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TRAC APPLICATIONS TO THE 2D/3D FACILITIES*

by

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The 2D/3D experimental program is a multinational (Federal Republic of Germany, Japan, and U.S.) cooperative effort to study portions of PWR LOCA behavior in large- and full-scale geometry. Germany is now in the process of designing and building an upper plenum test facility (UPTF) which will include a downcomer, lower plenum, core simulator, and full-scale upper plenum internals. The UPTF will simulate the end-of-blowdown, refill and reflood and will address phenomena such as ECC bypass, entrainment, de-entrainment, and re-entrainment. The Japanese contribution to the 2D/3D program consists of large-scale experiments in a cylindrical core test facility (CCTF) and slab core test facility (SCTF). The CCTF is a 2 000 rod, electrically heated cylindrical core (full height) currently designed to simulate reflood in a PWR LOCA. It is now in operation and a number of tests have been performed over the past year. The SCTF is a 2 000 rod, electrically heated experiment which is designed to have a full height, full radius geometry with a constant slab thickness of one assembly. These two heated Japanese facilities are designed to simulate the dynamics of reflood during a LOCA and hopefully, will be coupled to the UPTF either through experimental means, through the TRAC code, or both. The U.S. contribution to the 2D/3D program consists of advanced instrumentation development, design assistance, and analysis. LASL is providing the majority of the design assistance and analysis work using the TRAC code. A number of TRAC calculations, in support of the 2D/3D program, have been performed over the past year.

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*Work performed under the auspices of the U.S. Nuclear Regulatory Commission.

Initially, the CCTF test results are being used as both TRAC independent and developmental assessment tools. TRAC pretest predictions of the first four CCTF tests have been performed and to date, the results of these reflood calculations do not compare well with data. Based on these and other results a new reflood package is being installed in TRAC which should improve the agreement substantially. Future CCTF calculations include more pretest predictions, detailed posttest analyses, and calculations to assist in the operation of CCTF Core-II.

Over the past year, numerous SCTF design-assistance TRAC calculations have been performed primarily to investigate the SCTF behavior during combined ECC injection. The results indicated a need for an extra steam supply to adequately simulate the initial velocities during the end-of-blowdown period when compared to PWR conditions. Future calculations will concentrate on further design assistance.

Since the major design decisions for the UPTF were delayed, little analysis support was required for the UPTF. However, an initial TRAC noding scheme was setup near the end of the year. Future work will include TRAC studies to determine the system operating characteristics and to lend assistance to the UPTF designs.

In support of the actual facility calculations, a number of PWR calculations were performed. The most notable of these was the first TRAC simulation of a 200% cold-leg LOCA in a typical German PWR using hot- and cold-leg ECC injection. This calculation was followed by a noding study to reduce the running time and calculations of a German reference reactor design to assist the UPTF designers in determining flow magnitudes in the primary system. Other support activities included instrumentation location and accuracy specifications and other PWR calculations.

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2D/3D APPLICATIONS TASKS

- UPTF
  1. INITIAL TRAC MODEL COMPLETED.
  2. OPERATIONAL CHARACTERISTICS STUDIES.
  3. FUTURE PRETEST AND POSTTEST ANALYSES.

- CCTF
  1. PRETEST PREDICTIONS FOR INITIAL TESTS.
  2. POSTTEST ANALYSES - NEW REFLOOD PACKAGE.
  3. CORE-II OPERATION STUDIES.
  4. FUTURE PRETEST AND POSTTEST ANALYSES.

- SCTF
  1. COMBINED INJECTION STEAM SUPPLY STUDIES.
  2. OPERATIONAL CHARACTERISTICS STUDIES.
  3. FUTURE PRETEST AND POSTTEST ANALYSES.

- LPWR
  1. GERMAN FINE NODE.
  2. GERMAN NODING STUDIES.
  3. U.S. NODING STUDIES.
  4. REFERENCE REACTOR CALCULATIONS (COLD-LEG AND HOT-LEG BREAKS).
  5. FUTURE STUDIES.

