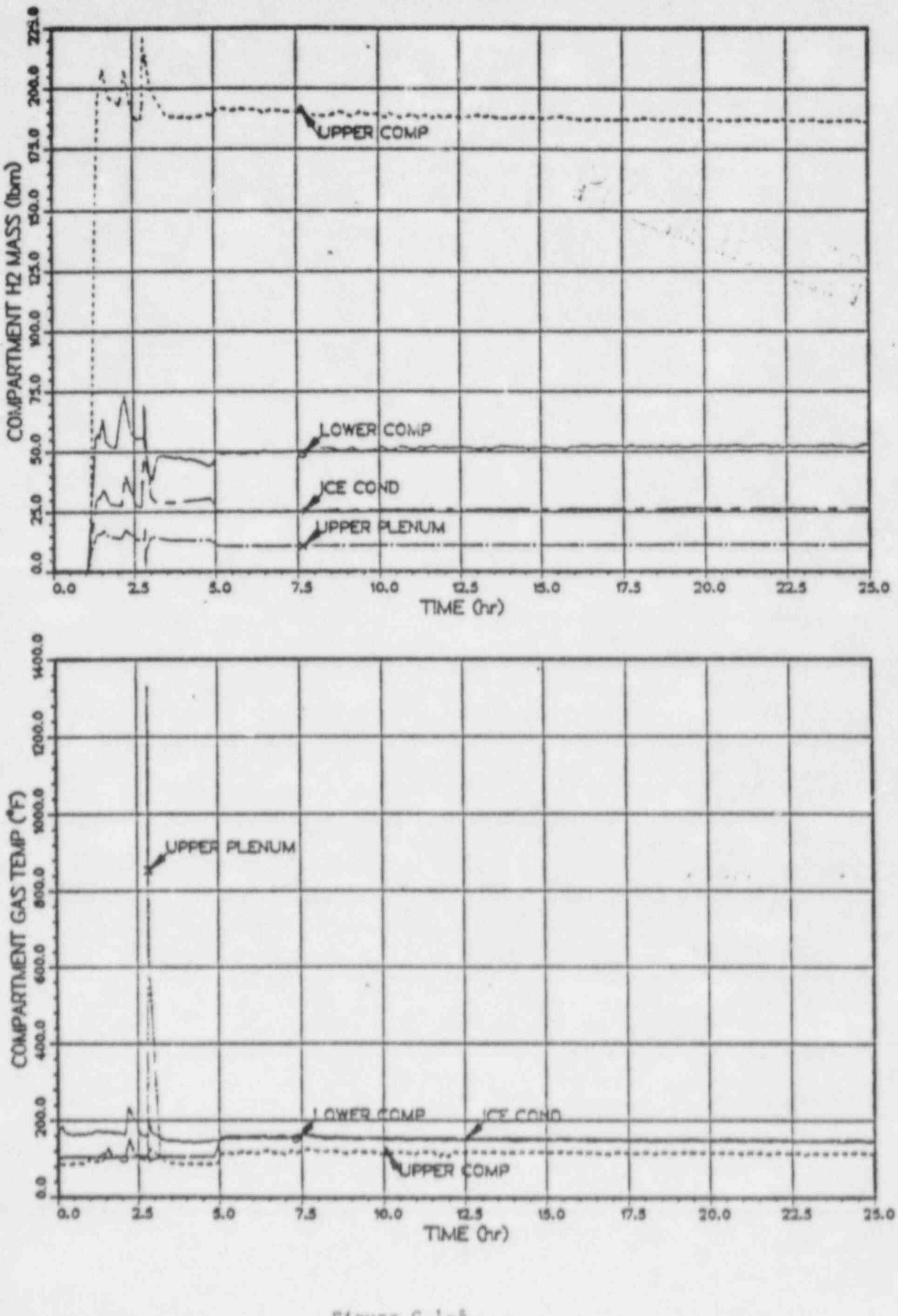

COMPARTMENT H2 MASS (lbm)
UPPER COMP
LOWER COMP
ICE COND
UPPER PLENUM
TIME (hr)
COMPARTMENT GAS TEMP (°F)
UPPER PLENUM
LOWER COMP
ICE COND
UPPER COMP
TIME (hr)

Figure C.1-5

S2H U2MAAP

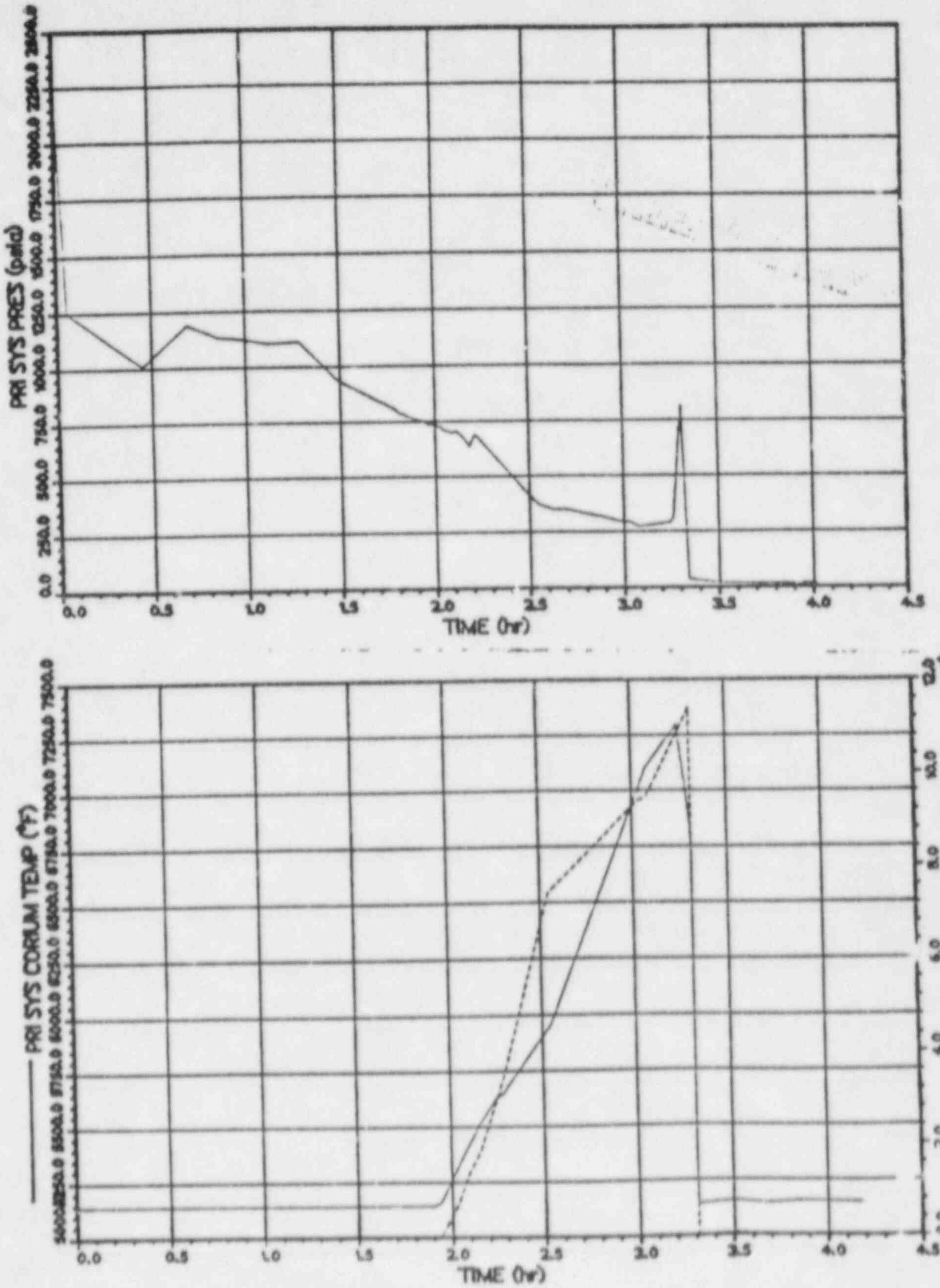
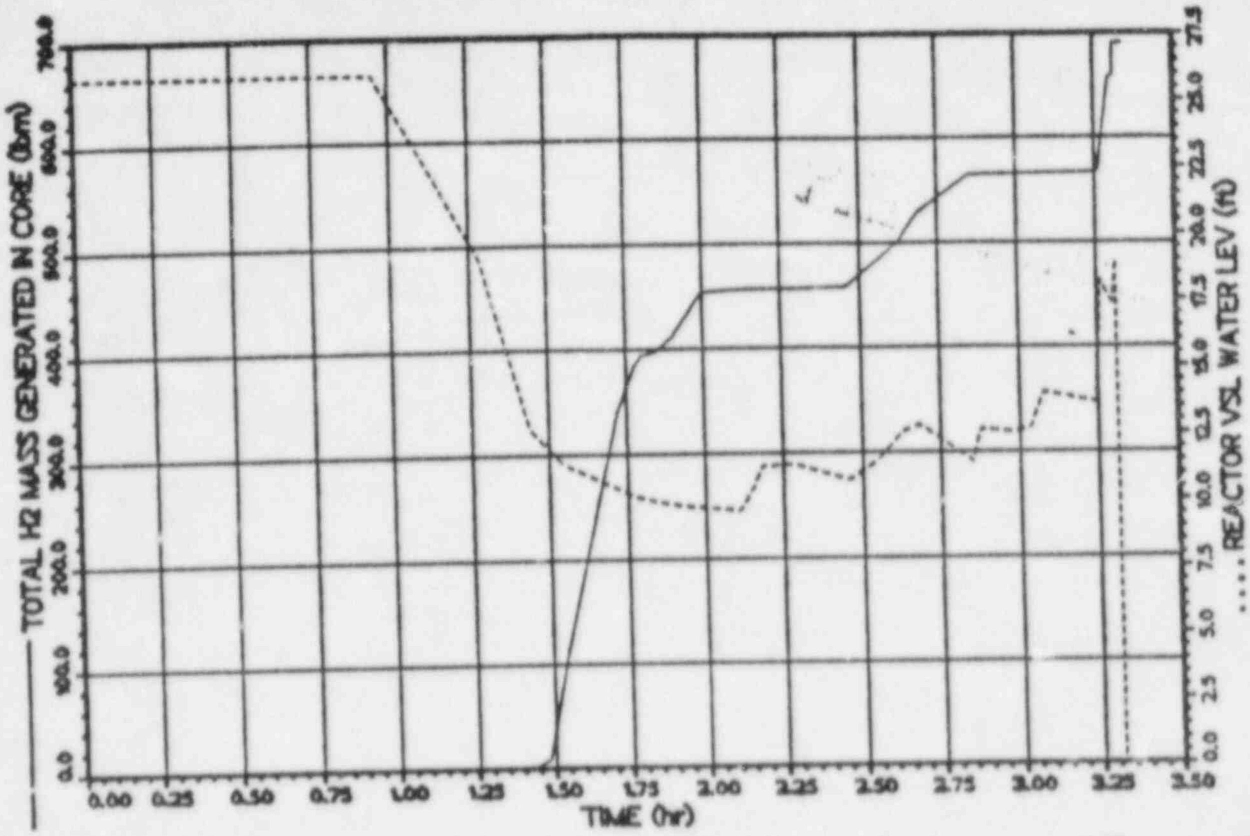


Figure C.2-1


TOTAL H2 MASS GENERATED IN CORE (lbm)
REACTOR VSL WATER LEV (ft)
TIME (hr)
0.0
100.0
200.0
300.0
400.0
500.0
600.0
700.0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
3.25
3.50

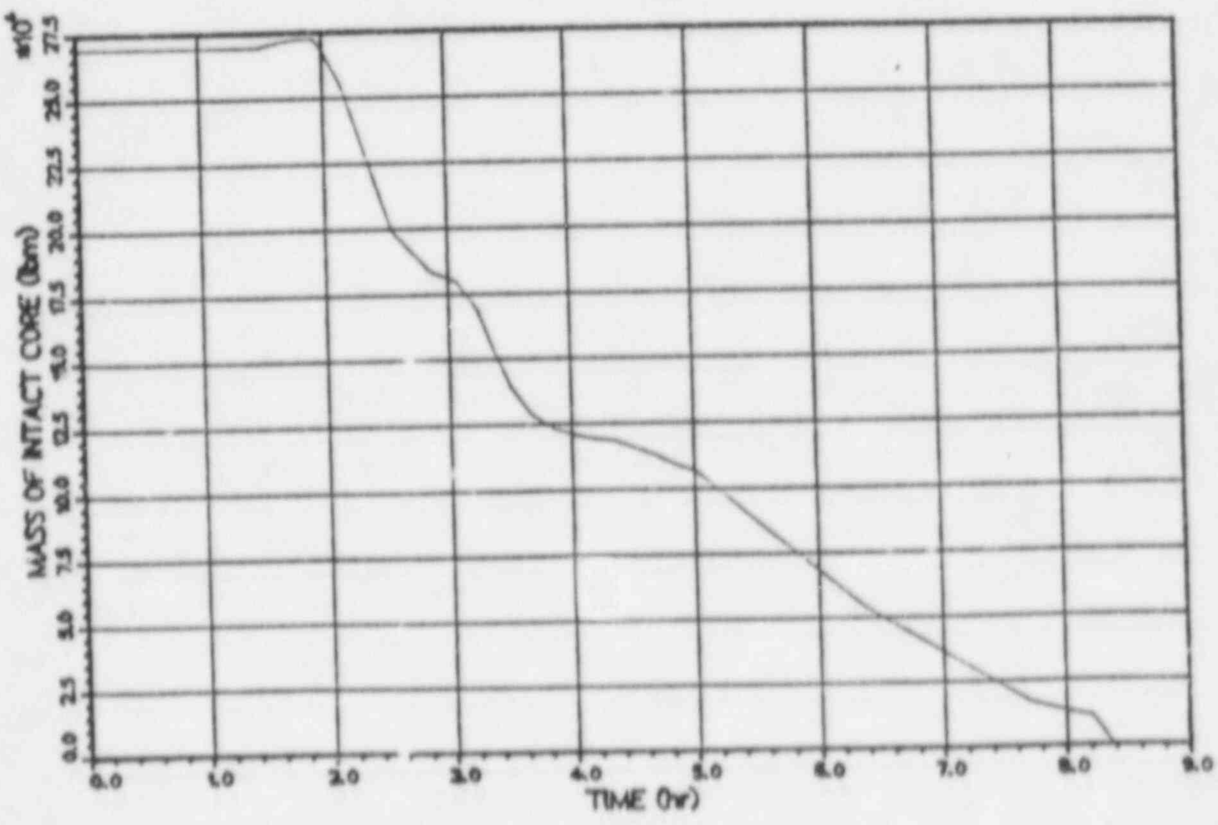
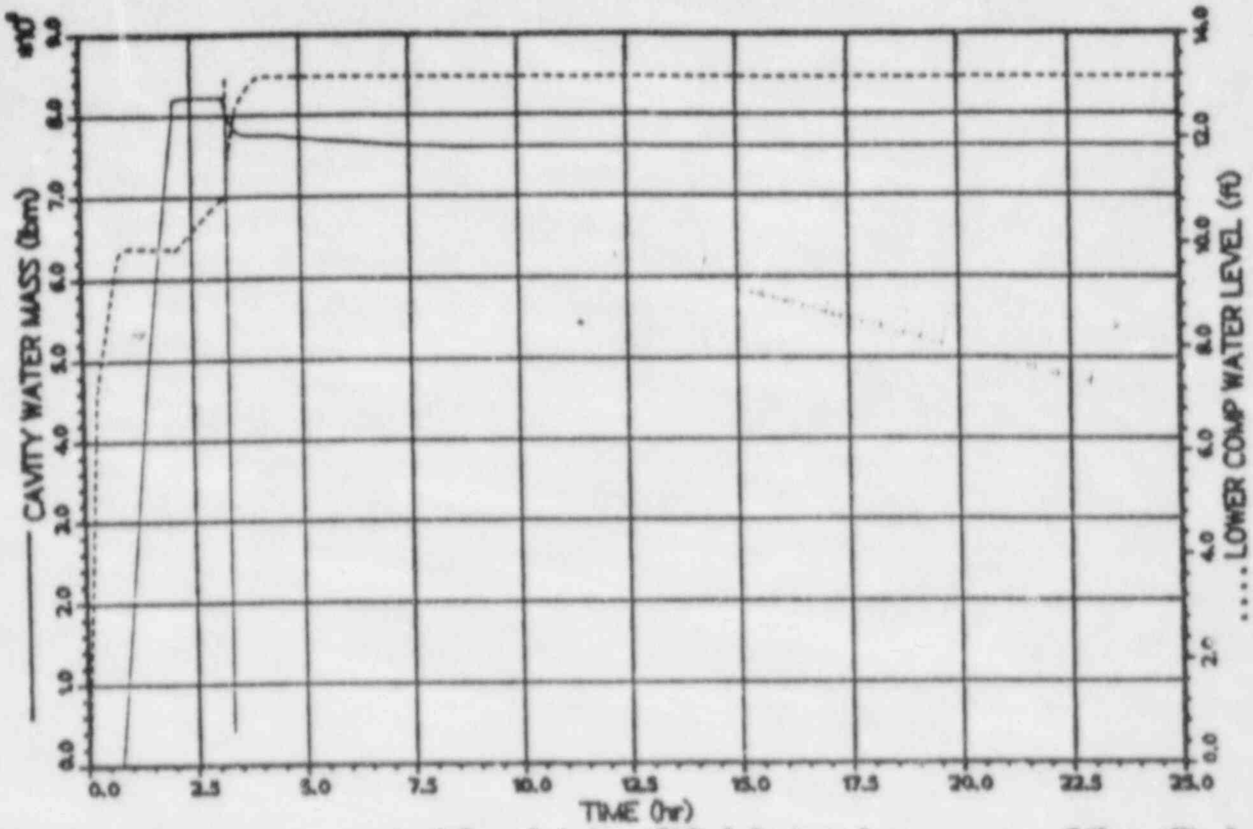

MASS OF INTACT CORE (lbm)
x10⁴
TIME (hr)
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0

Figure C.2-2

S2H U2MAAP



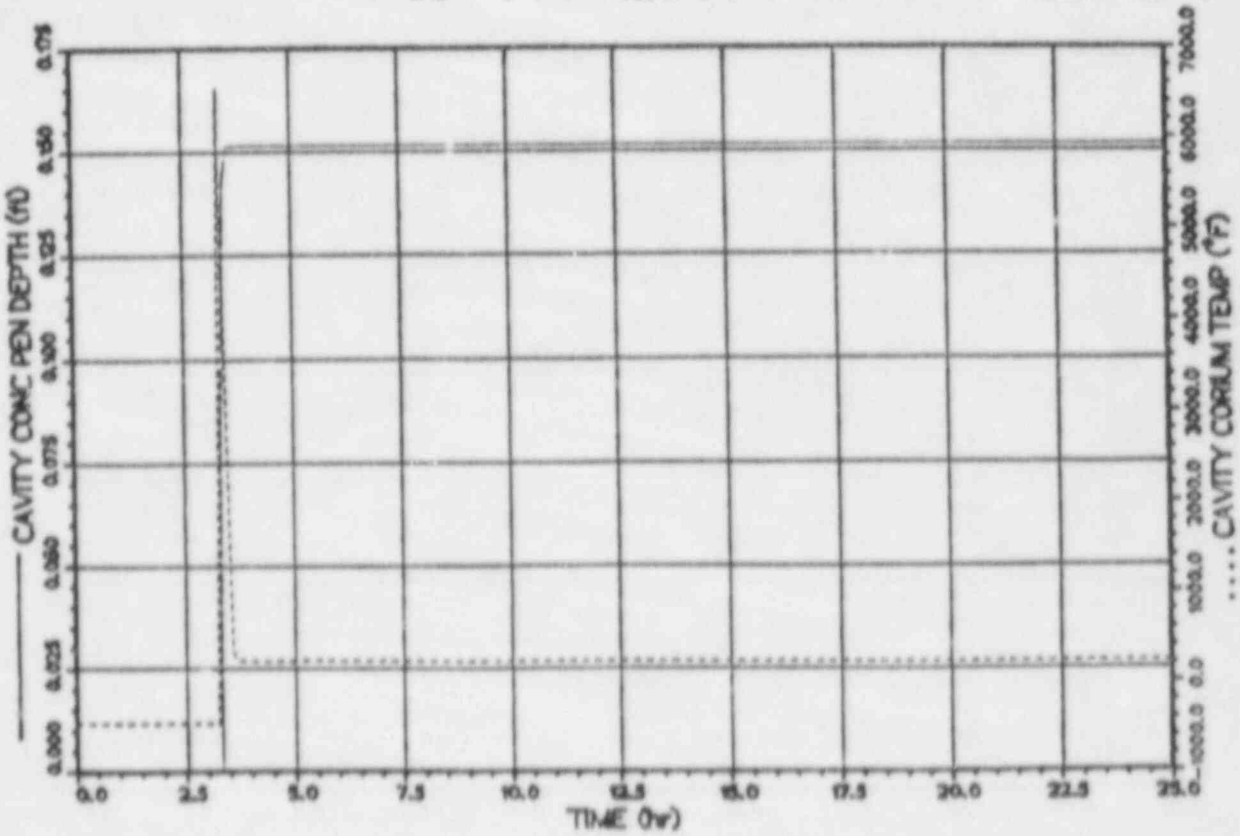
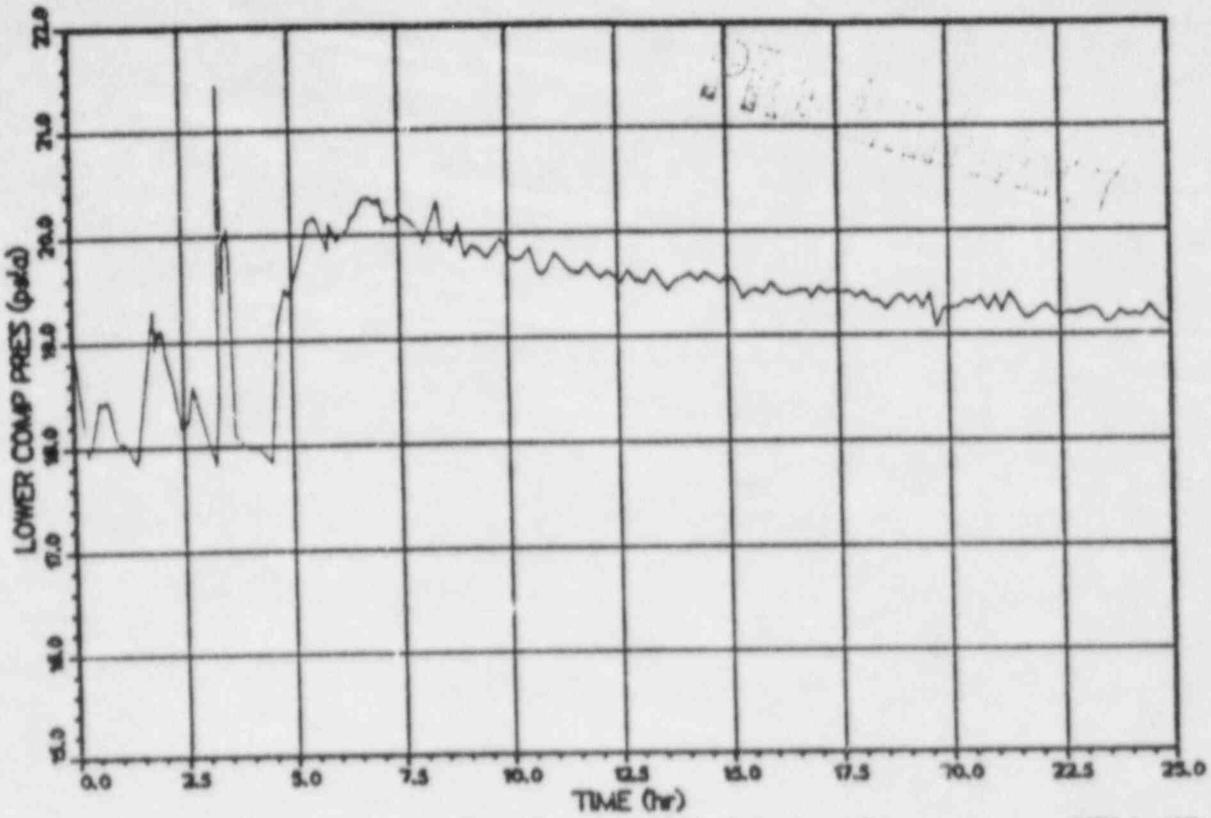


Figure C.2-3


LOWER COMP PRES (psia)
22.0
21.0
20.0
19.0
18.0
17.0
16.0
15.0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
TIME (hr)

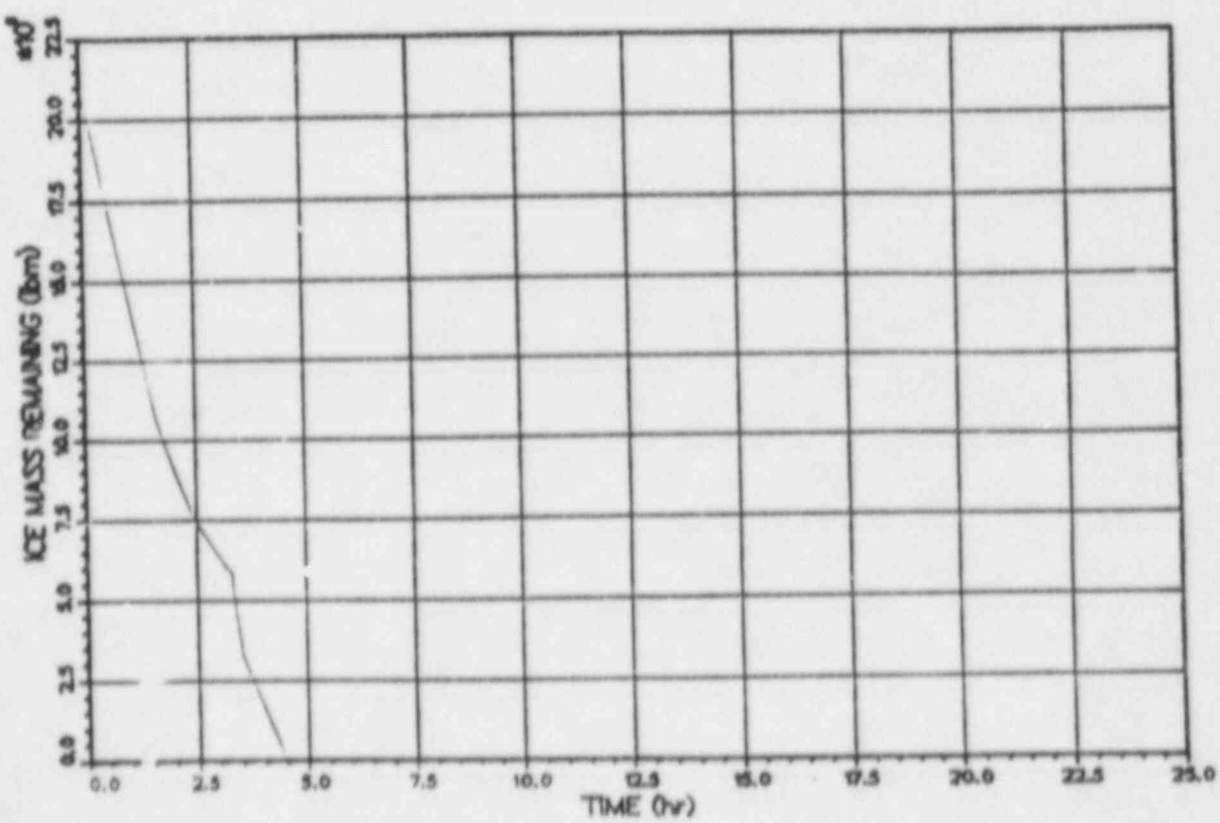

x10³
ICE MASS REMAINING (lbm)
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
TIME (hr)

Figure C.2-4

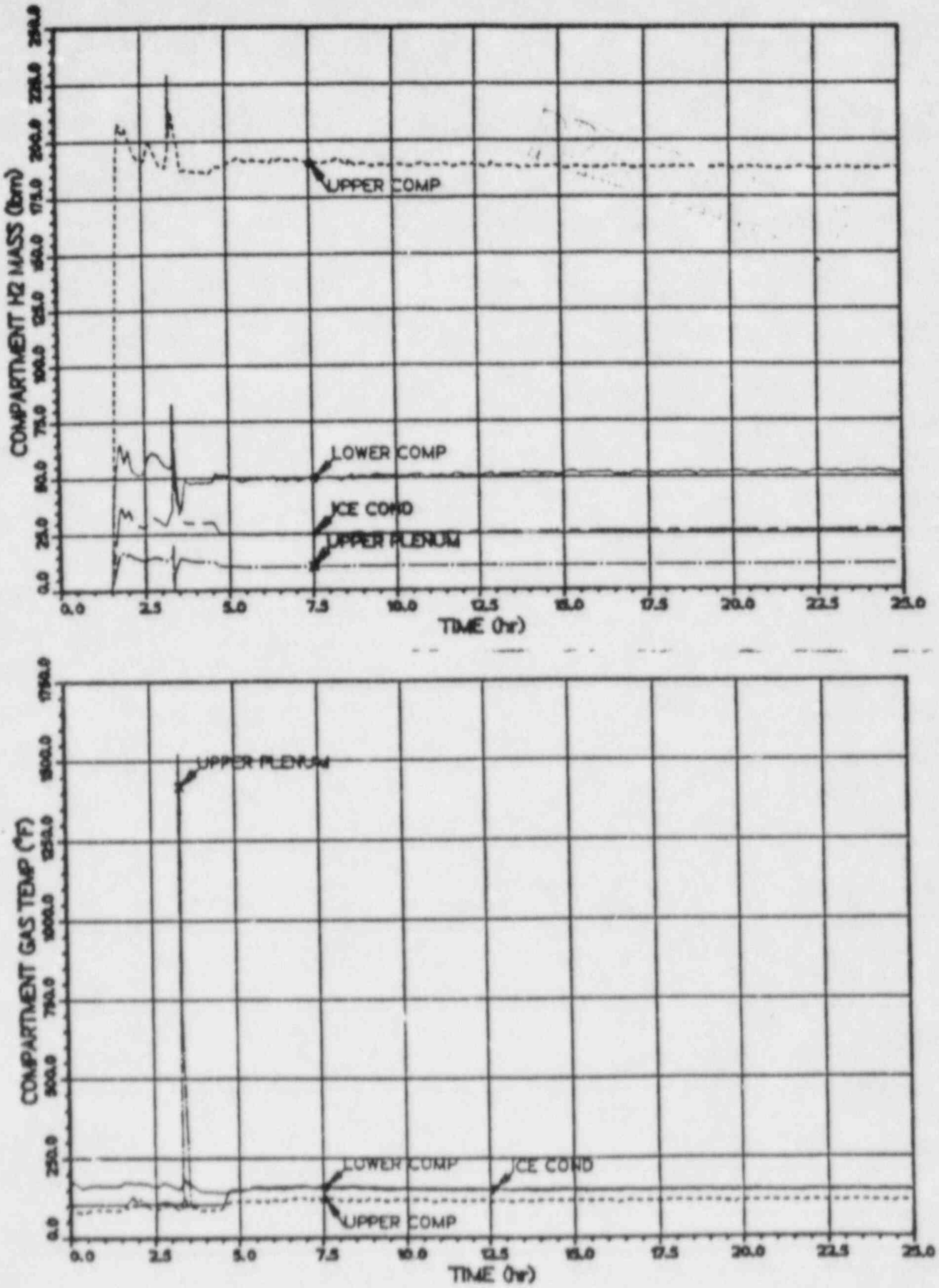

COMPARTMENT H2 MASS (lbm)
250.0
225.0
200.0
175.0
150.0
125.0
100.0
75.0
50.0
25.0
0.0
UPPER COMP
LOWER COMP
ICE COND
UPPER PLENUM
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
TIME (hr)
COMPARTMENT GAS TEMP (°F)
1750.0
1500.0
1250.0
1000.0
750.0
500.0
250.0
0.0
UPPER PLENUM
LOWER COMP
ICE COND
UPPER COMP
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
TIME (hr)

Figure C.2-5

S2HF U3MAAP (DRAIN OPEN)

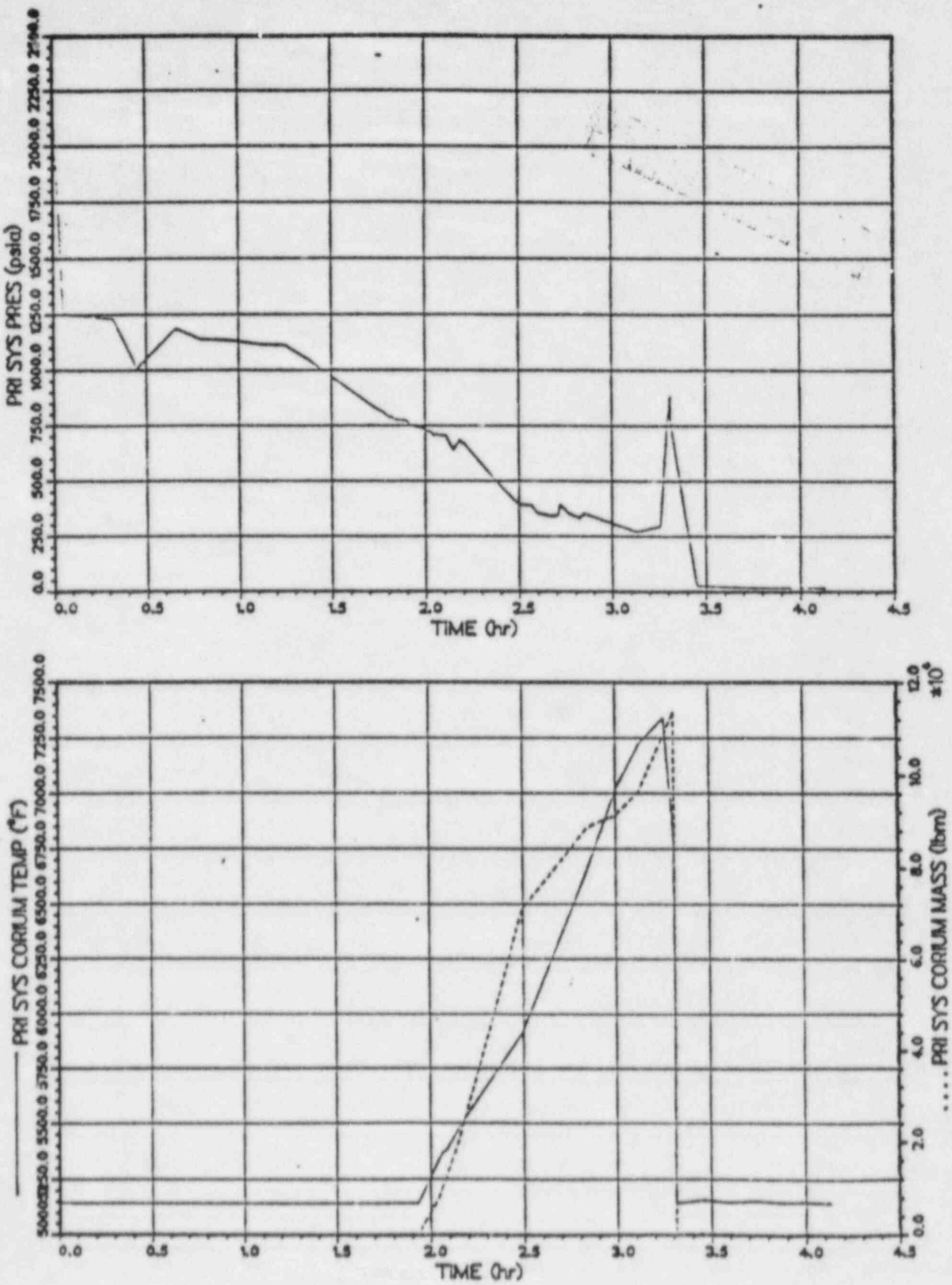


Figure C.3-1

S2HF USMAAP (DRAIN OPEN)