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FACILITY CHARACTERISTICS

- UPTF
  1. DOWNCOMER
  2. LOWER PLENUM
  3. CORE SIMULATOR (17 SPRAY ZONES)
  4. FULL-SCALE 360^{o} UPPER PLENUM
  5. PARTIAL LOOP SIMULATION
  6. BLOWDOWN FROM 9×10^{5} Pa to $1\text{-}4 \times 10^{5}$ Pa
  7. COMBINED ECC INJECTION
  8. ECC BYPASS
  9. ENTRAINMENT, DE-ENTRAINMENT, AND RE-ENTRAINMENT

- CCTF
  1. 2 000 ELECTRICALLY HEATED RODS
  2. 3 RADIAL ZONES
  3. FULL-HEIGHT
  4. LOOP SIMULATION
  5. IN OPERATION
  6. CORE-II MAY BLOWDOWN FROM 9×10^{5} Pa

- SCTF
  1. 2 000 ELECTRICALLY HEATED RODS
  2. SLAB GEOMETRY (FULL HEIGHT AND RADIUS)
  3. NO LOOPS - SEPARATE EFFECTS
  4. CORE-I WILL RUN BLOCKAGE TESTS
  5. BLOWDOWN FROM 9×10^{5} Pa.

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GERMAN REACTOR CALCULATIONS

- TYPES OF CALCULATIONS:
  1. TYPICAL PWR 200% COLD-LEG LOCA-FINE NODE.
  2. NODING STUDIES AND NEW CONDENSATION MODEL.
  3. REFERENCE REACTOR CALCULATIONS - COARSE NODE.
     - A. BASE CASE - 200% COLD-LEG LOCA.
     - B. 200% HOT-LEG LOCA
     - C. OTHERS

- MAJOR RESULTS:
  1. RODS QUENCH IN ~100 S.
  2. CLADDING TEMPERATURES DO NOT FALL AS RAPIDLY AS IN U.S. PWR.
  3. CONDENSATION MODEL CHANGE MAKES LITTLE DIFFERENCE.
  4. NODING CHANGES REDUCE RUNNING TIMES BY A FACTOR OF 3-4.
  5. HOT-LEG BREAK TEMPERATURES ARE LOW.

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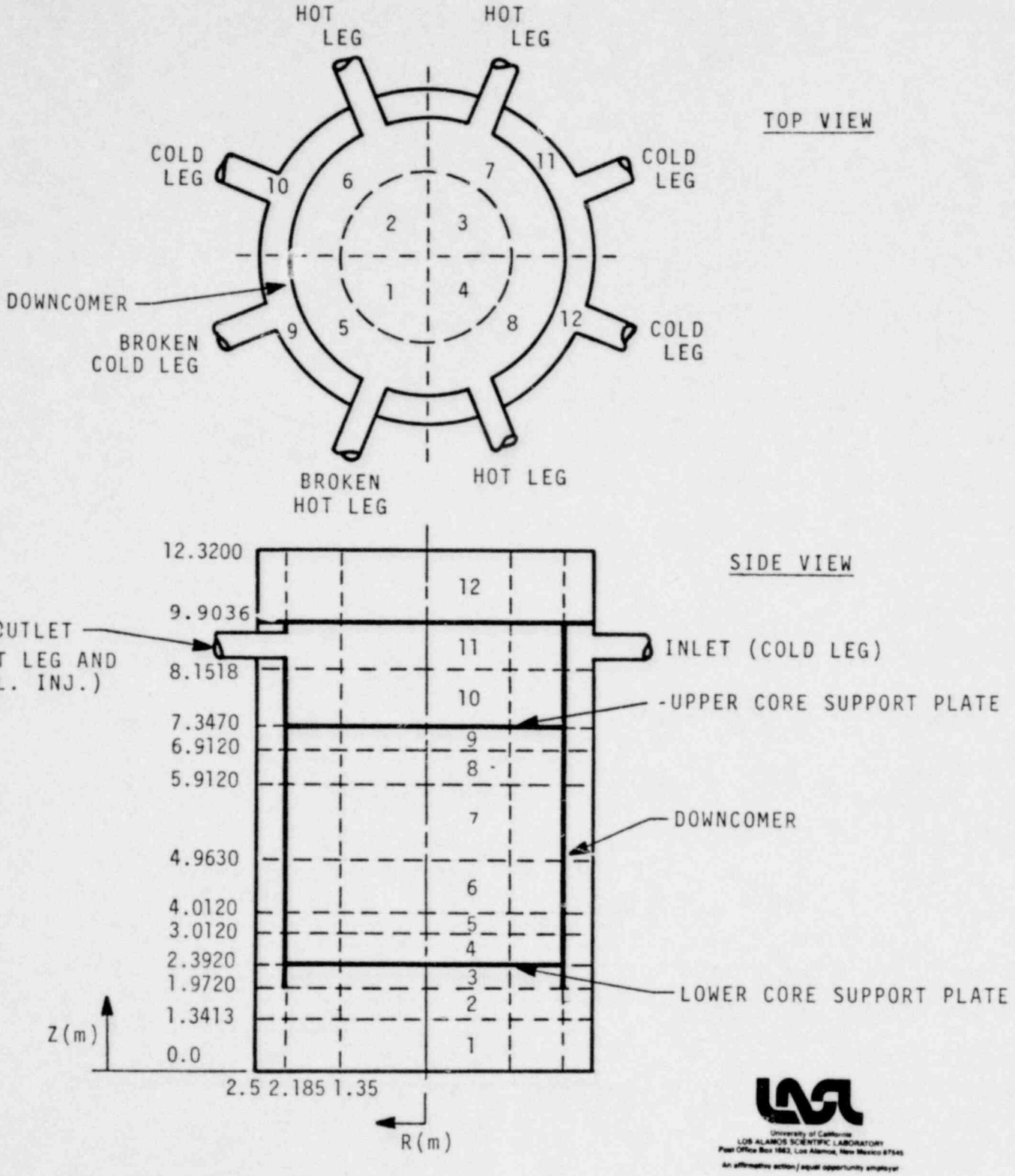