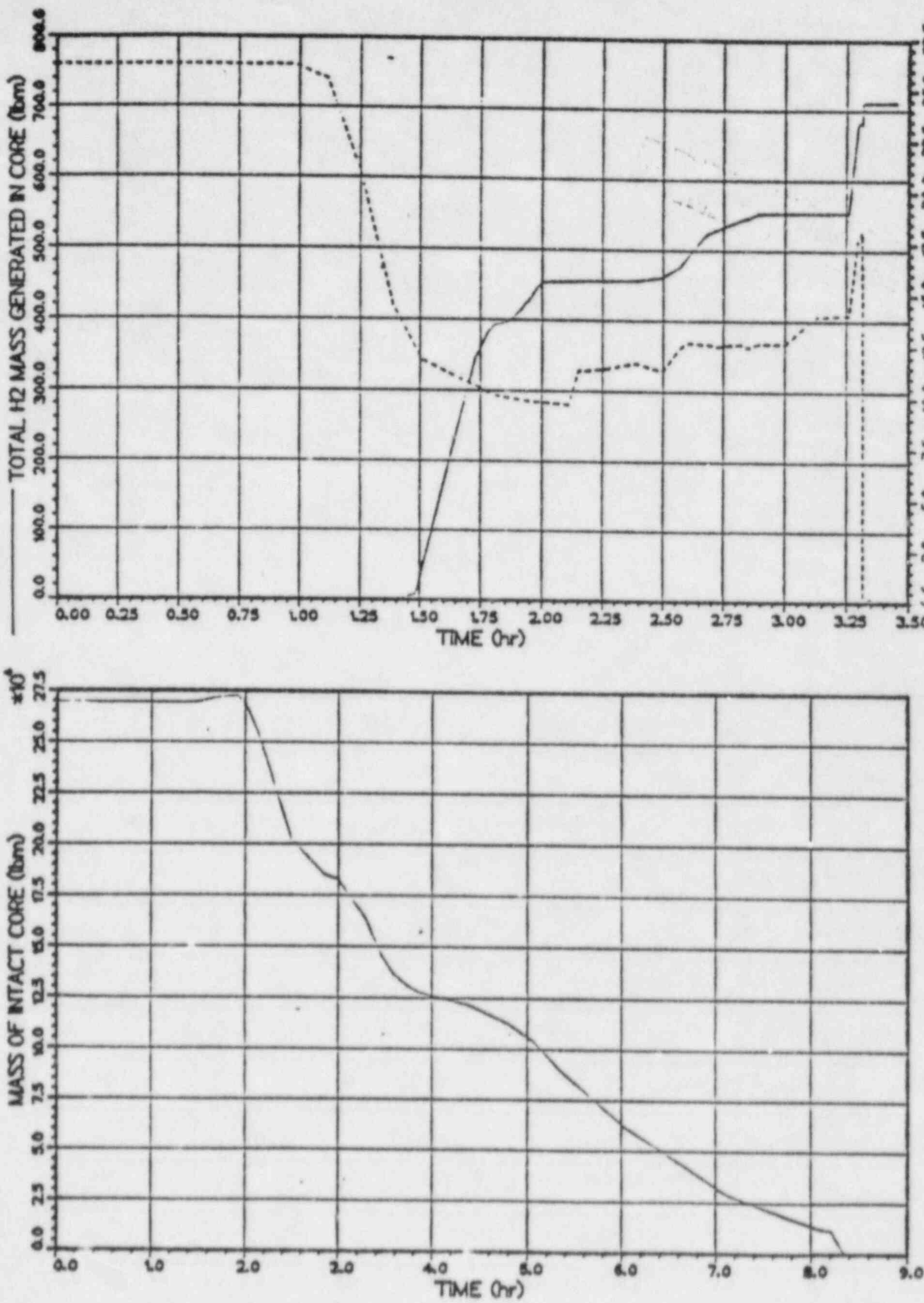


Figure C.3-2

S2HF U3MAAP (DRAIN OPEN)

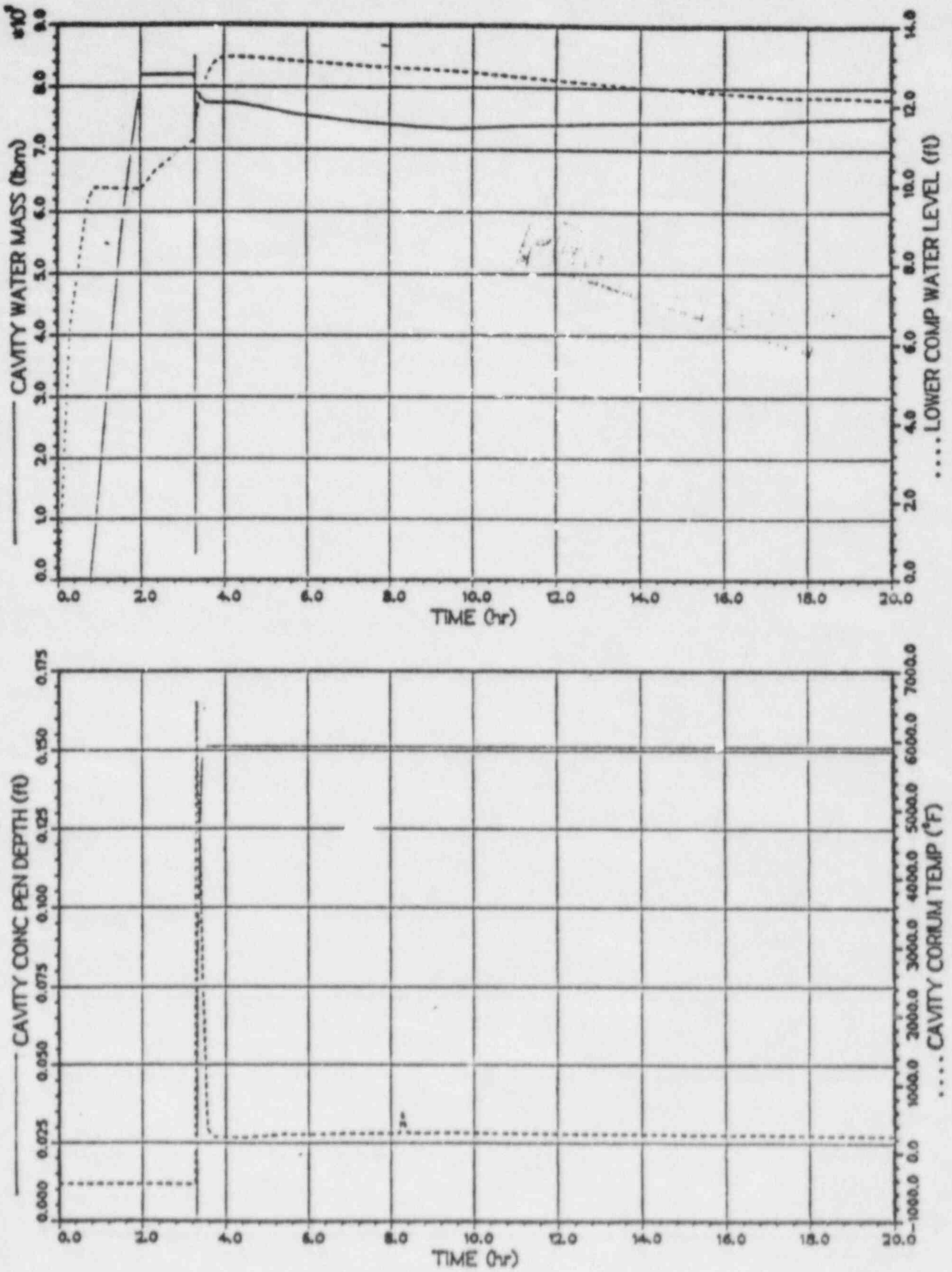
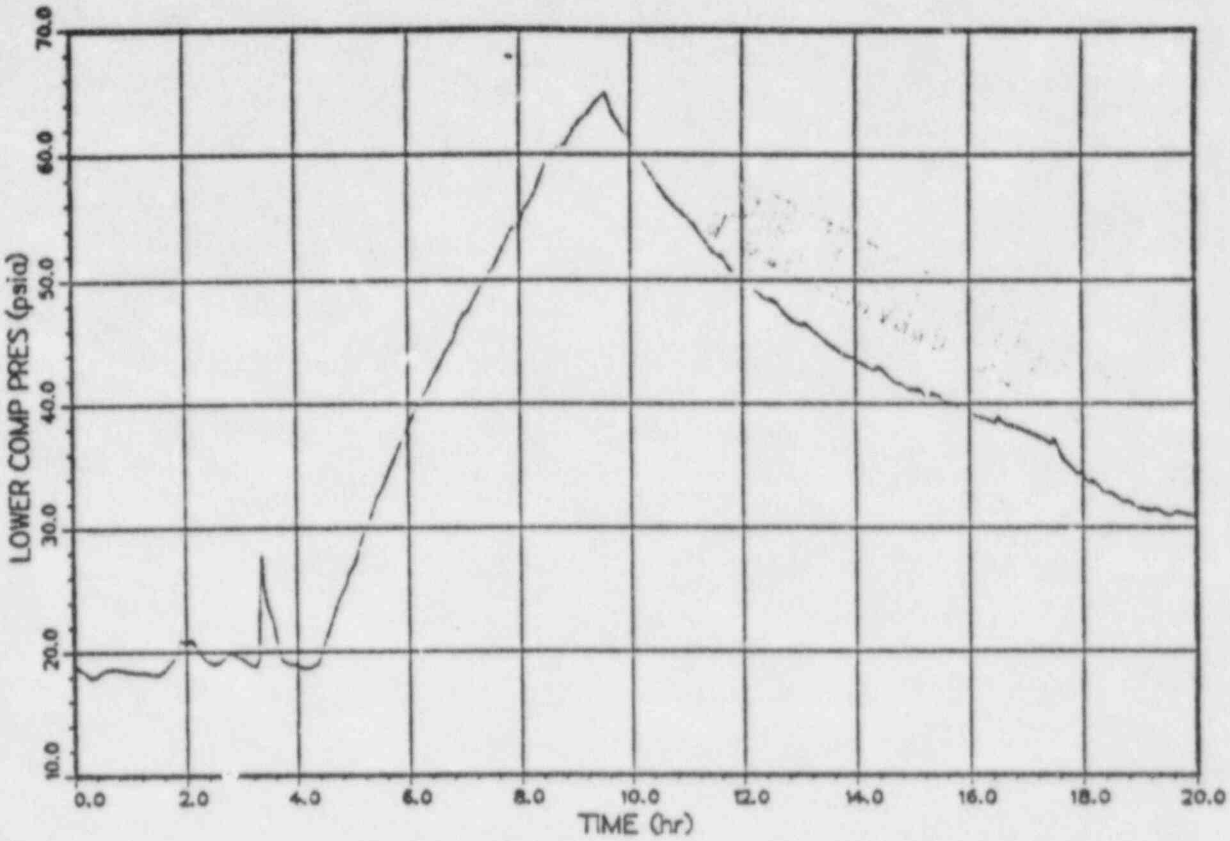


Figure C.3-3

S2HP USMAAP (DRAIN OPEN)



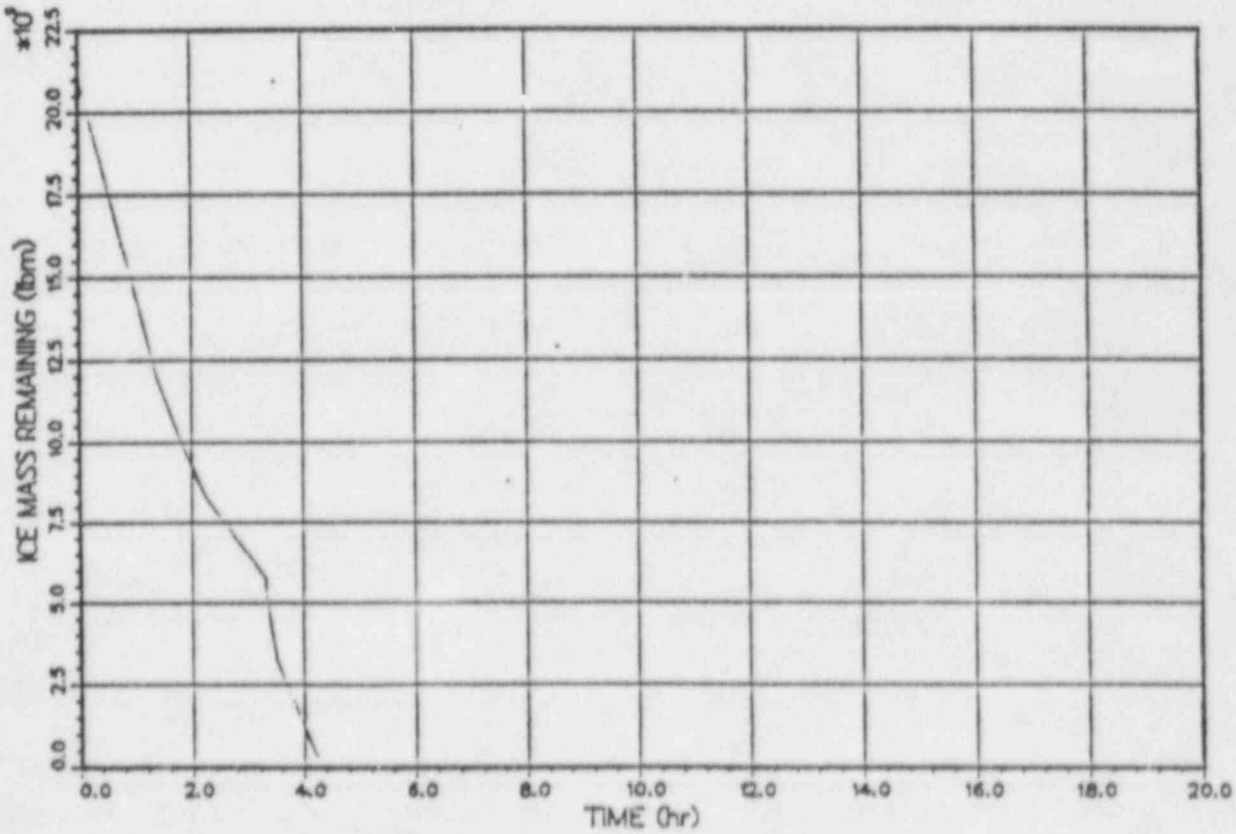


Figure C.3-4

S2HF U3MAAP (DRAIN OPEN)

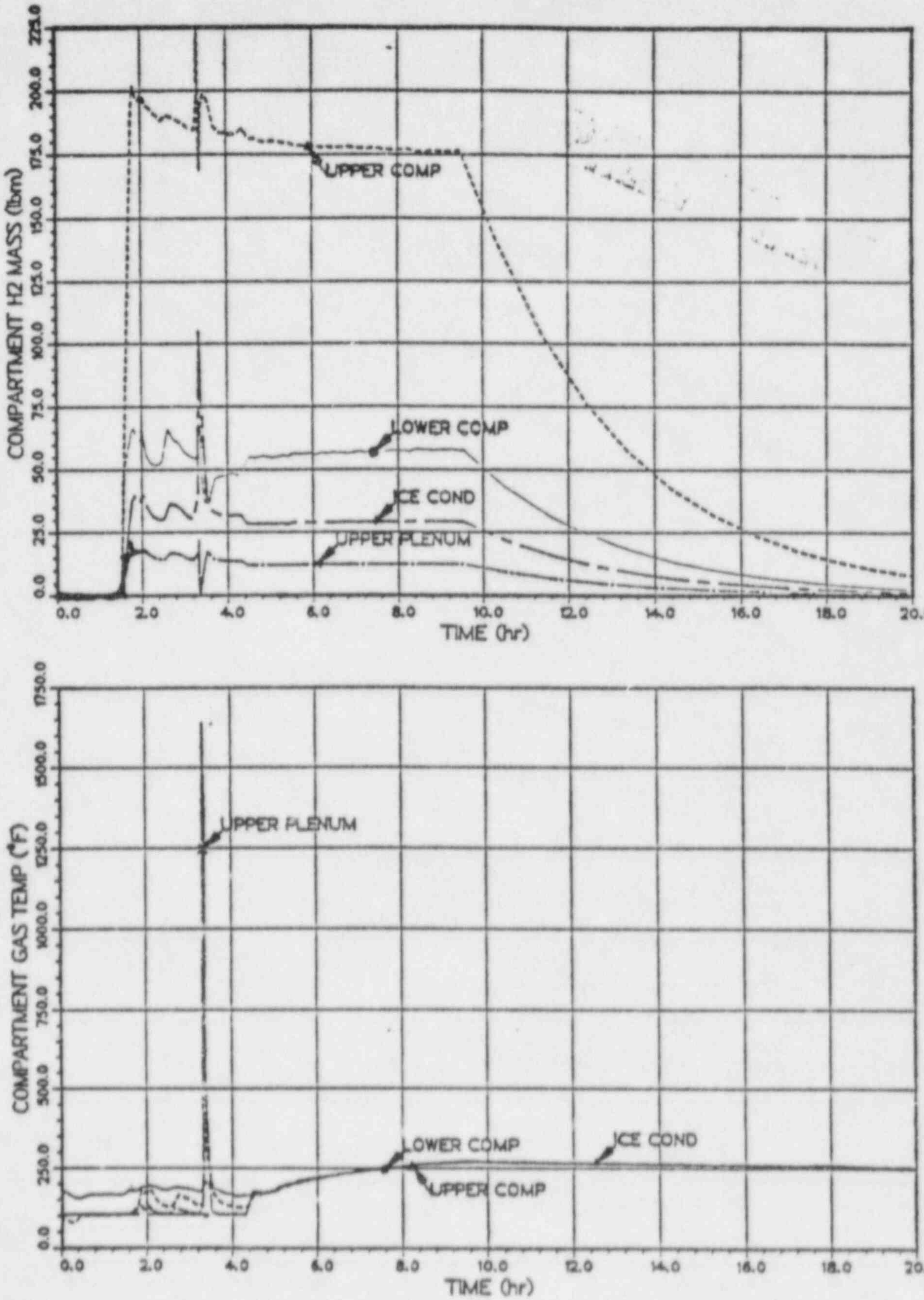
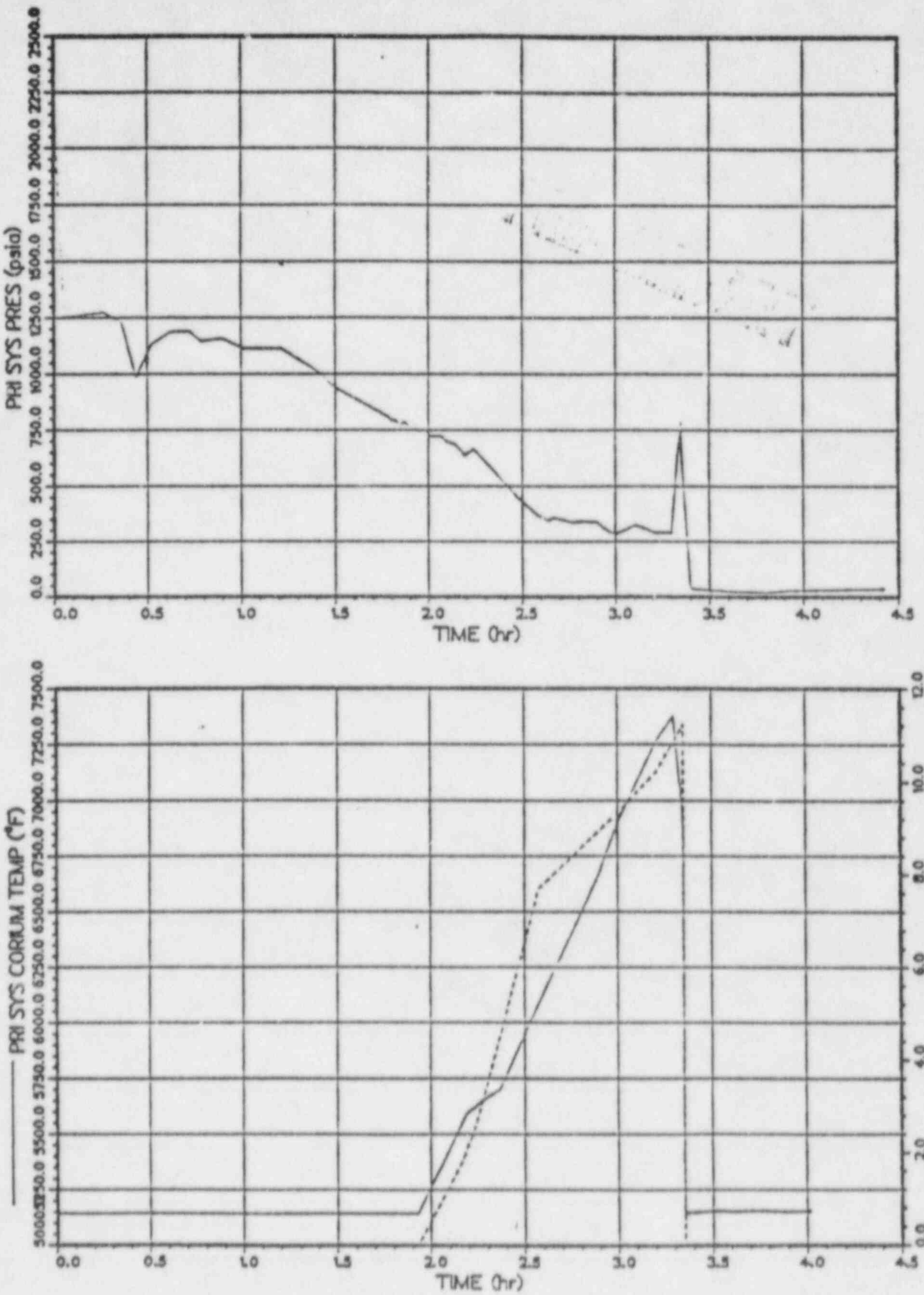