TRAC NODING FOR GERMAN PWR VESSEL.

GERMAN PWR

TABLE OF EVENTS

		TIME(S)	
		FINE-NODED	INTERMEDIATE - NODED
1.	200% DOUBLE-ENDED COLD-LEG BREAK (CLOSE OFF SECONDARY SIDE STEAM GENERATOR: TRIP REACTOR POWER AND PUMPS)	0.0	0.0
2.	FIRST AVERAGE ROD PEAK CLAD TEMPERATURE REACHED (ROD 4,2 - CORE LEVEL 3 - 1020 K)	6.2	6.2
3.	ACCUMULATOR FLOWS BEGIN IN ALL LOOPS	15.0	14.0
4.	SECOND AVERAGE ROD PEAK CLAD TEMPERATURE REACHED (ROD 12 - CORE LEVEL 3 - 1046 K)	20.8	-
5.	PRESSURIZER EMPTIES (LEVEL BELOW 0.1 m)	25.7	26.0
6.	LPIS FLOWS INITIATED IN COLD LEGS (ALL LOOPS)	58.0	52.1
7.	LOWER PLENUM REFILLED	59.0	70.0
8.	LPIS FLOWS INITIATED IN HOT LEGS (ALL LOOPS)	68.0	61.8
9.	QUENCH FRONTS MOVE THROUGH CORE MIDPLANE:		
	A. CENTRAL RODS	96.0	97.0
	B. PERIPHERAL RODS	55.0	70.0
10.	ENTIRE CORE QUENCHED	100.0	-

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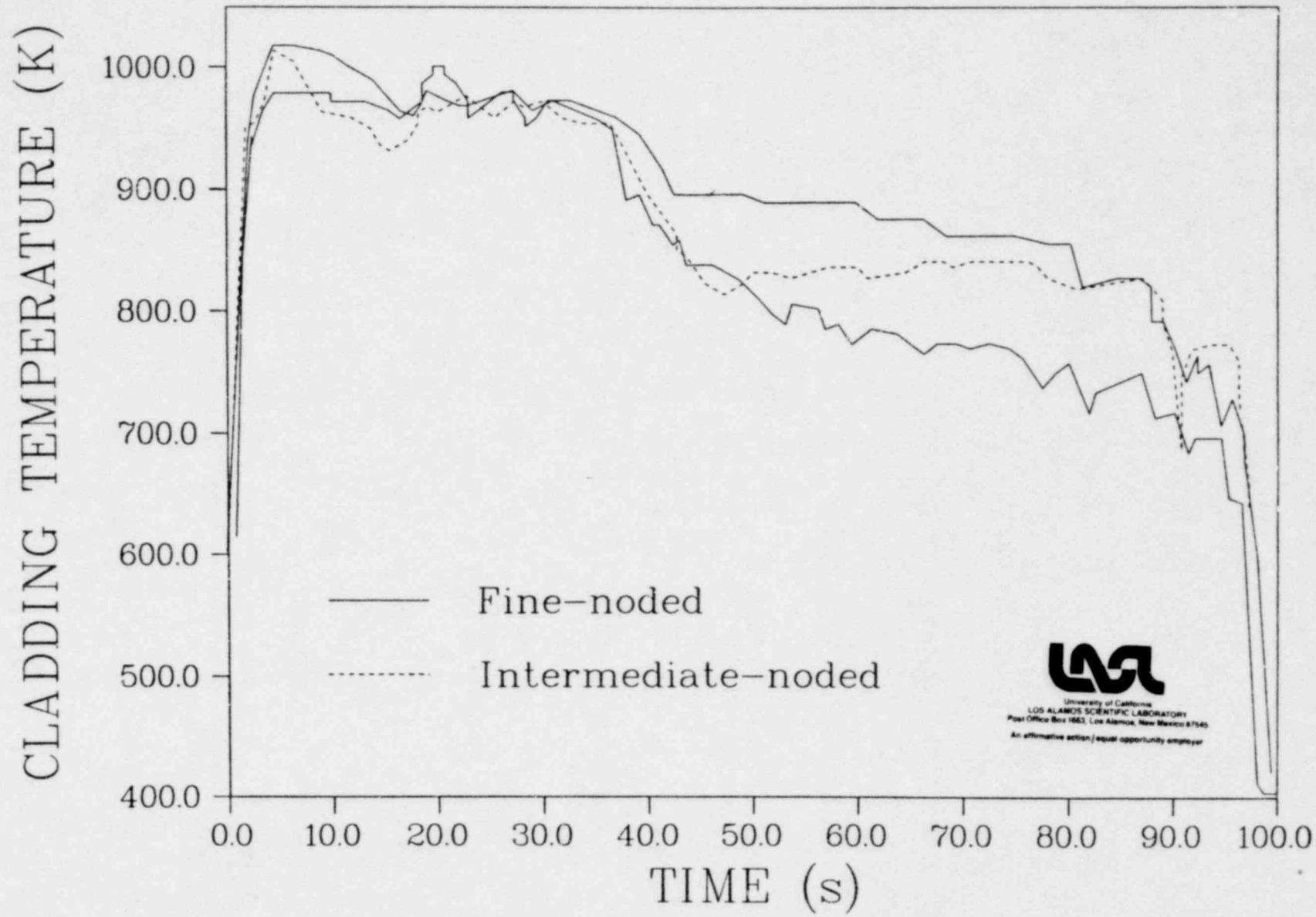