Figure C.3-5



PRI SYS PRES (psia)
0.0
250.0
500.0
750.0
1000.0
1250.0
1500.0
1750.0
2000.0
2250.0
2500.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
TIME (hr)
PRI SYS CORIUM TEMP (°F)
5000.0
5250.0
5500.0
5750.0
6000.0
6250.0
6500.0
6750.0
7000.0
7250.0
7500.0
PRI SYS CORIUM MASS (lbm)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
$\times 10^4$
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
TIME (hr)

Figure C.3-6

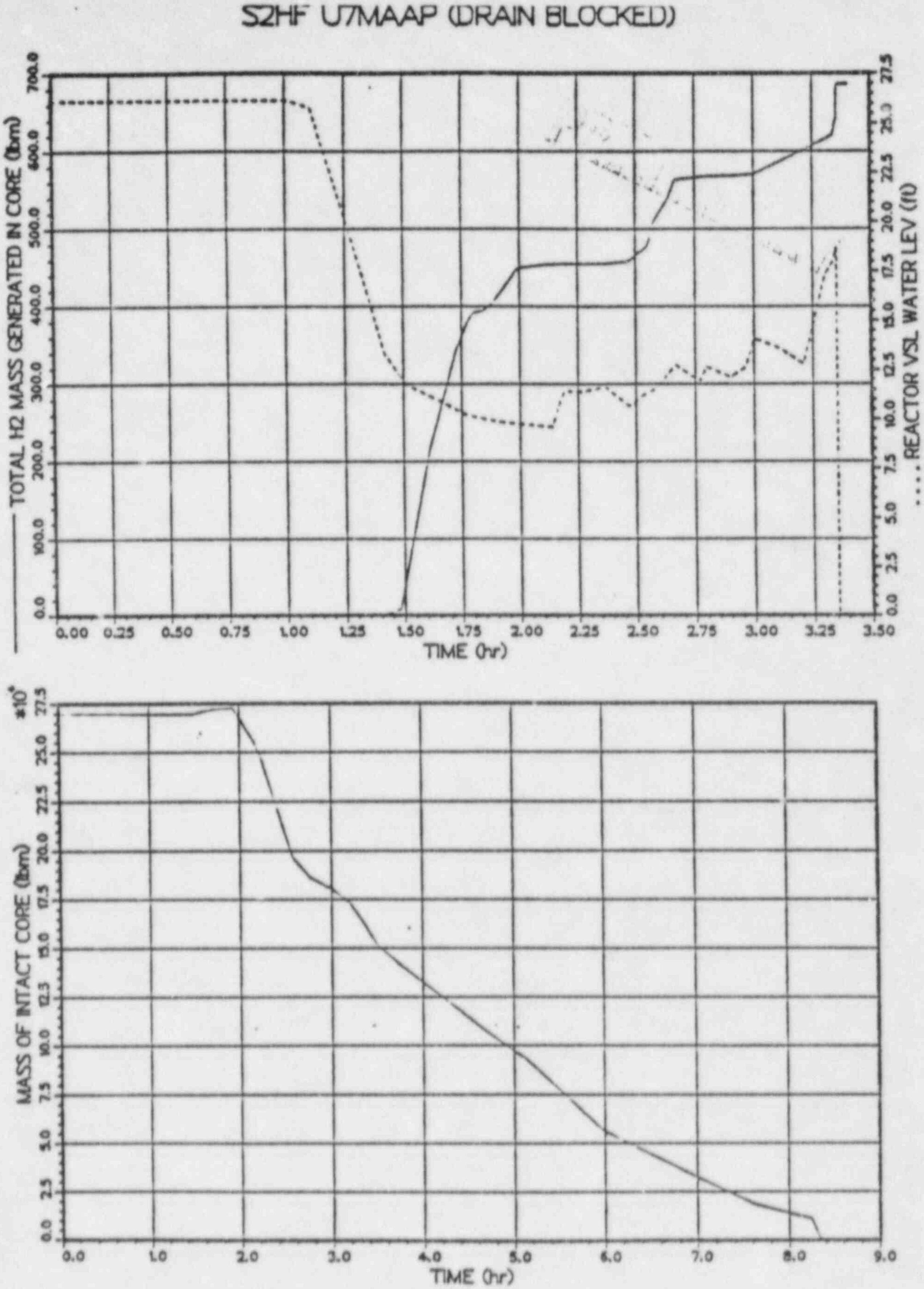

S2HF U7MAAP (DRAIN BLOCKED)
TOTAL H2 MASS GENERATED IN CORE (lbm)
REACTOR VSL WATER LEV (ft)
TIME (hr)
MASS OF INTACT CORE (lbm)
TIME (hr)

Figure C.3-7

S2HF U/MAAP (DRAIN BLOCKED)

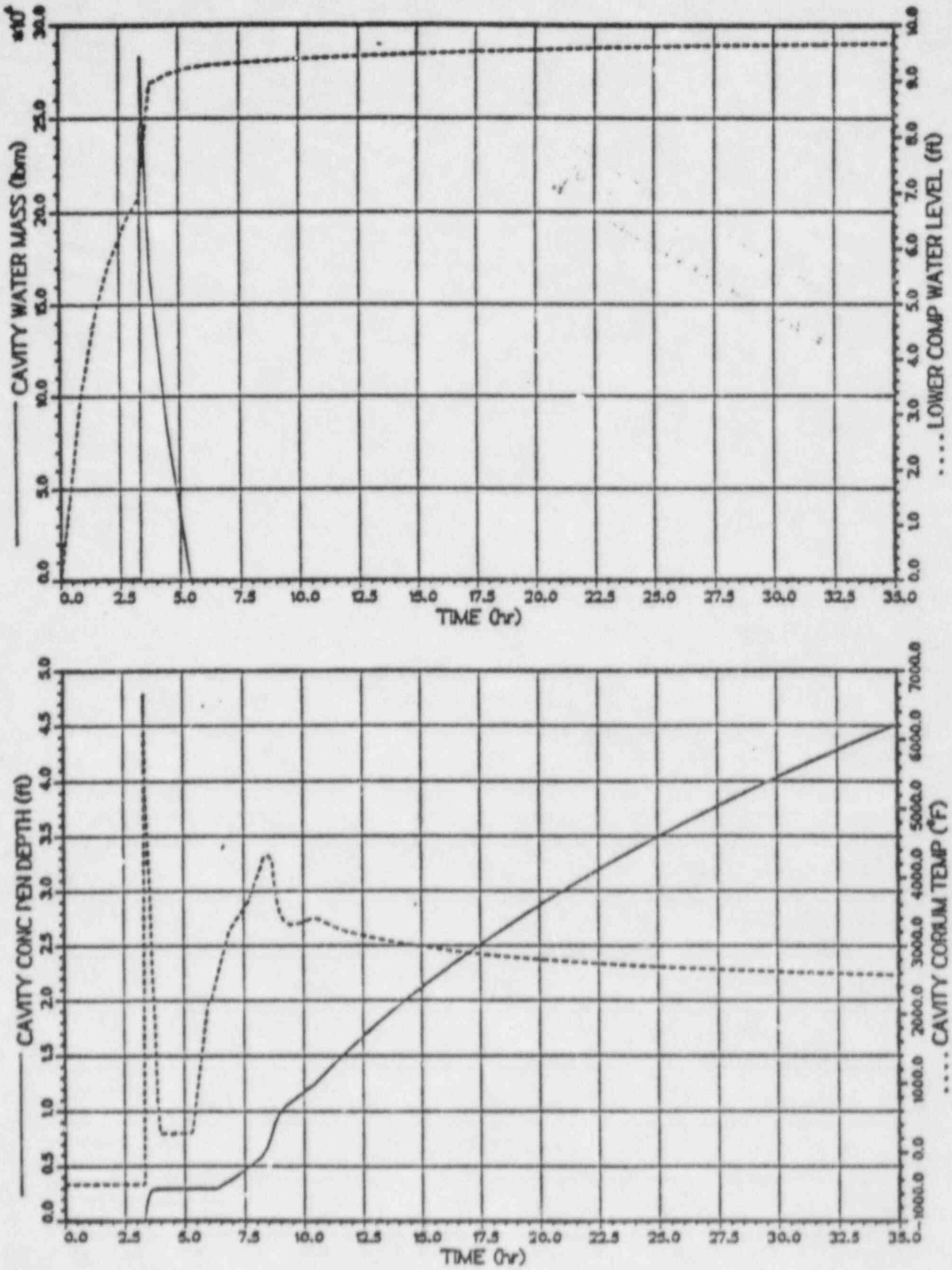


Figure C.3-8

S2HF U7/MAAP (DRAIN BLOCKED)

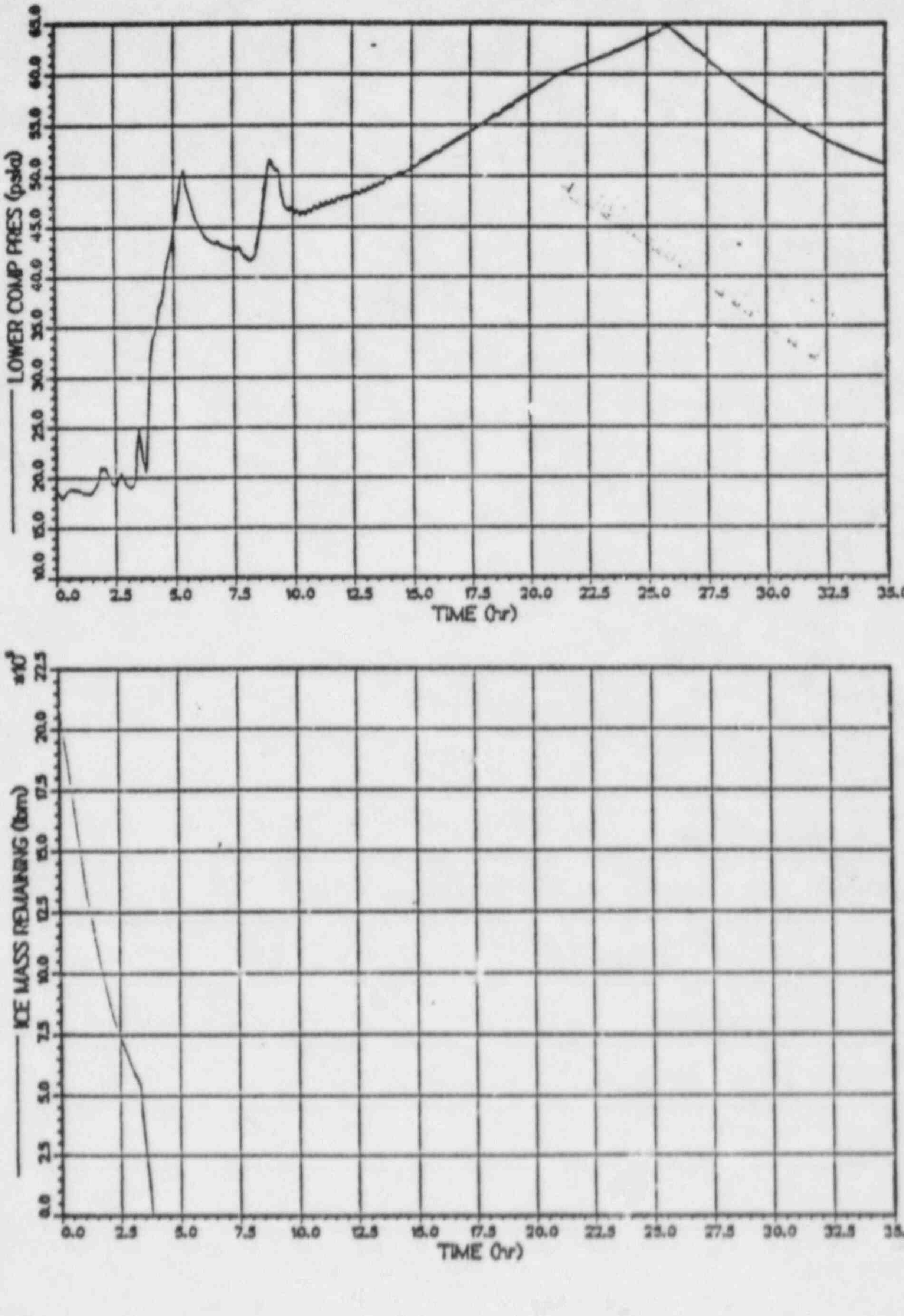
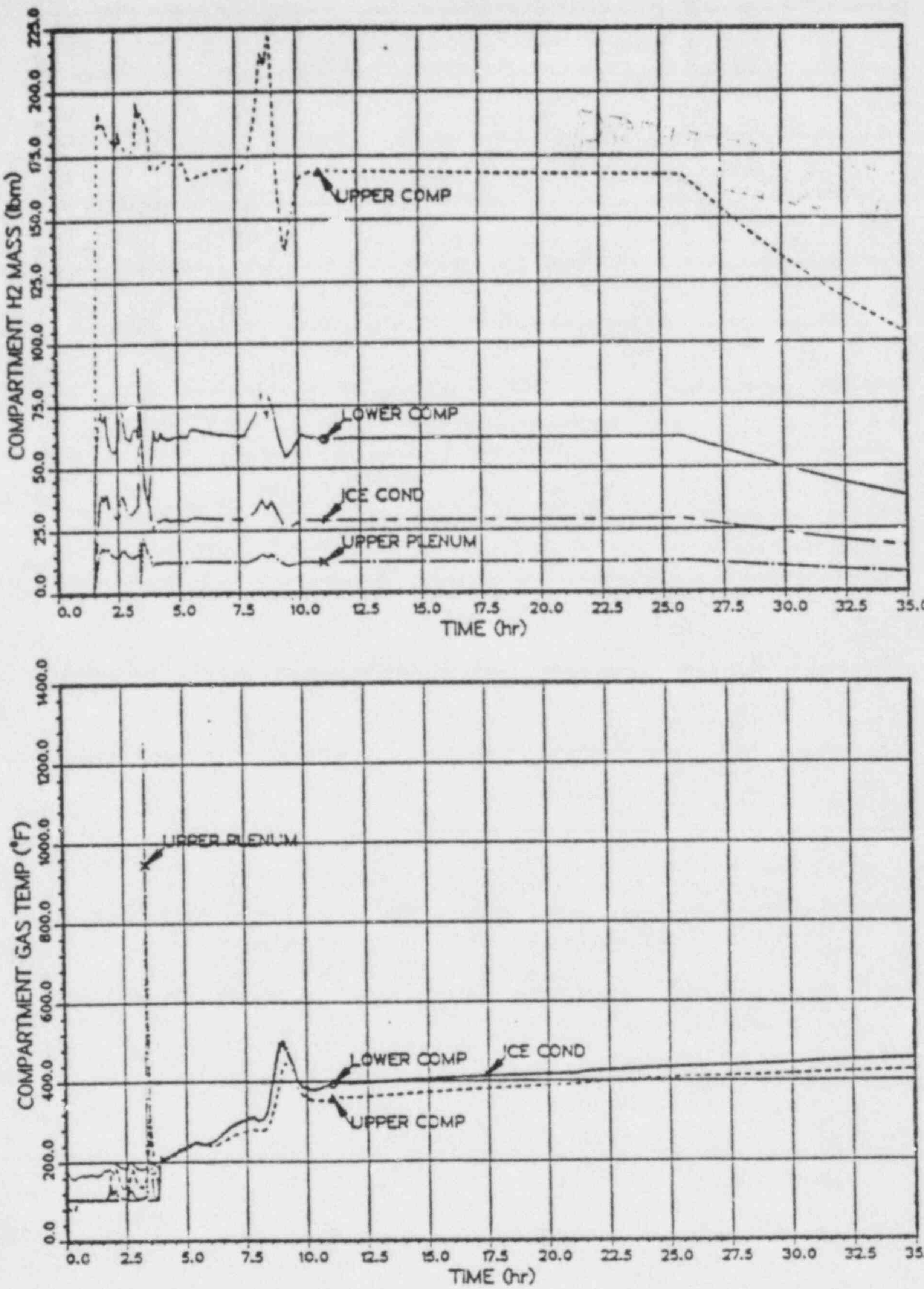


Figure C.3-9



COMPARTMENT H2 MASS (lbm)
UPPER COMP
LOWER COMP
ICE COND
UPPER PLENUM
TIME (hr)
COMPARTMENT GAS TEMP (°F)
UPPER PLENUM
LOWER COMP
ICE COND
UPPER COMP
TIME (hr)

Figure C.3-10

TMLB' U4MAAP (NON-ADIABATIC)

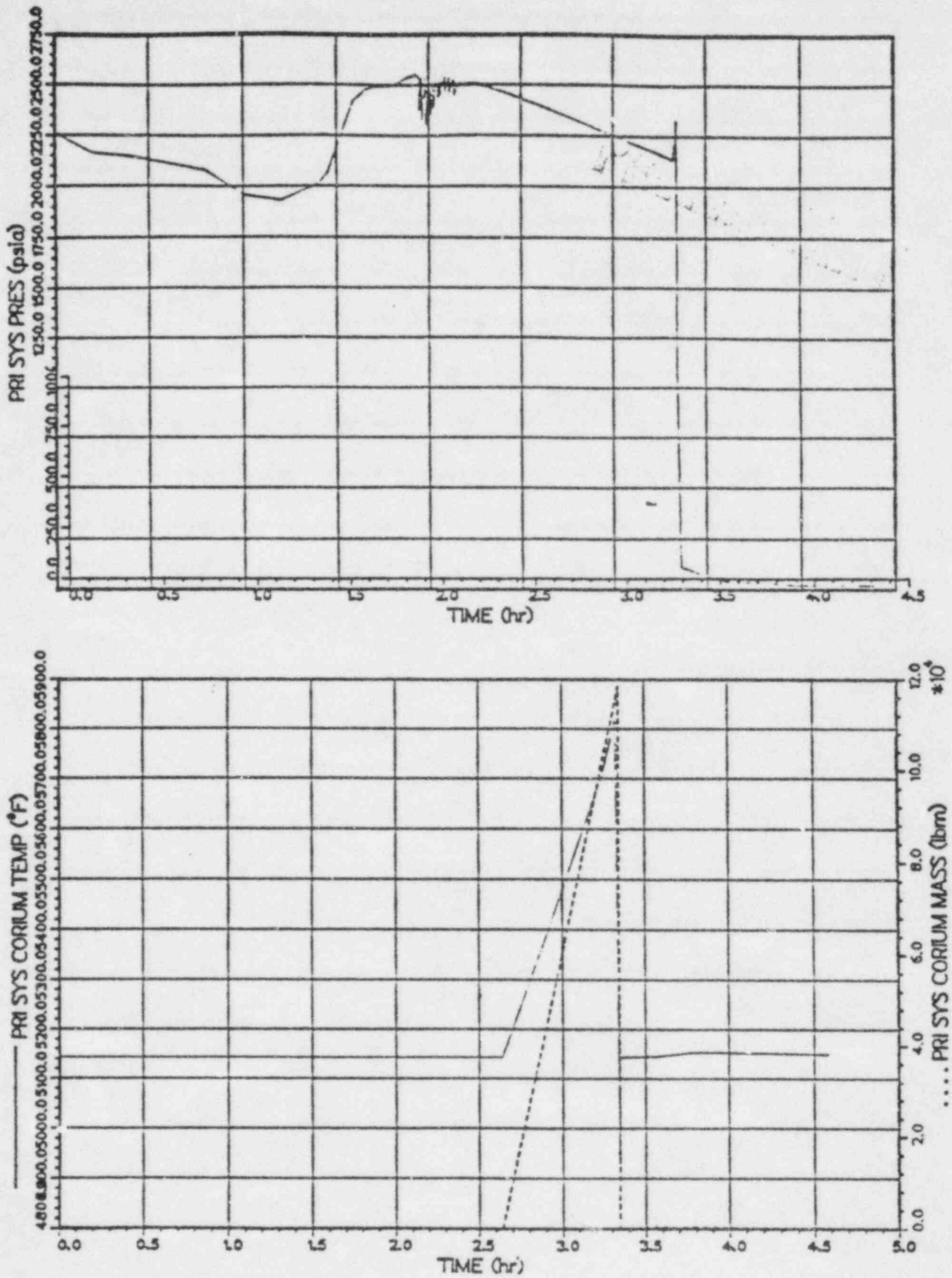


Figure C.4-1

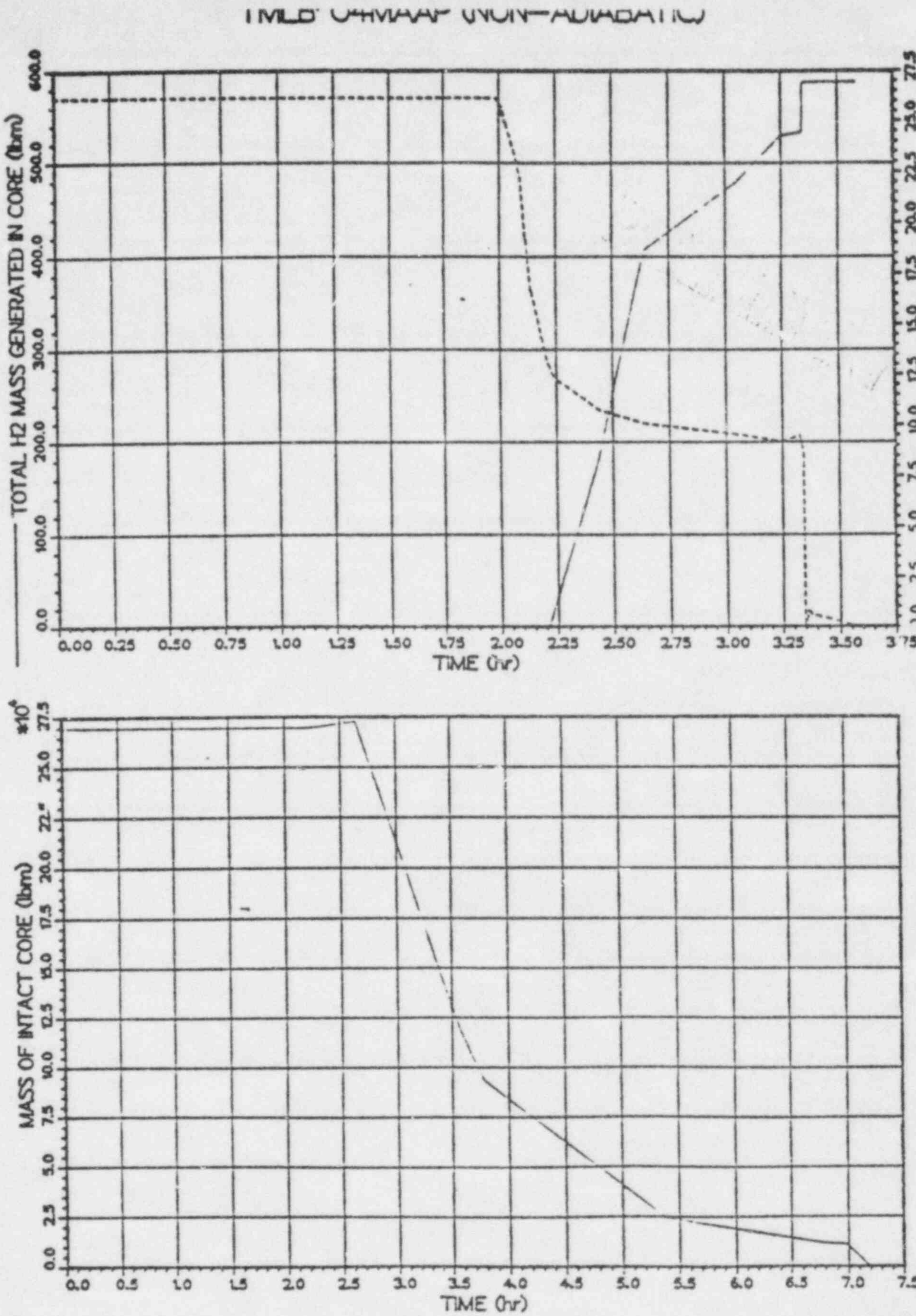
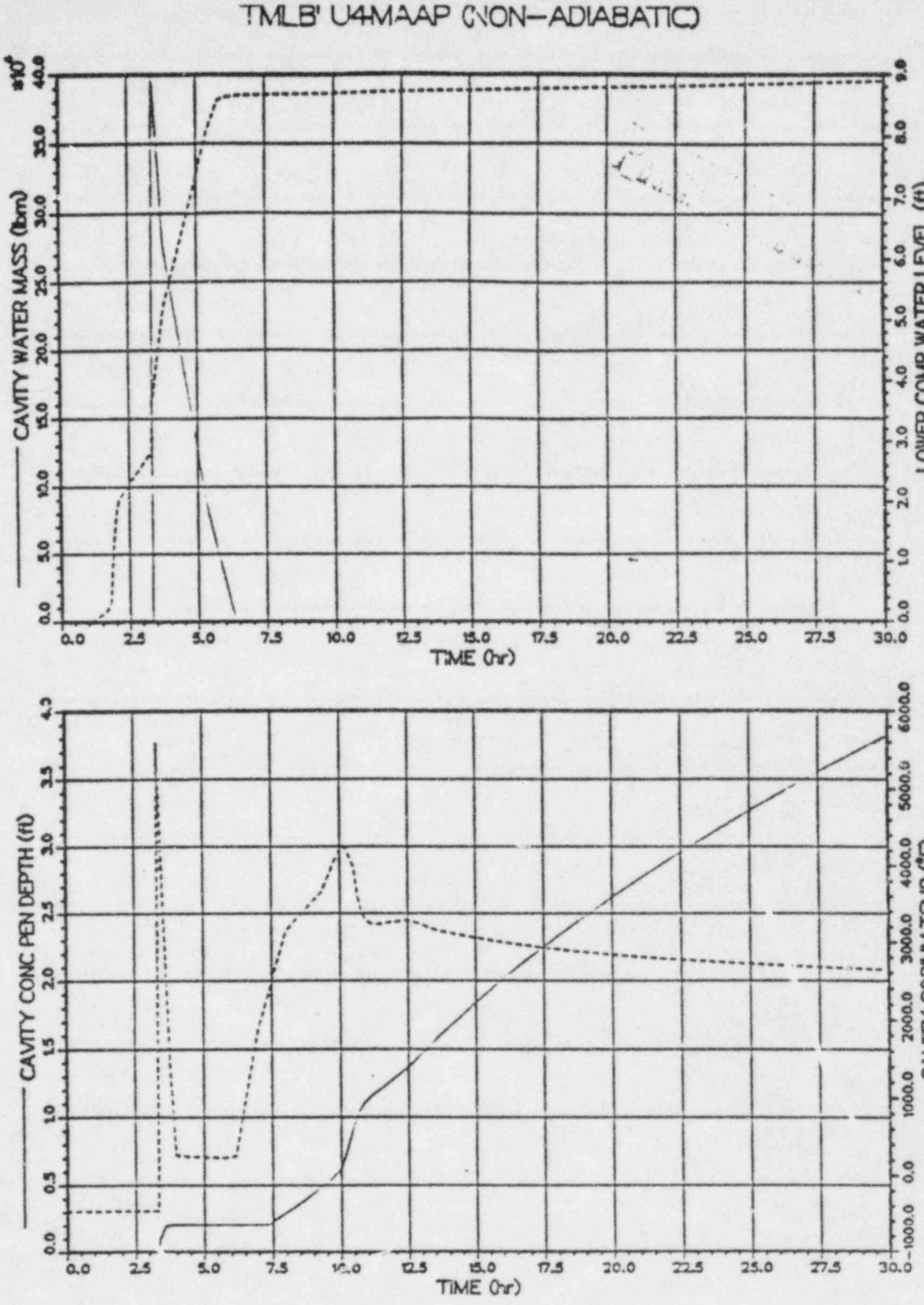

TMLB' 04MAAP (NON-ADIABATIC)
TOTAL H2 MASS GENERATED IN CORE (lbm)
.... REACTOR VSL WATER LEV (ft)
TIME (hr)
MASS OF INTACT CORE (lbm)
*10^4
TIME (hr)

Figure C.4-2



TMLB' U4MAAP (NON-ADIABATIC)
CAVITY WATER MASS (lbm)
LOWER COMP WATER LEVEL (ft)
TIME (hr)
CAVITY CONC PEN DEPTH (ft)
CAVITY CORIUM TEMP (°F)
TIME (hr)

Figure C.4-3

TMLB' U4MAAP (NON-ADIABATIC)

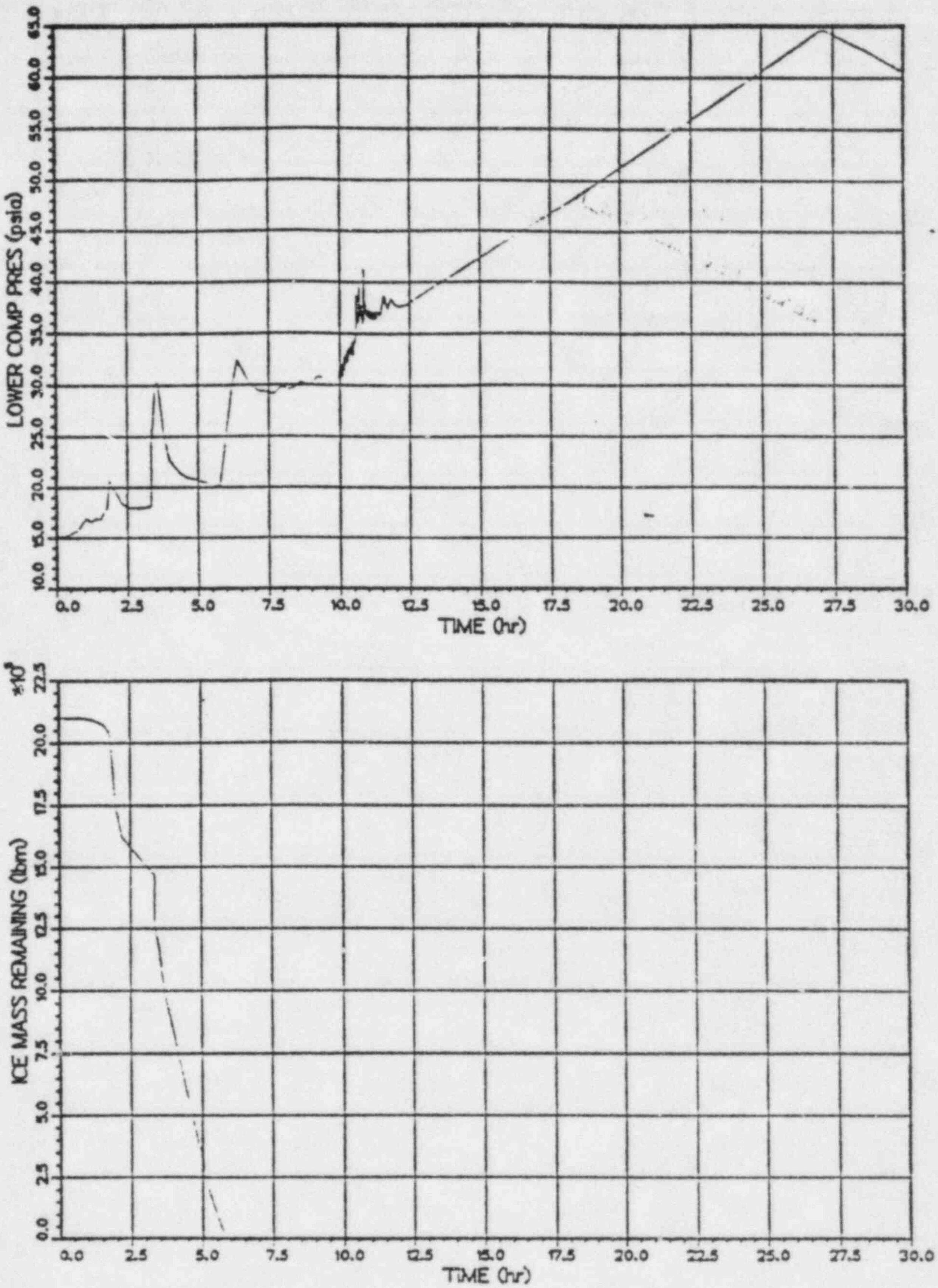
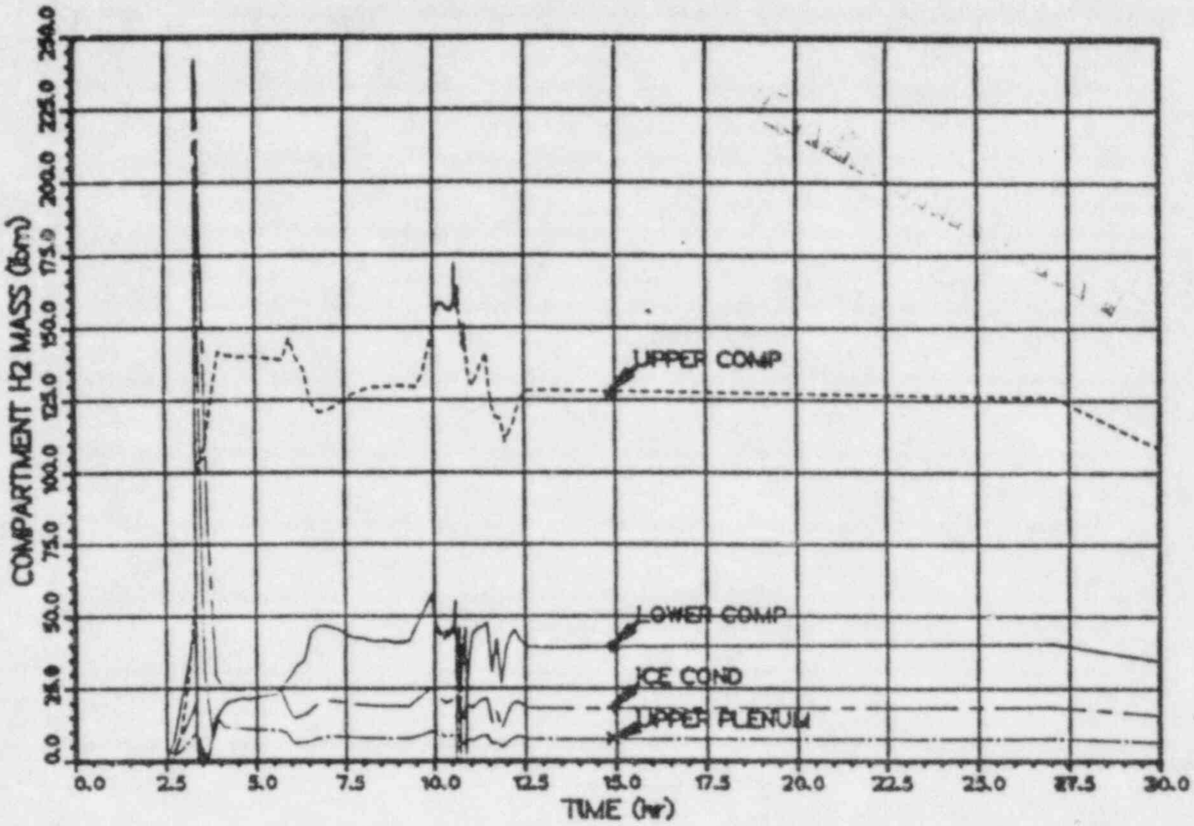


Figure C.4-5

TMLB' U4MAAP (NON-ADIABATIC)