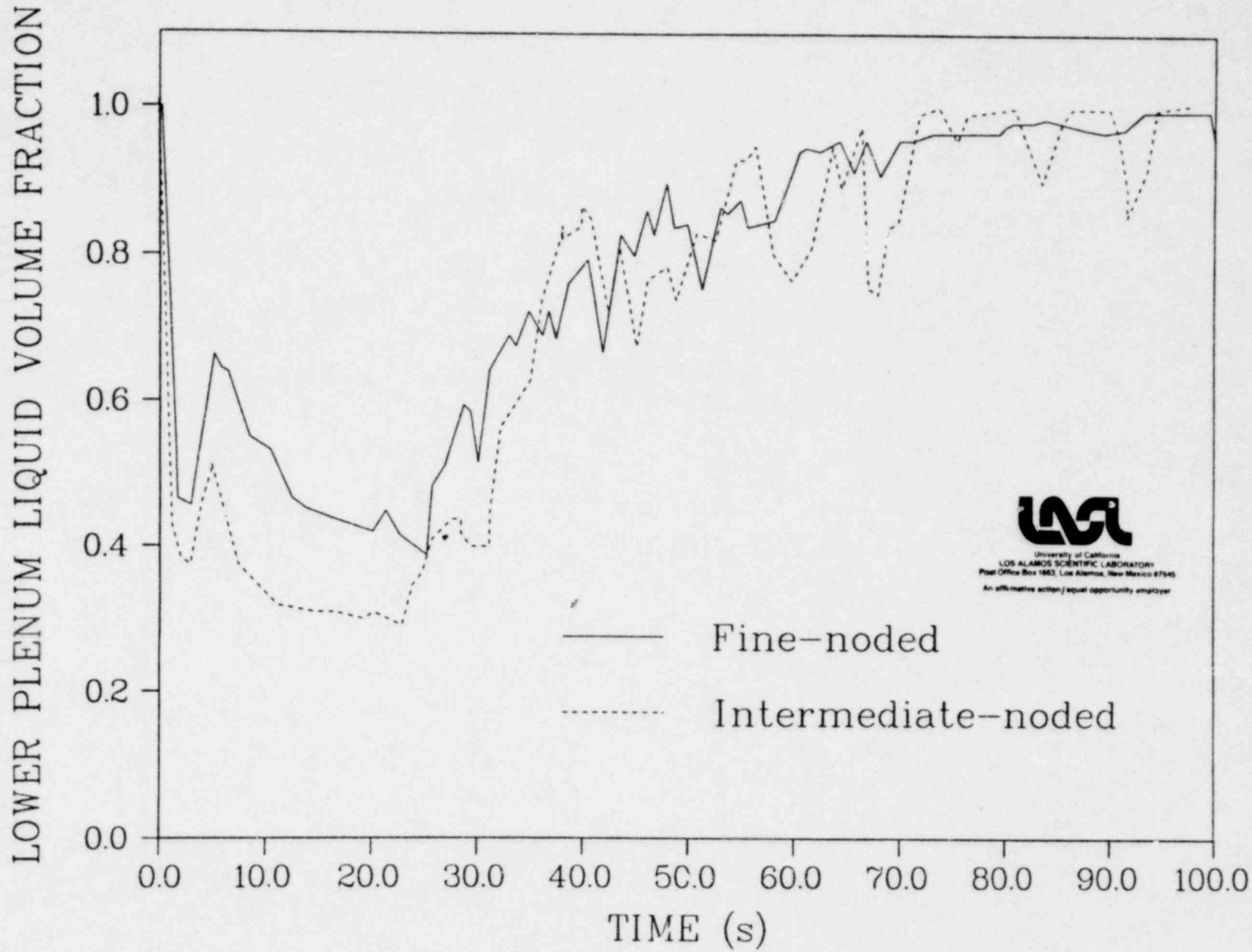
LOWER PLENUM LIQUID VOLUME FRACTION
1.0
0.8
0.6
0.4
0.2
0.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
TIME (s)
Fine-noded
Intermediate-noded
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SCTF STEAM SUPPLY CALCULATIONS

- OBJECTIVE: TO DETERMINE THE NECESSITY OF AN ADDITIONAL STEAM SUPPLY TO PROPERLY SIMULATE THE END-OF-BLOWDOWN AND REFILL IN THE SCTF WITH COMBINED INJECTION.

- MAJOR RESULTS:
  1. STEAM SUPPLY IS NECESSARY FOR PROTOTYPIC FLOWS (BASED ON TRAC PWR CALCULATIONS).
  2. NEED ON THE ORDER OF 400 KG TOTAL STEAM.
  3. WILL BE VERY DIFFICULT TO MAINTAIN PROTOTYPIC FLOWS.