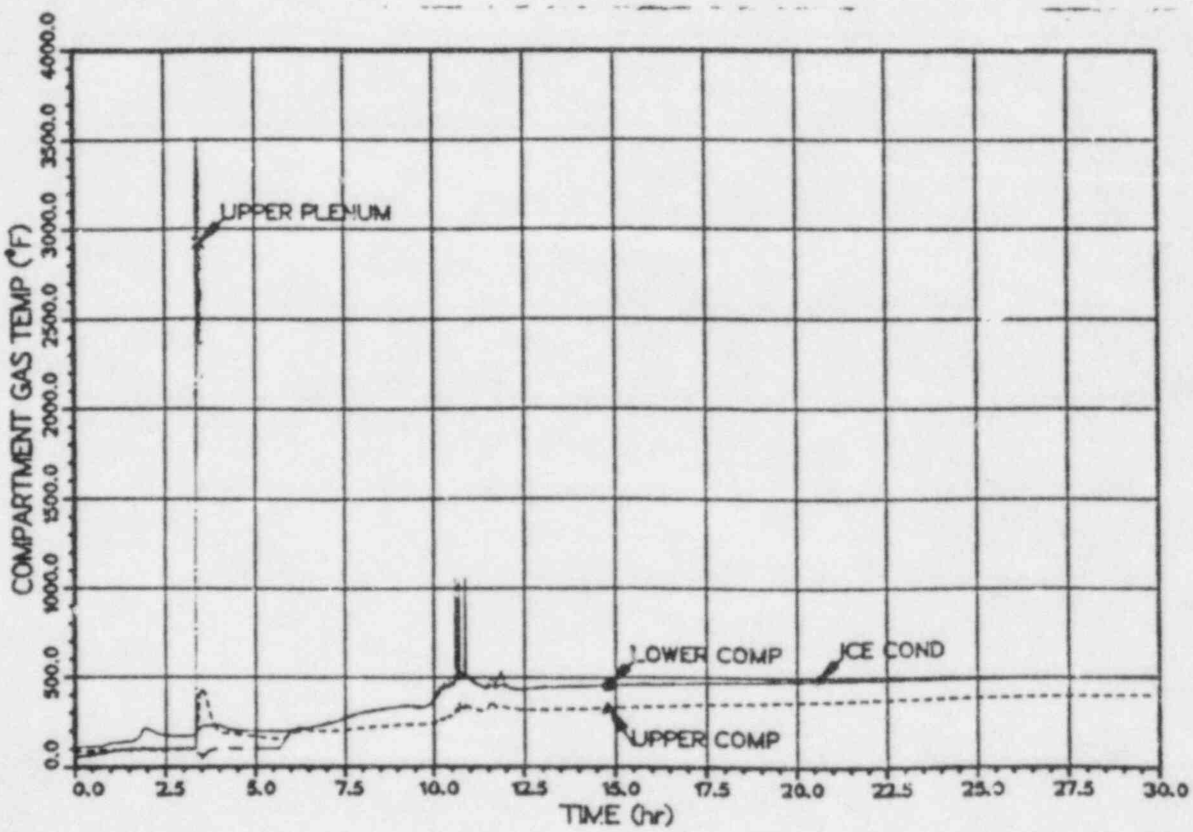


Figure C.4-6

T23ML USMAAP

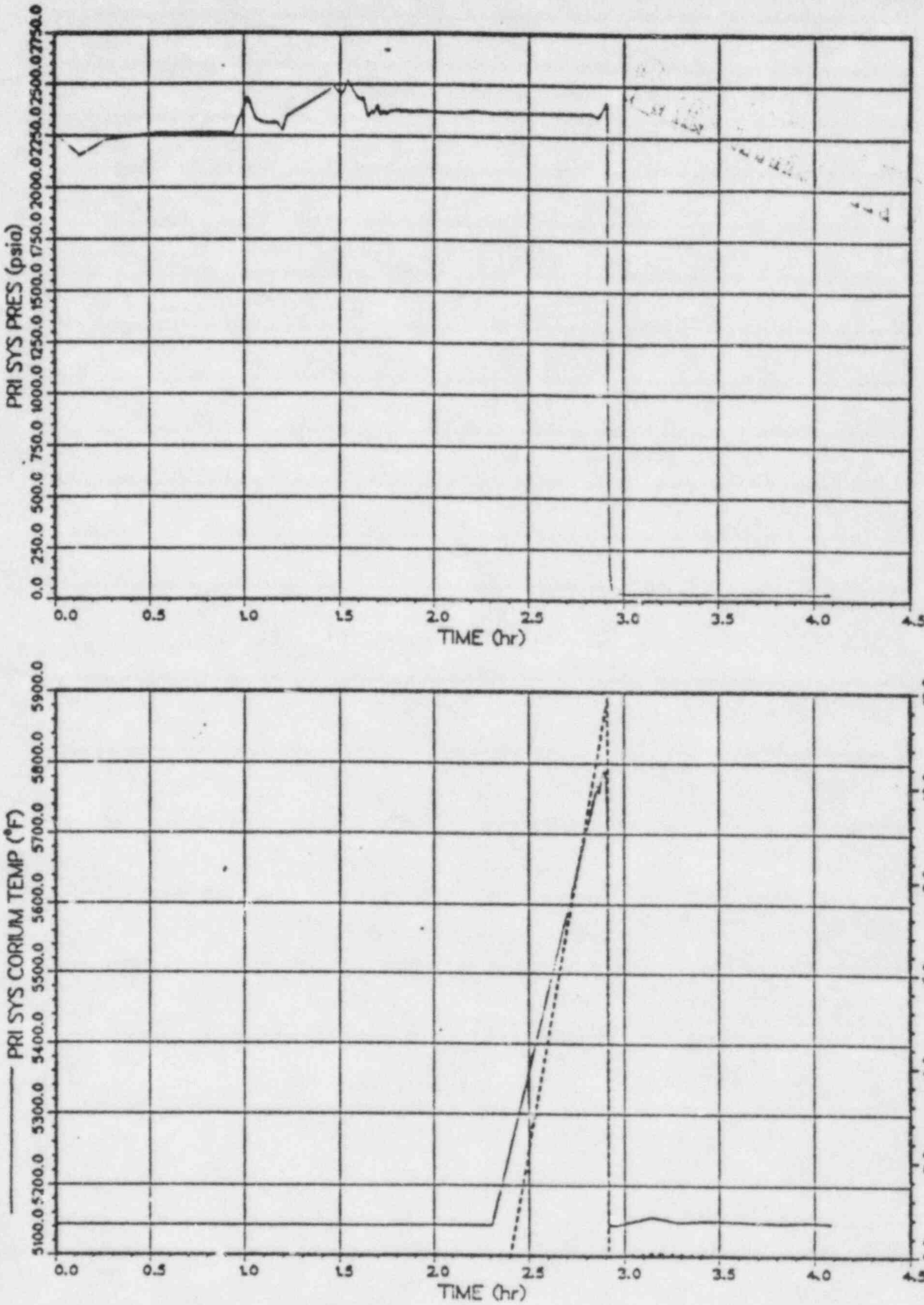
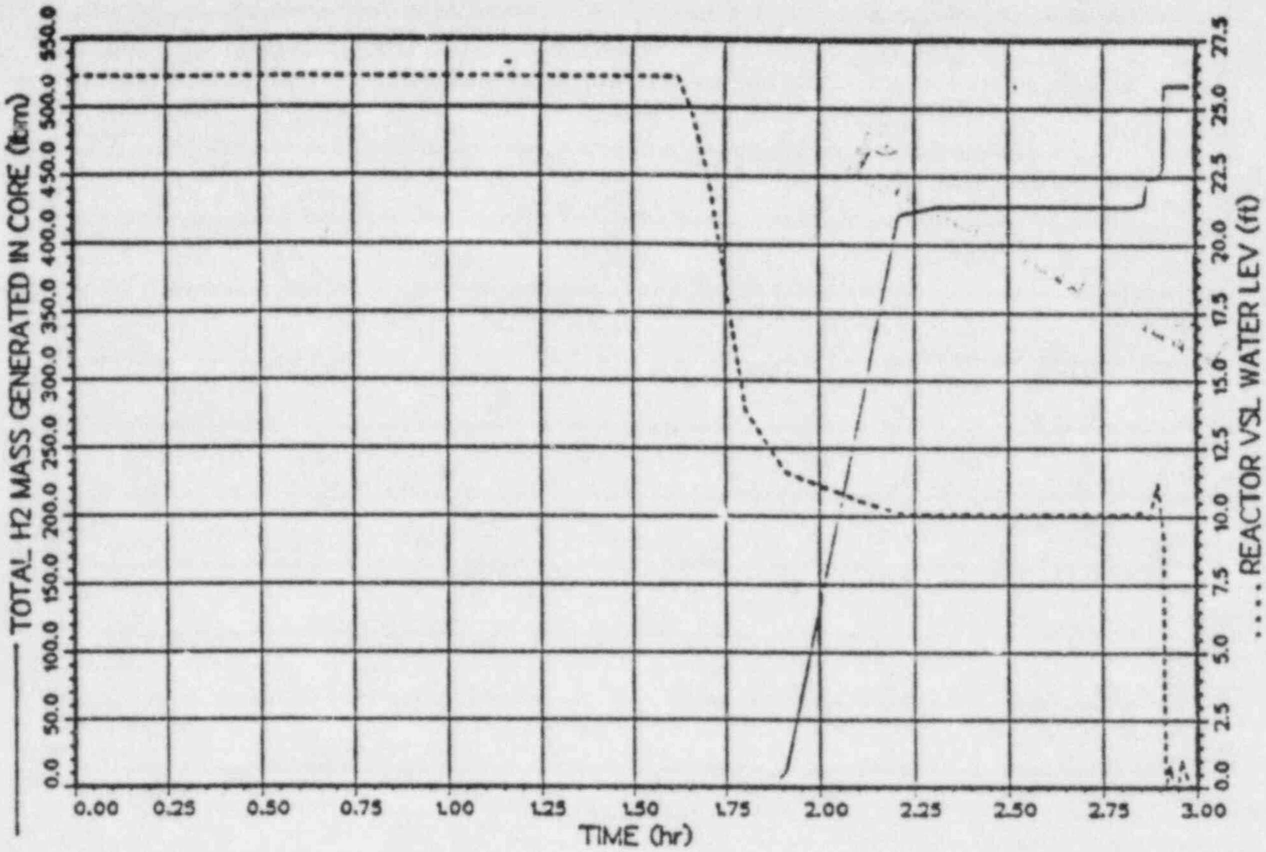


Figure C.5-1

T23ML U5MAAP



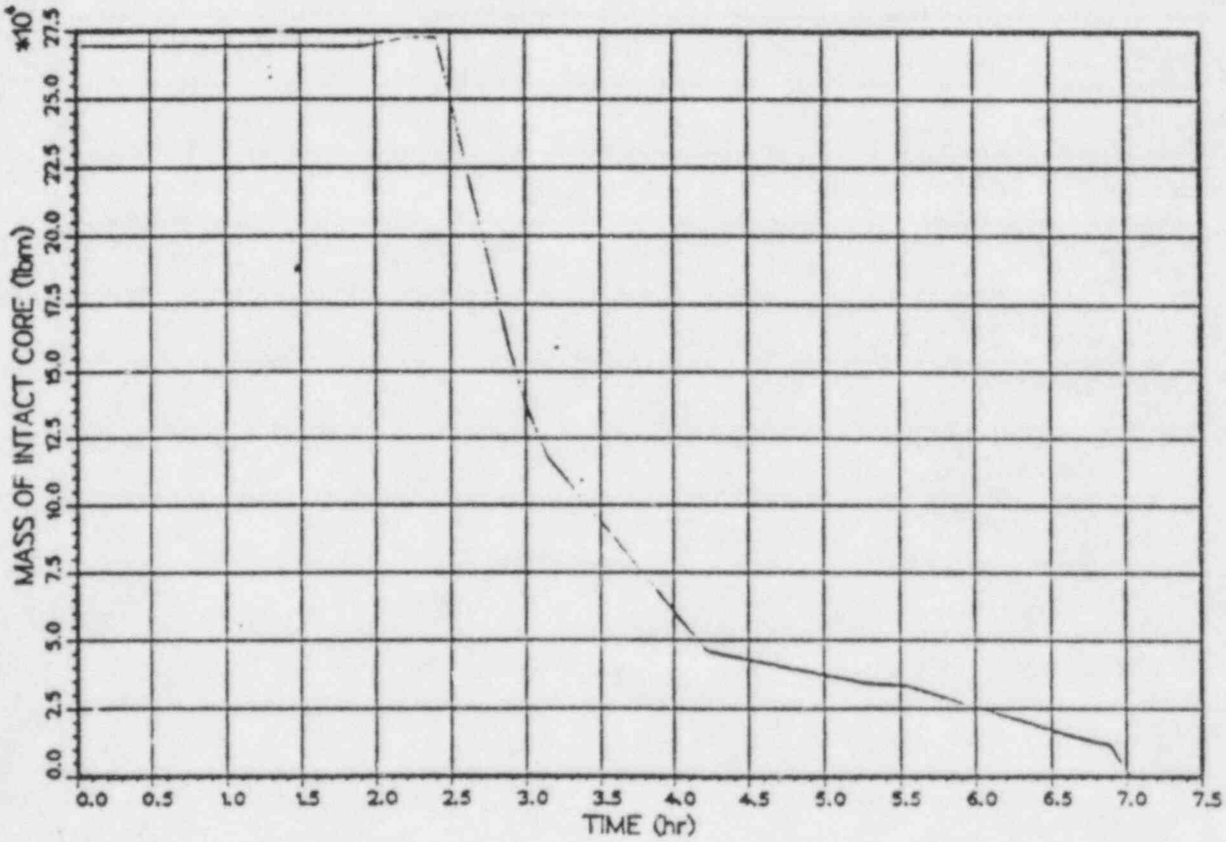


Figure C.5-2

T23ML USMAAP

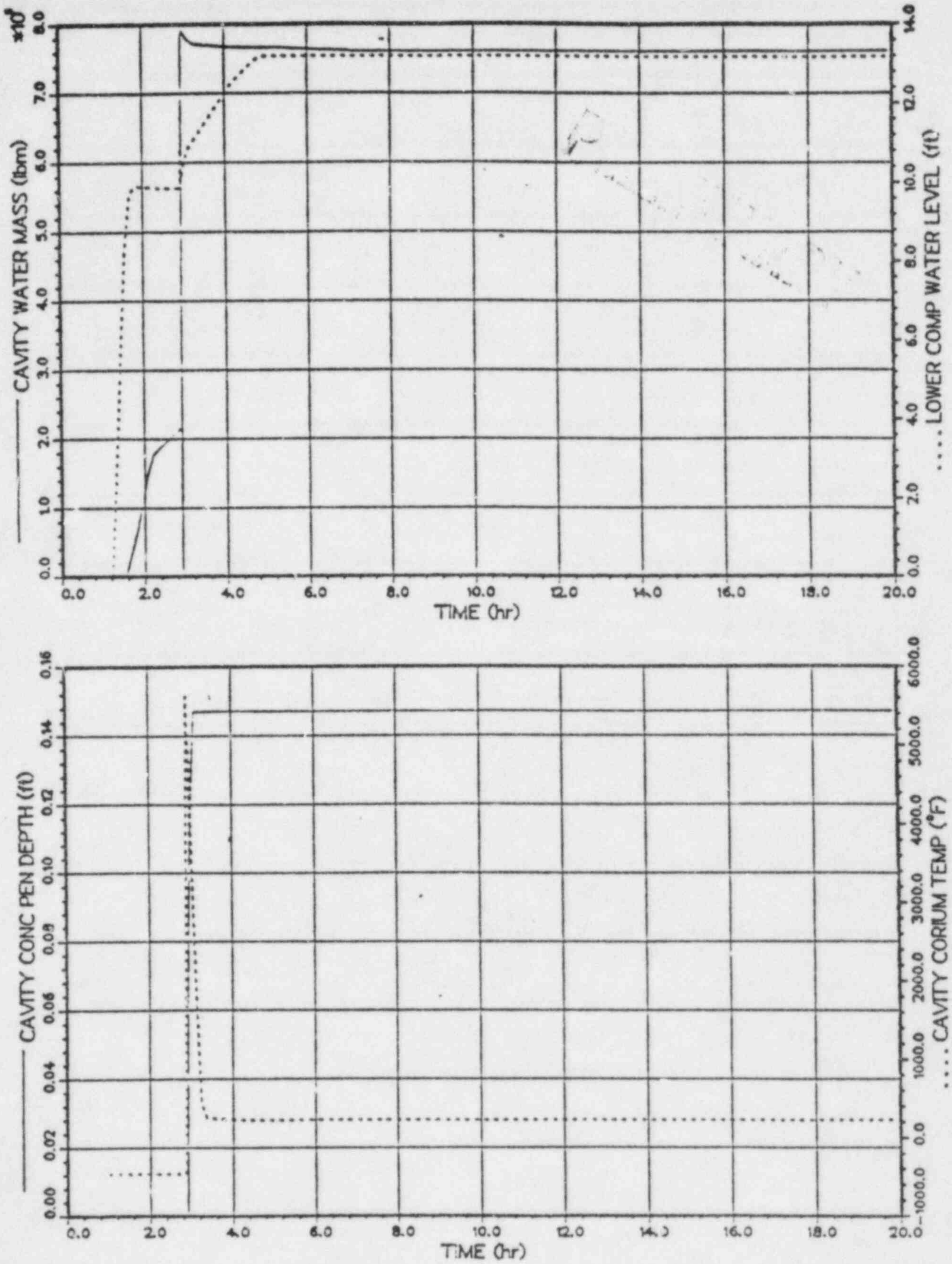
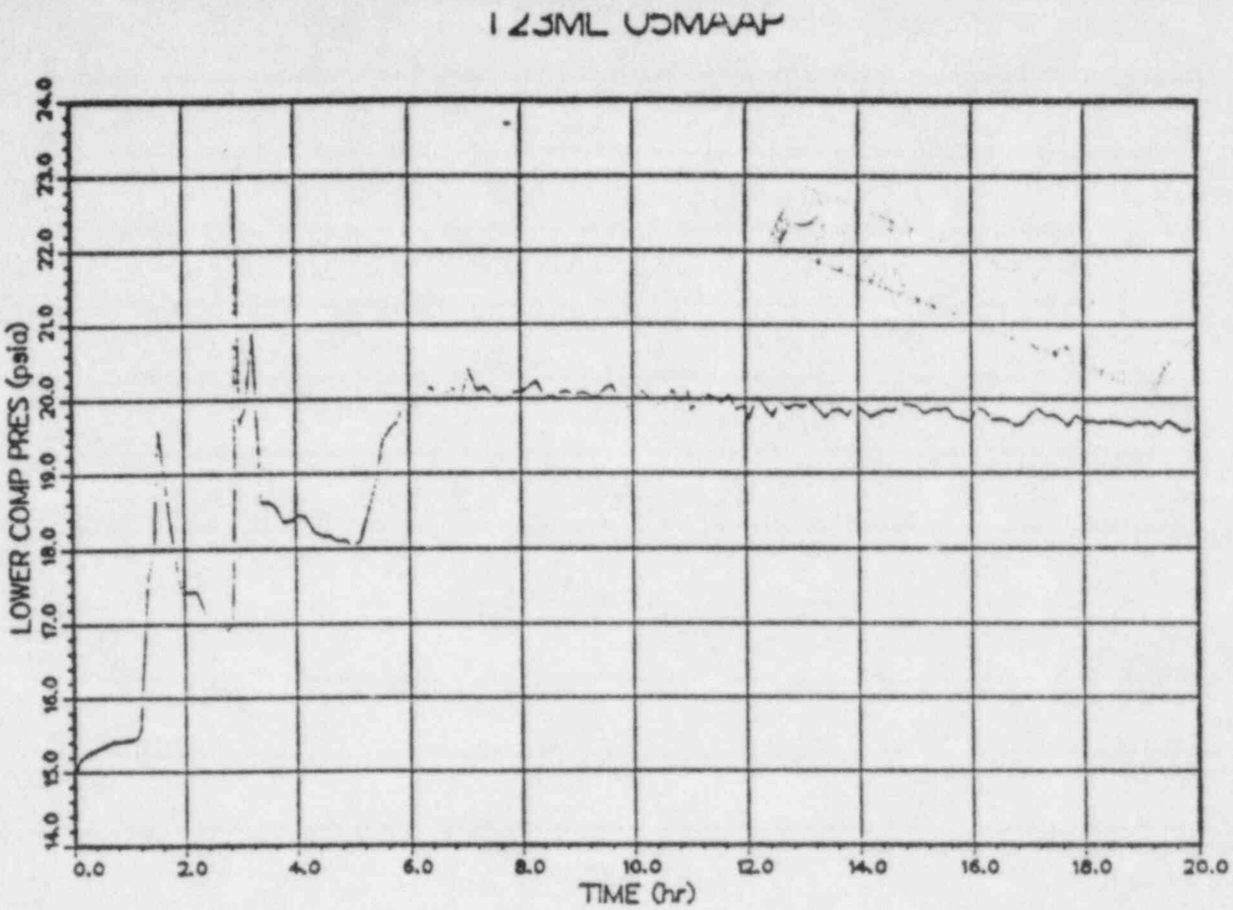