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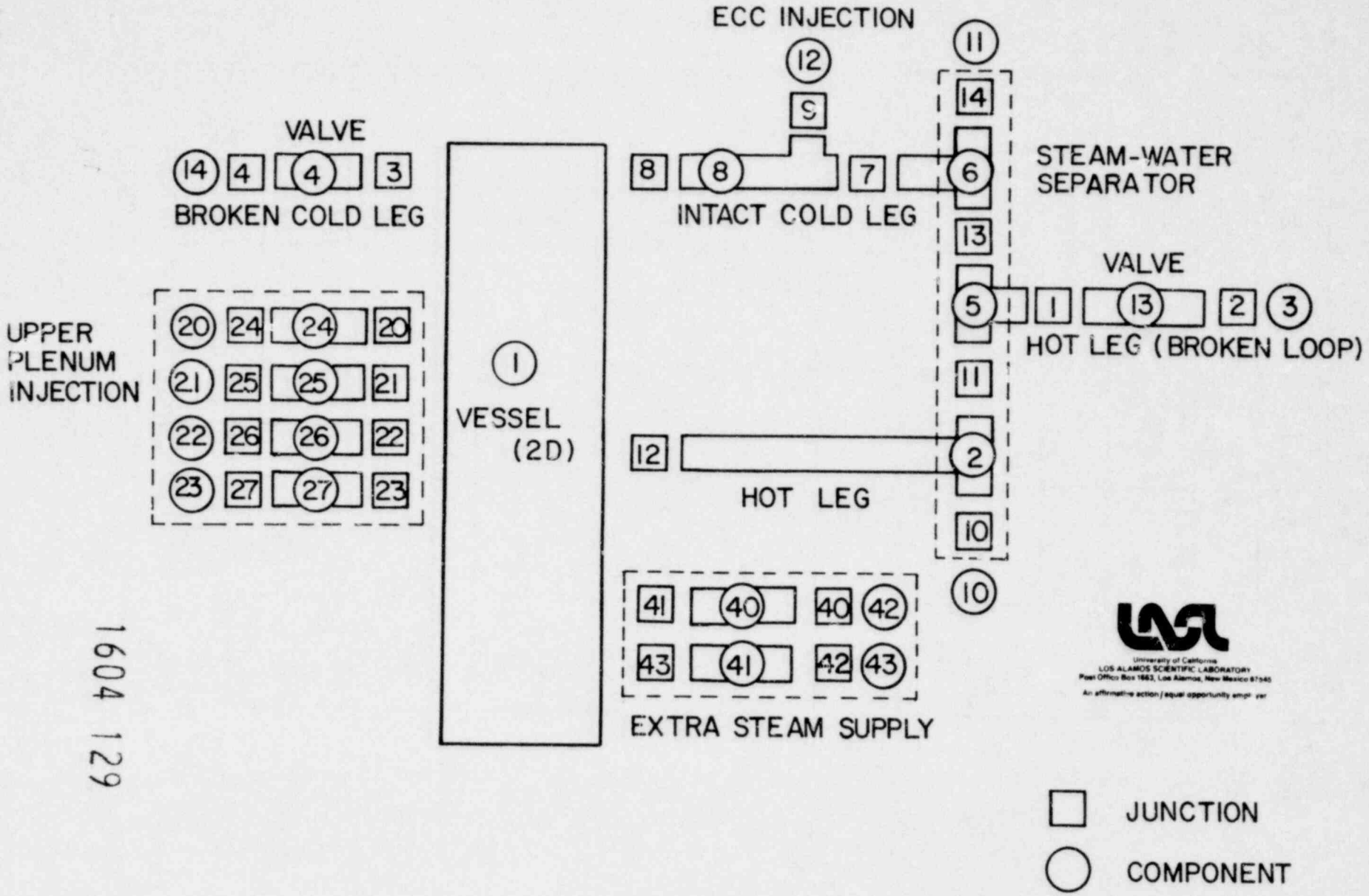
SCTF SYSTEM NODING DIAGRAM