Figure C.5-3


T23ML USMAAP
LOWER COMP PRES (psia)
24.0
23.0
22.0
21.0
20.0
19.0
18.0
17.0
16.0
15.0
14.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
TIME (hr)

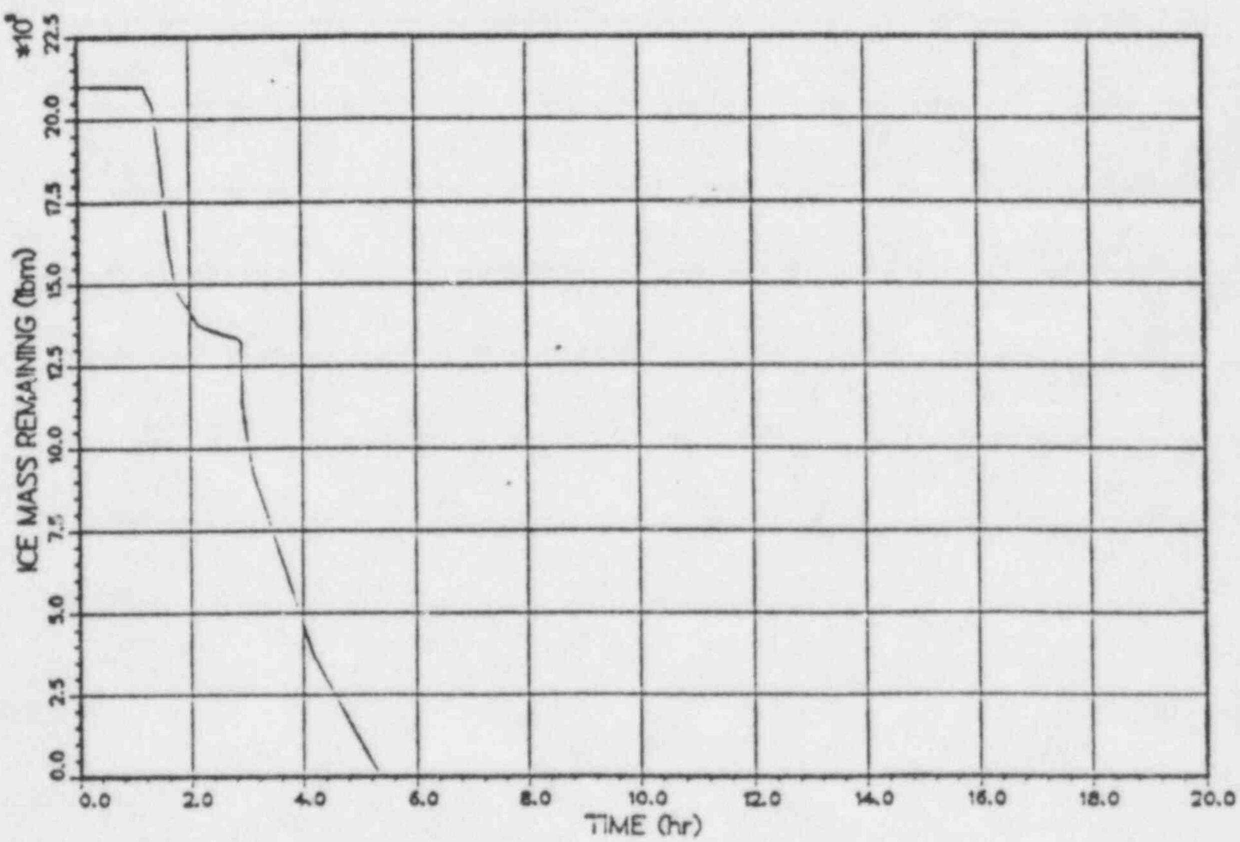

ICE MASS REMAINING (lbm)
x10^4
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
TIME (hr)

Figure C.5-4

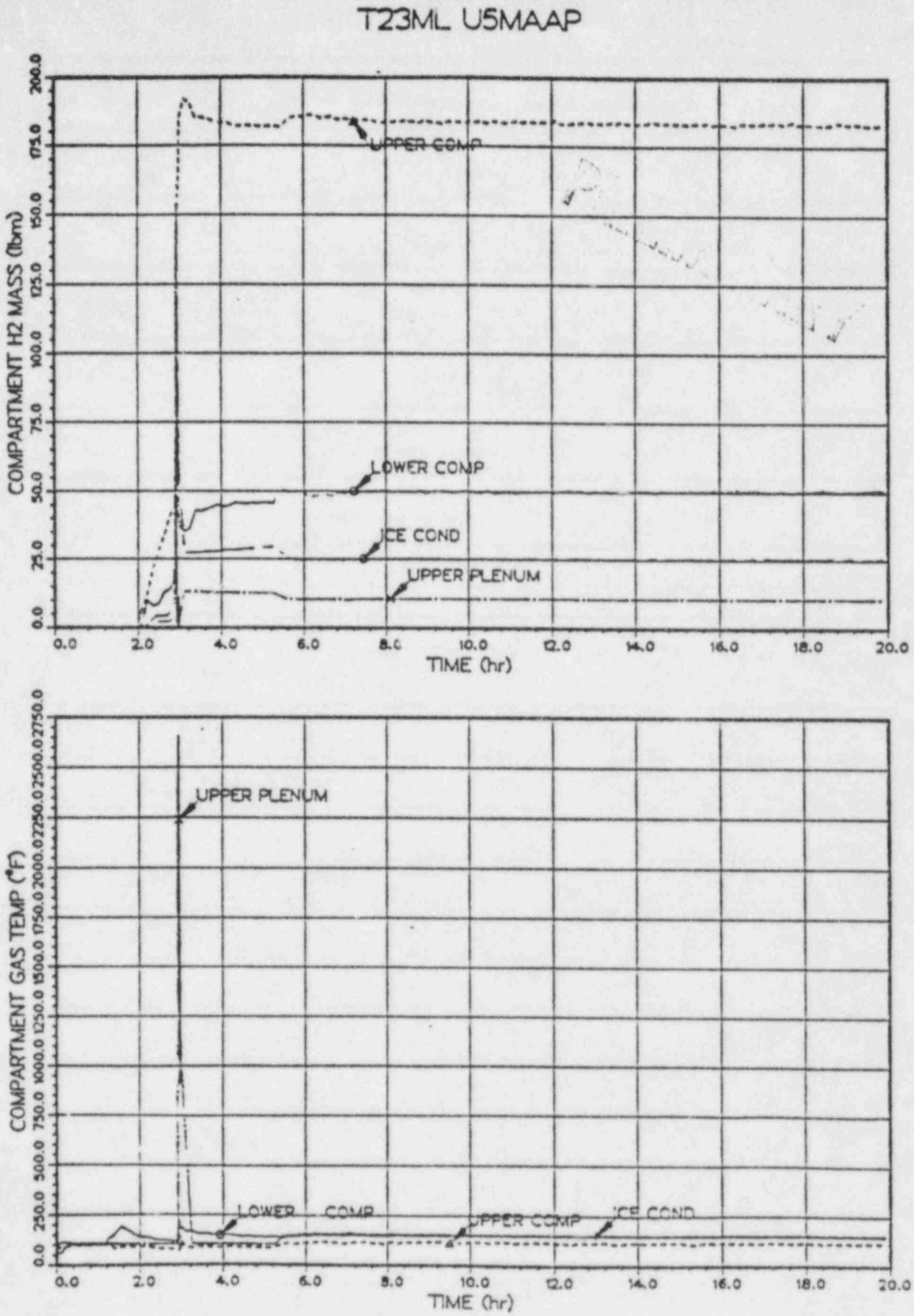
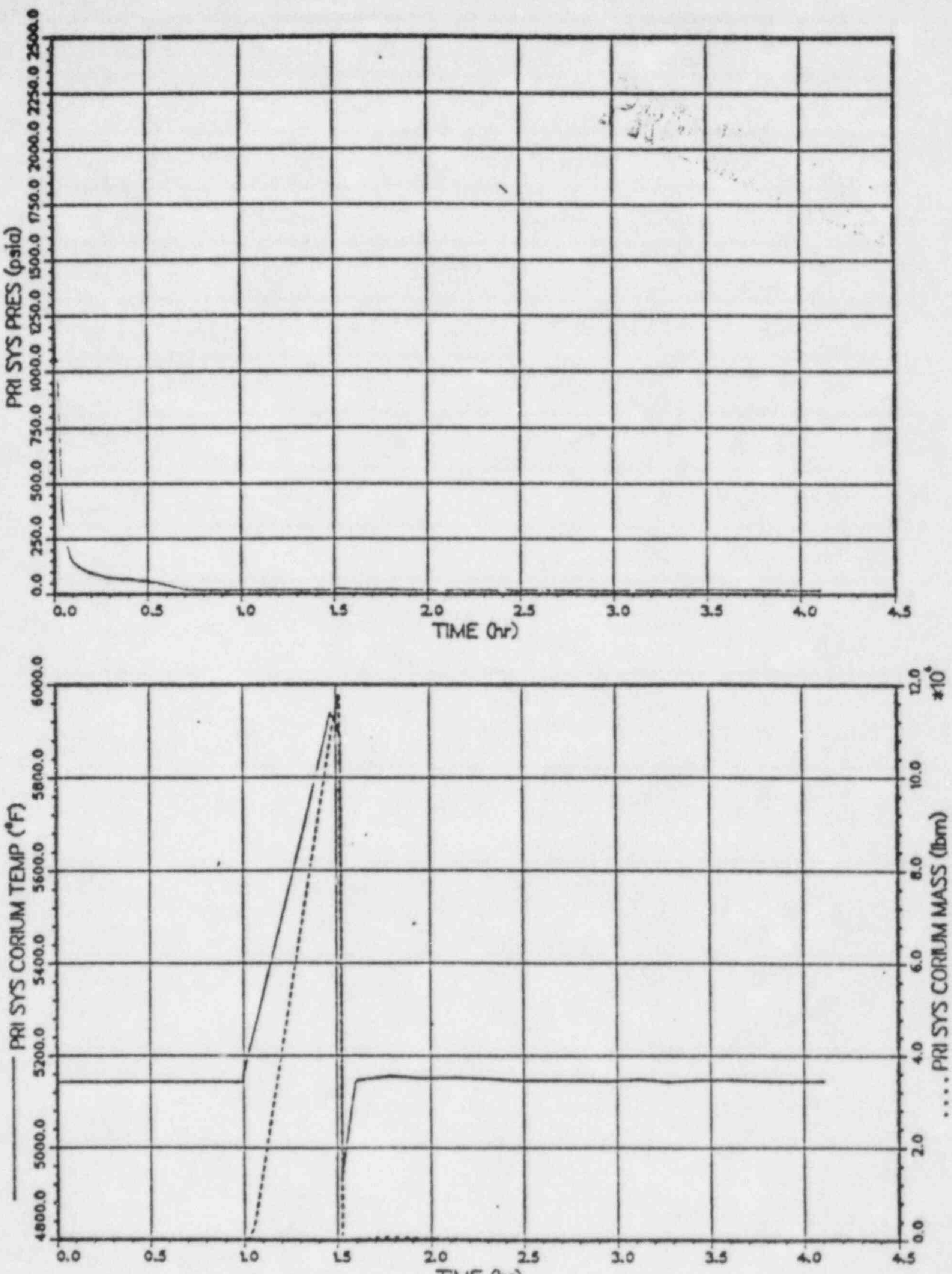

T23ML U5MAAP
COMPARTMENT H2 MASS (lbm)
UPPER COMP
LOWER COMP
ICE COND
UPPER PLENUM
TIME (hr)
COMPARTMENT GAS TEMP (°F)
UPPER PLENUM
LOWER COMP
UPPER COMP
ICE COND
TIME (hr)

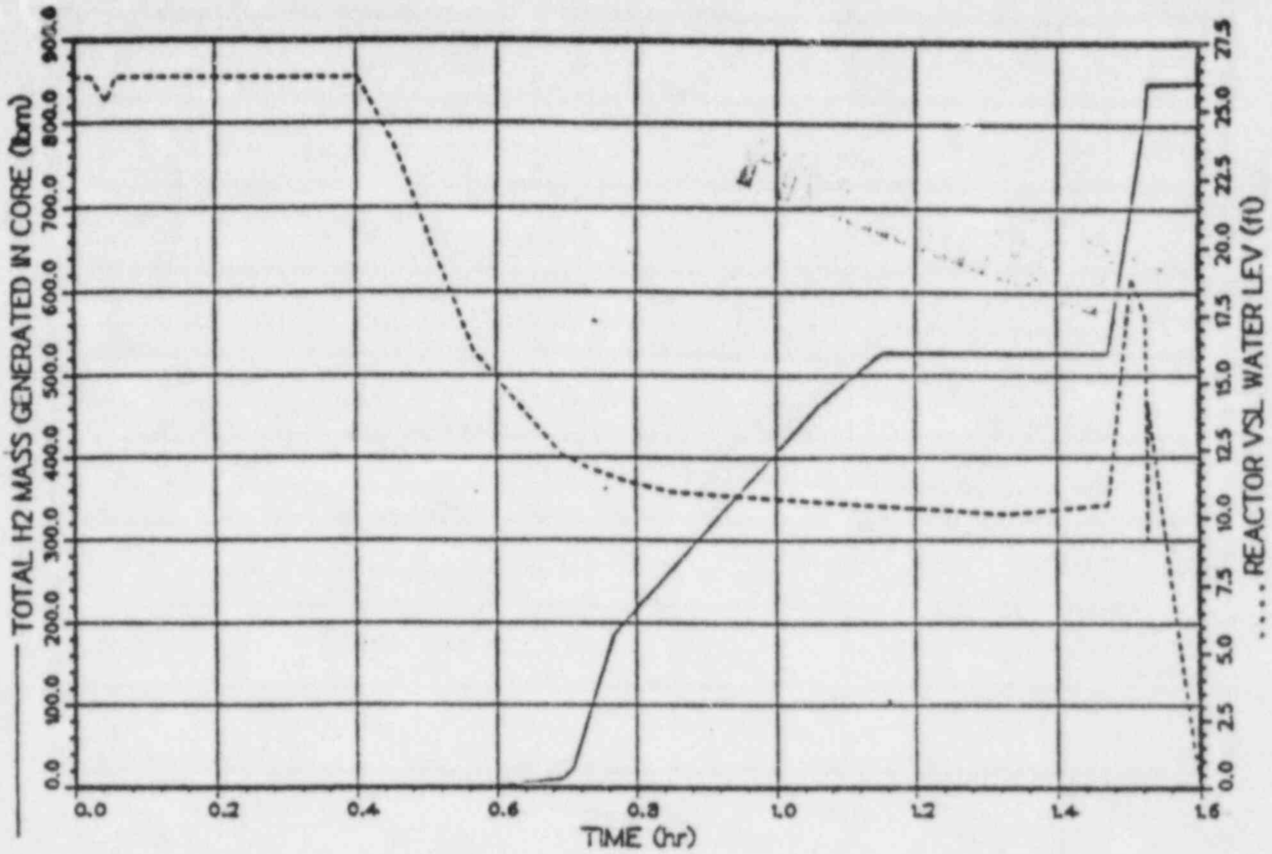
Figure C.5-5



PRI SYS PRES (psia)
TIME (hr)
PRI SYS CORIUM TEMP (°F)
PRI SYS CORIUM MASS (lbm)
TIME (hr)