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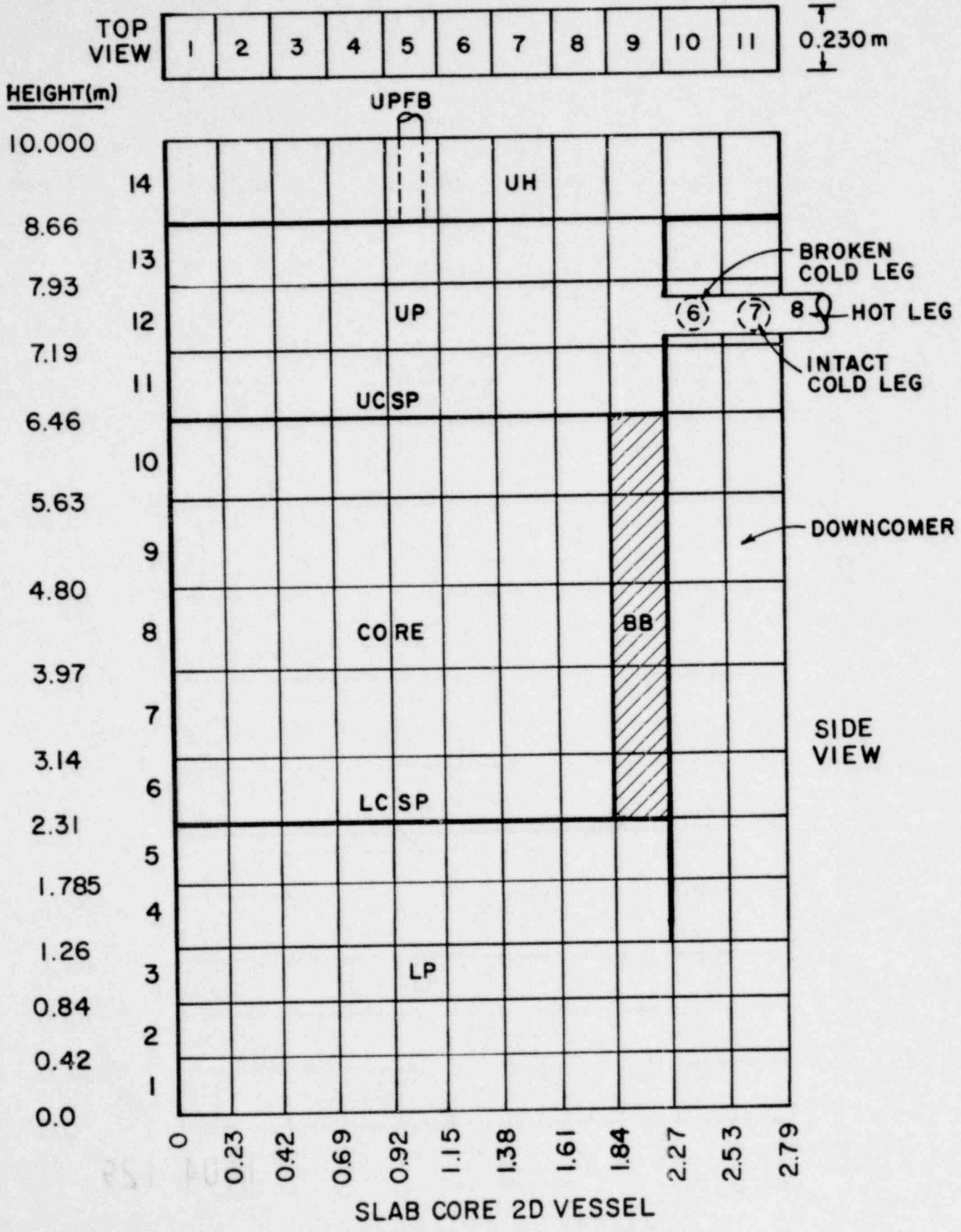
TOP VIEW
1
2
3
4
5
6
7
8
9
10
11
0.230m
HEIGHT(m)
10.000
8.66
7.93
7.19
6.46
5.63
4.80
3.97
3.14
2.31
1.785
1.26
0.84
0.42
0.0
UPFB
UH
UP
UCSP
CORE
LCSP
LP
BB
BROKEN COLD LEG
HOT LEG
INTACT COLD LEG
DOWNCOMER
SIDE VIEW
0
0.23
0.42
0.69
0.92
1.15
1.38
1.61
1.84
2.27
2.53
2.79
SLAB CORE 2D VESSEL

SCTF INITIAL CONDITIONS

POWER: 11.0MW (ANS DECAY)

PRESSURES: SYSTEM - 6.0 BARS
BREAK - 3.0 BARS

TEMPERATURES: PEAK CLAD - 885°K
VESSEL INTERNALS - 430°K (SATURATION)
COLD LEG ECC - 330°K
UPPER PLENUM ECC - 400°K
LOWER PLENUM LIQUID - 430°K
PRIMARY PIPING - 430°K

LOWER PLENUM 72% FULL

COLD LEG INJECTION FLOW RATE - SCALED FROM GERMAN PWR

UPPER PLENUM INJECTION FLOW RATE - 60 KG/S.

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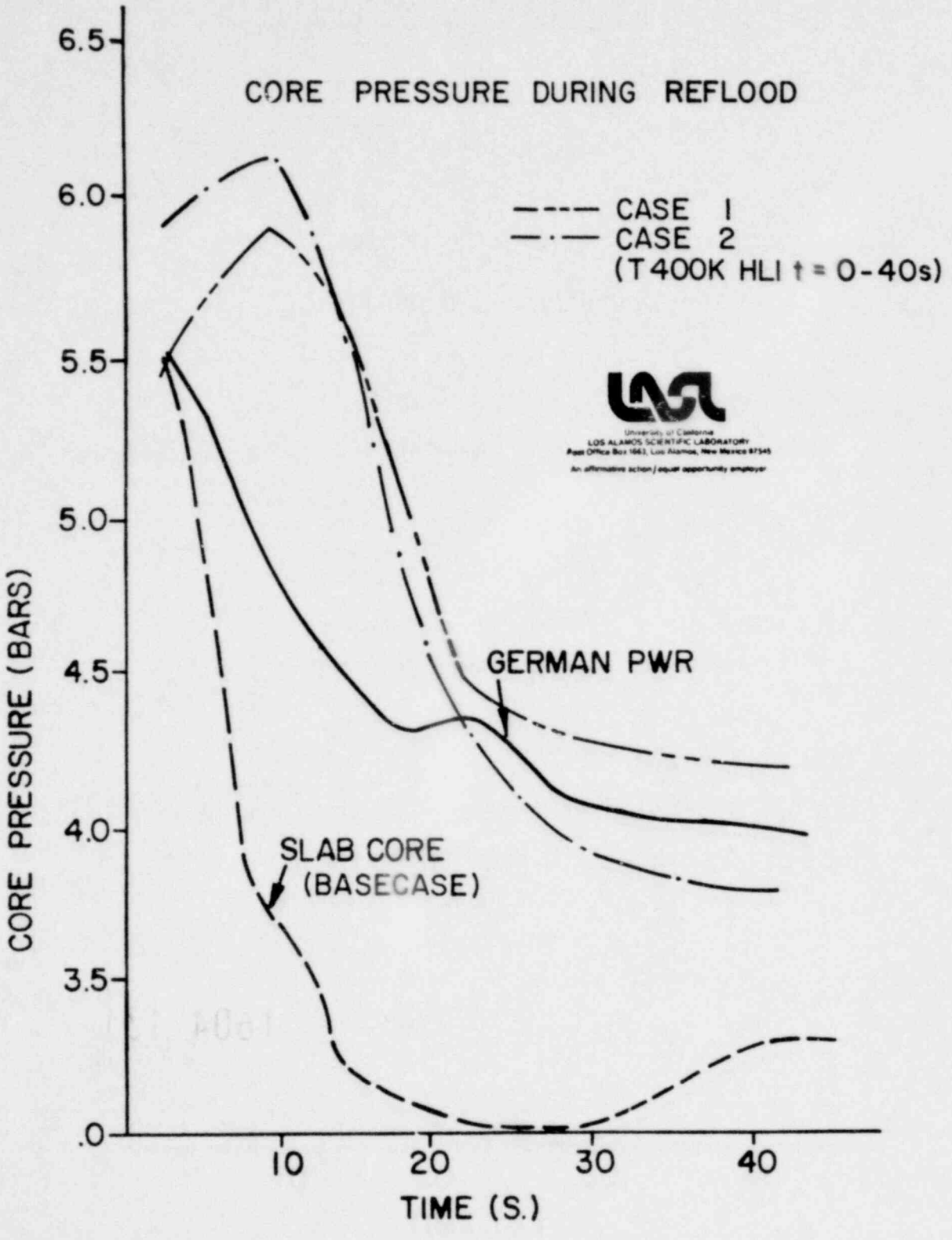

CORE STEAM FLOW RATES DURING REFLOOD