Figure C.6-1

AD U6MAAP



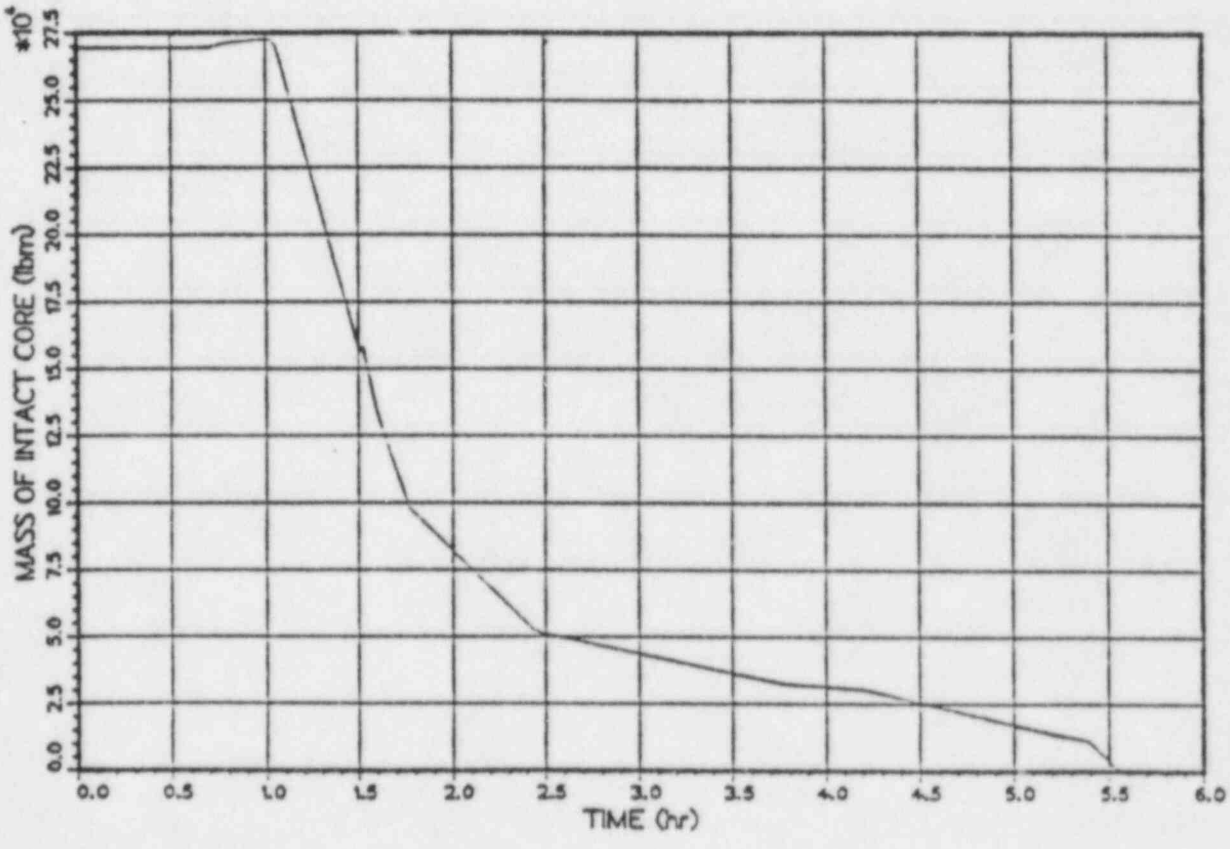


Figure C.6-2

AD U6MAAP

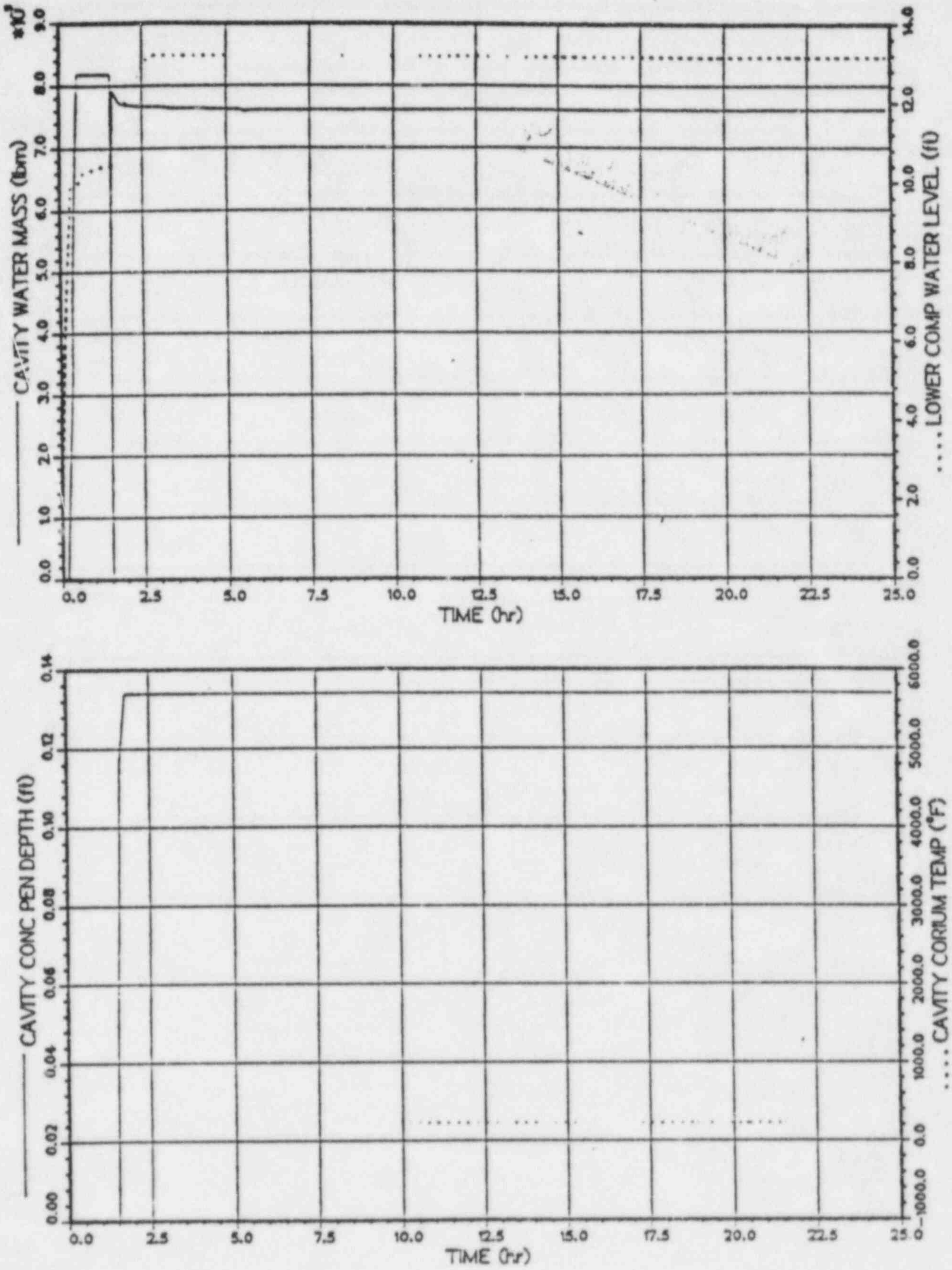
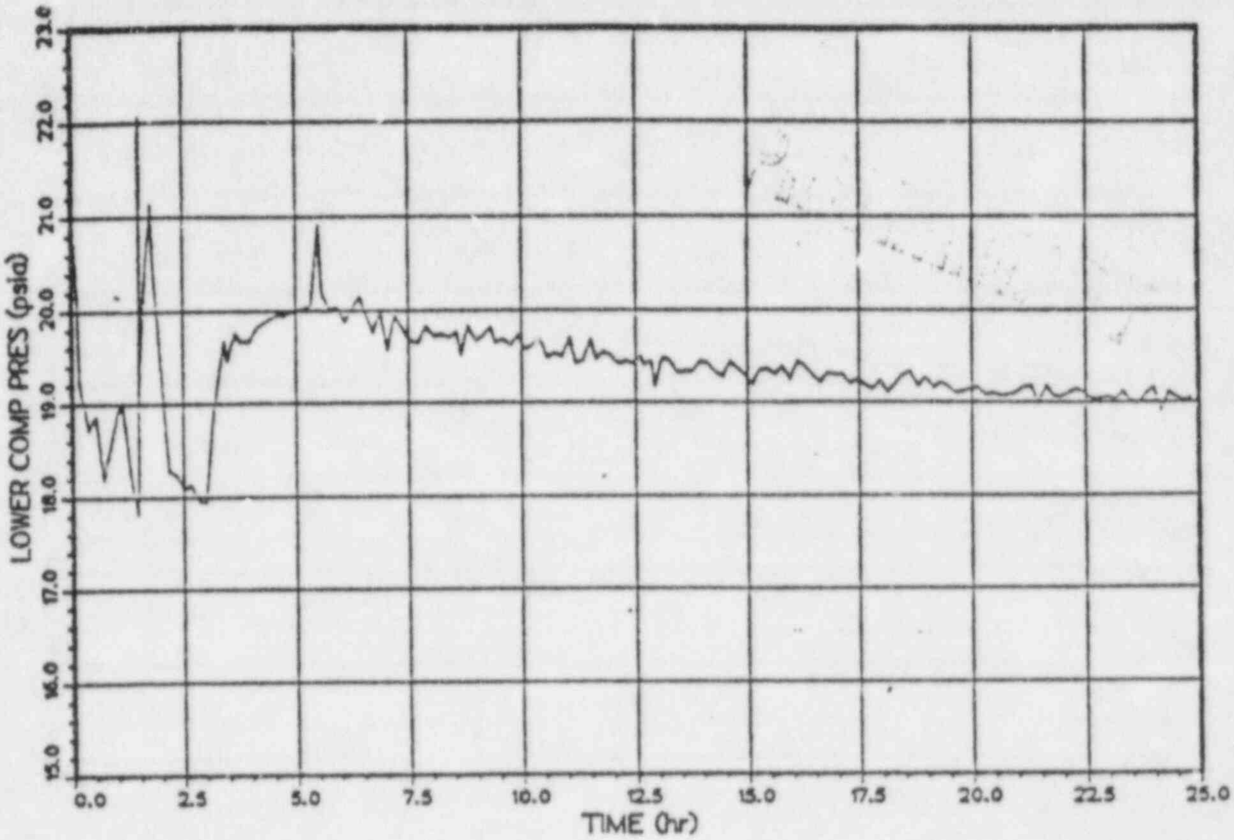


Figure C.6-3

AD U6MAAP



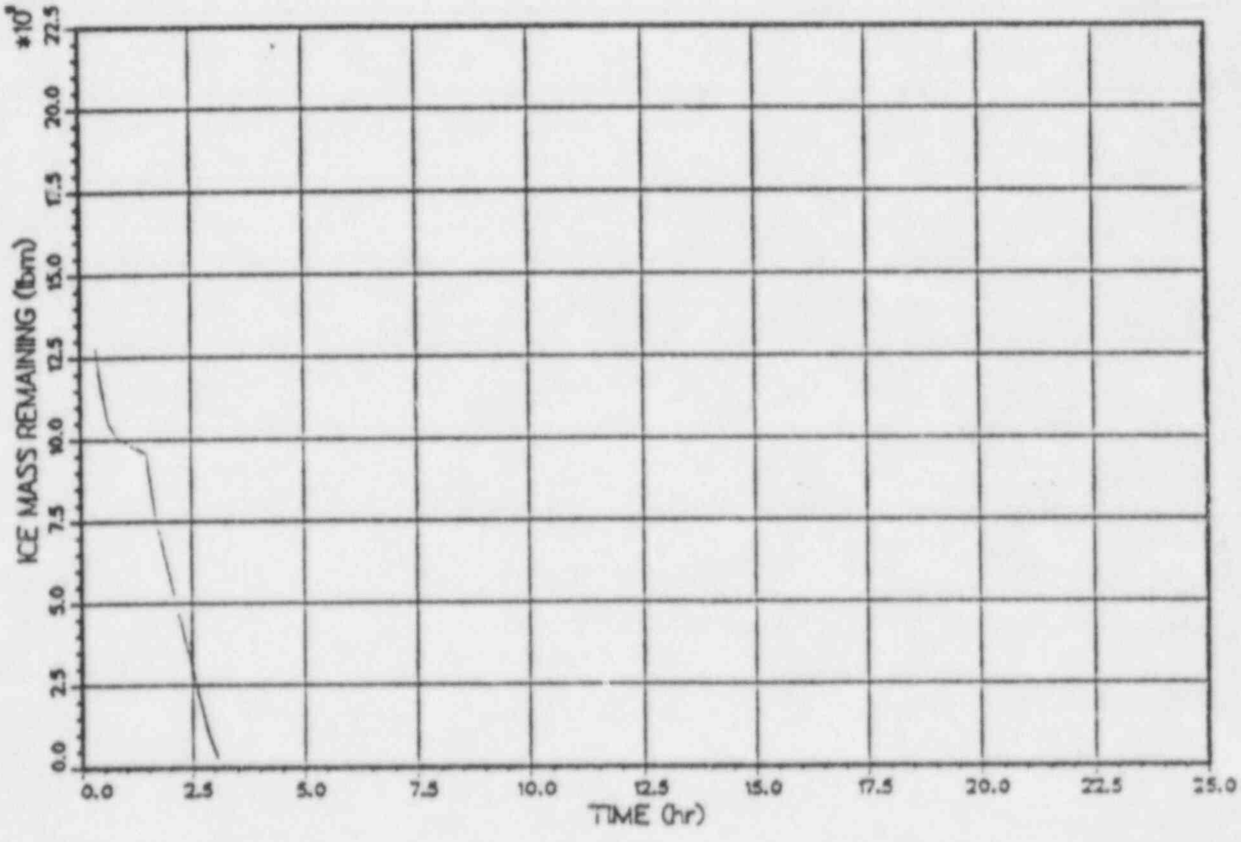
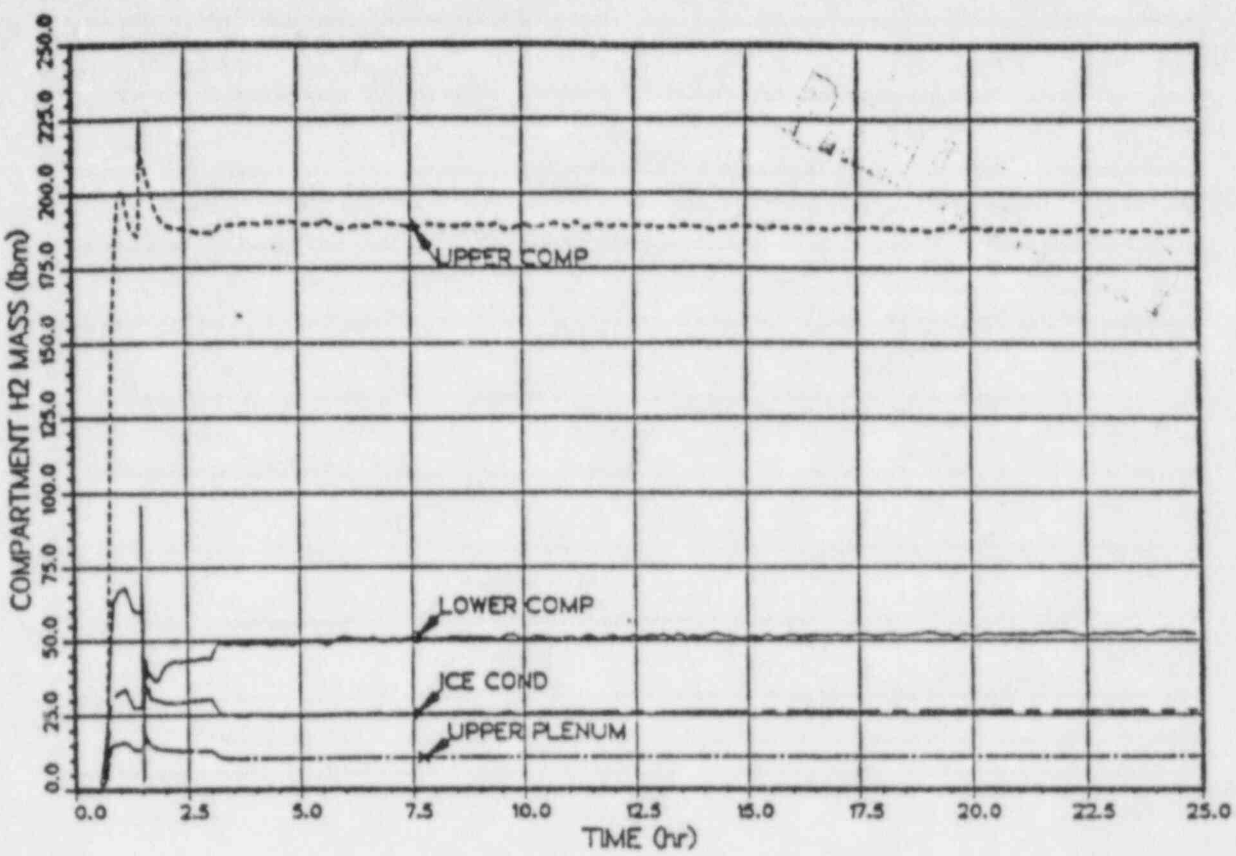


Figure C.6-4

AD U6MAAP



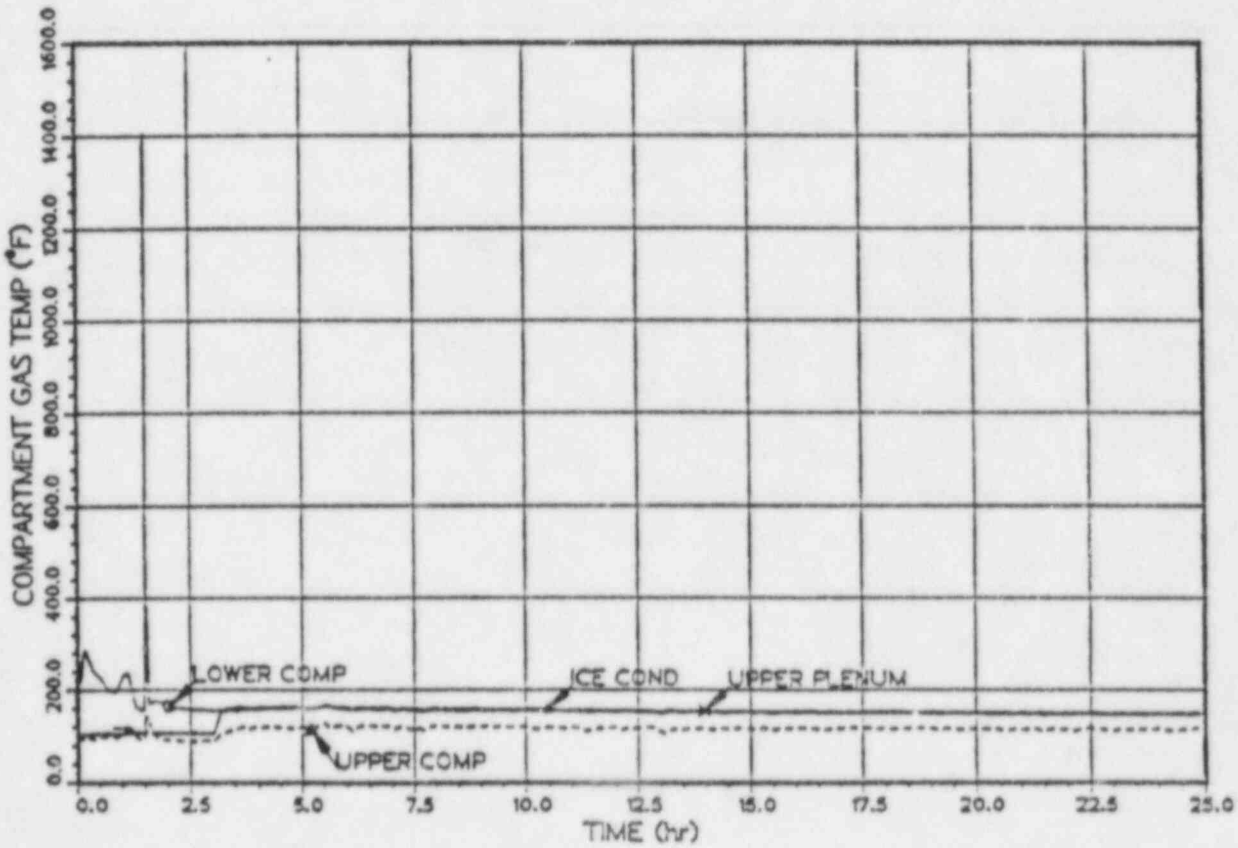


Figure C.6-5