March 15, 1982

MEMORANDUM TO: Robert B. Minogue, Director
Office of Nuclear Regulatory Research

FROM: D. F. Ross, Deputy Director, RES

SUBJECT: TRIP REPORT, CHINA & JAPAN

I visited PRC on March 3-6, 1982, and Japan on March 8-11, 1982, and have the following to report.

China

The first day, March 3, consisted of a series of lectures by me on NRC licensing procedures, siting & environmental matters, and regulation of operating plants. The audience consisted of about 40 staff from the 2nd Ministry of Power, and the Ministry of Nuclear Power. (See Table 1 for some names and titles). The co-hosts were Wei Zhaolin and Jin Shiqu (the General Director of the Nuclear Power Bureau in the Ministry of Power). In a separate meeting Mr. Jin stressed his concern about increasing the ability of the Chinese engineers to perform safety analysis using available computer codes. I mentioned that we might be able to send H. Sullivan in connection with his April Tokyo visit. Both Jin and Wei were very concerned about publicity on Ginna (i.e., a story implying that as a result, 1/3 of US reactors were shut down).

On March 4 I journeyed to the Institute of Atomic Energy and lectured to about 100 engineers on transient & accident analysis, TMI-2, severe accidents, and PRA. The host there was Dai Chuanzeng. In the questioning there was the most interest in safety analysis and computer codes, and PRA. Dai wants information on international standard problem. He also has an interest in detailed discussion on PRA. I mentioned that we could send an expert (Bernero) but that funding would have to be worked out, as Bernero had no nearby mission (A syllabus should be sent to our Peking Embassy scientific counselor Otto Schnepp, for information).

On March 6 I met with Jiang Shengjie, Vice-Minister of 2nd Ministry of Machine Building. This meeting was largely arranged by our Dr. Schnepp, on the basis that in PRC there is a substantial government-wide reorganization in progress, and that Mr. Jiang might be a more pertinent continuing contact. Mr. Jiang's responsibilities include R&D, design, construction, fuel, components, and nuclear safety. He also would like to have more information from us on safety analysis. We discussed future cooperative R&D; I said I would send our LRRP when published. They need immediate help now in QA, licensing procedures, and design standards. Mr. Jiang may request sending a detail to NRC for an extended period. He indicated an interest in operating data, from ocean-based plants, on environmental effect and radioactive releases to the ocean. I said we could provide.

Japan (See Table 2 for contacts)

On Monday, March 8, I (and H. Sullivan) toured the JAERI facilities at Tokai. Our host was Mr. Nozawa, Director of the Reactor Safety Research Center. We toured CCTF, SCTF, ROSA II-III, and their version of ACRR named NSRR. They also are interested in Ginna, and would like a sequence of events. They plan to contribute to PBF-Severe Fuel Damage, but need our Severe Accident Research Plan soon (~6 weeks), in order to bolster their FY 83 budget request. We had a detailed presentation on ROSA-IV which, in my opinion, can generate safety information at least as useful as LOFT. We are in the program on the basis of two loaned engineers (or ~200K/yr). Tests will start in 2 years, on TMI simulation, ATWS, SBLOCA, National Circulation, and others. There are 1080 heated rods (total power 10 Mw).

On Tuesday, March 9, we met with Nozawa. fmann (of FRG) and edited the 2D-3D program plan. Then we (Harold & to Hitachi and met with Mr. Naitoh and his department manager, Y. .atuo (of the Energy Research Laboratory, at 1168 Moriyama-cho, Hitachi-shi, Ibaraki-ken, 316 Japan). We discussed the two-bundle loop (TBL) and the 60^{o} core spray tests. TBL is sponsored by 6 utilities plus Hitachi and Toshiba (both BWR Manufacturers). TBL is being refurbished to start series 2 (intermediate and SB) about October 82. A total of 10 Mw electrical heat is available. They are now using RELAP5, MOD 0, but wish to use cycle 14, as well as TRAC Version 12. A satisfactory arrangement was developed.

The 2D-3D Steering Committee met on March 10, 1982, in JAERI headquarters, Tokyo. The representatives were:

USNRC	FRG	JAERI
D. Ross	W. Schmidt-Küster	I. Miyanaga
L. H. Sullivan	K. Hofmann	M. Nozawa
		K. Hirano

I. Miyanaga, member of Board of Directors of JAERI (as SC member from Japan) was the chairman. Dr. Nozawa, Director of the Reactor Safety Research Center of JAERI-Tokai (and Japan TCC member) served as assistant meeting chairman.

Dr. Schmidt-Küster, director-general of Energy, Environment, Resources Directorate of BMFT (Seipel's boss, and acting SC member) made opening remarks. He noted severe challenge in project continuation due to financial constraints. He thought there was no further margin, financially.

Ross indicated that he hoped that 2D/3D data would be useful and used in the licensing process, either for optimizing ECCS for new designs, or a realistic assessment of LOCA (for existing designs).

Hofmann discussed the status of UPTF. His viewgraphs are attached.

Sullivan presented the status of the US portion of 2D/3D. His viewgraphs are attached.

Hirano gave the JAERI status report (slides attached).

(NOTE: When each party discussed cost-to-complete, only US used constant dollars. We should, in any future internal discussions, show also allowance for inflation.)

Hofmann, in discussing the program, noted that, at present, UPTF will start testing 3-1/2 years later than the trilaterial agreement signed 2 years ago.

Schmidt-Küster suggested condensing our proposed rewrite of the US page on DAS, making it more general in some respects. (Ross would not agree to more than $1.5M whether parts or labor). The condensed version is shown on p. 48 of the revised program plan, which was accepted and signed by all (copy attached).

We agreed that the Fall '82 meeting (TCC/Coordination) would be in October, in Washington, D.C. In the spring of 83, there will be TCC/Coordination/SC meeting in FRG. The dates and sites were switched to make better use of the October WRSR meeting here.

<u>Other Matters</u>

Extension of the agreement past April 1985 was discussed. Parties will exchange plans before the SC meeting in April '83.

On Thursday, March 11, Ross & Sullivan met with K. Aisaka (roughly, Bassett's counterpart) of MITI; M. Shiba of JAERI attended as interpreter; S. Nagamatsu of MITI also attended (see Table 3). We discussed our Steam Generator Project.

MITI is organizing a committee of Japanese utilities which, it is planned, will contract with PNL as a cosponsor. They expect to have arrangements complete by this fall.

MITI is sending 3 people (Tariguchi and two others) to NRC week of March 15-19. They wish to discuss SASA with us. This team will get information on Ginna, also. Their local agent, Kamimura (of OEISI) may contact us for further information.

DFRoss

D. F. Ross, Deputy Director
Office of Nuclear Regulatory Research

Attachments:
As stated

TABLE 1

Jiang Shengjie

Executive Vice President, the Chinese Nuclear Society, Vice Minister, the Second Ministry of Machine Building

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Wei Zhaolin

Director, the Fifth Bureau of the State Scientific and Technological Commission

The State Scientific and Technological Commission, Beijing (Peking) PRC

Zhang Shiguan

Engineer
The Technical Information Institute, The Second Ministry of Machine Building

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Dai Chuanzeng, Ph.D.

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Member of Mathematics & Physics Division, Academia Sinica

Institute of Atomic Energy, Second Ministry of Machine Building
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Zhang Chongyan

Engineer
the Fifth Bureau of the State Scientific and Technological Commission

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TABLE 2

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Table 3

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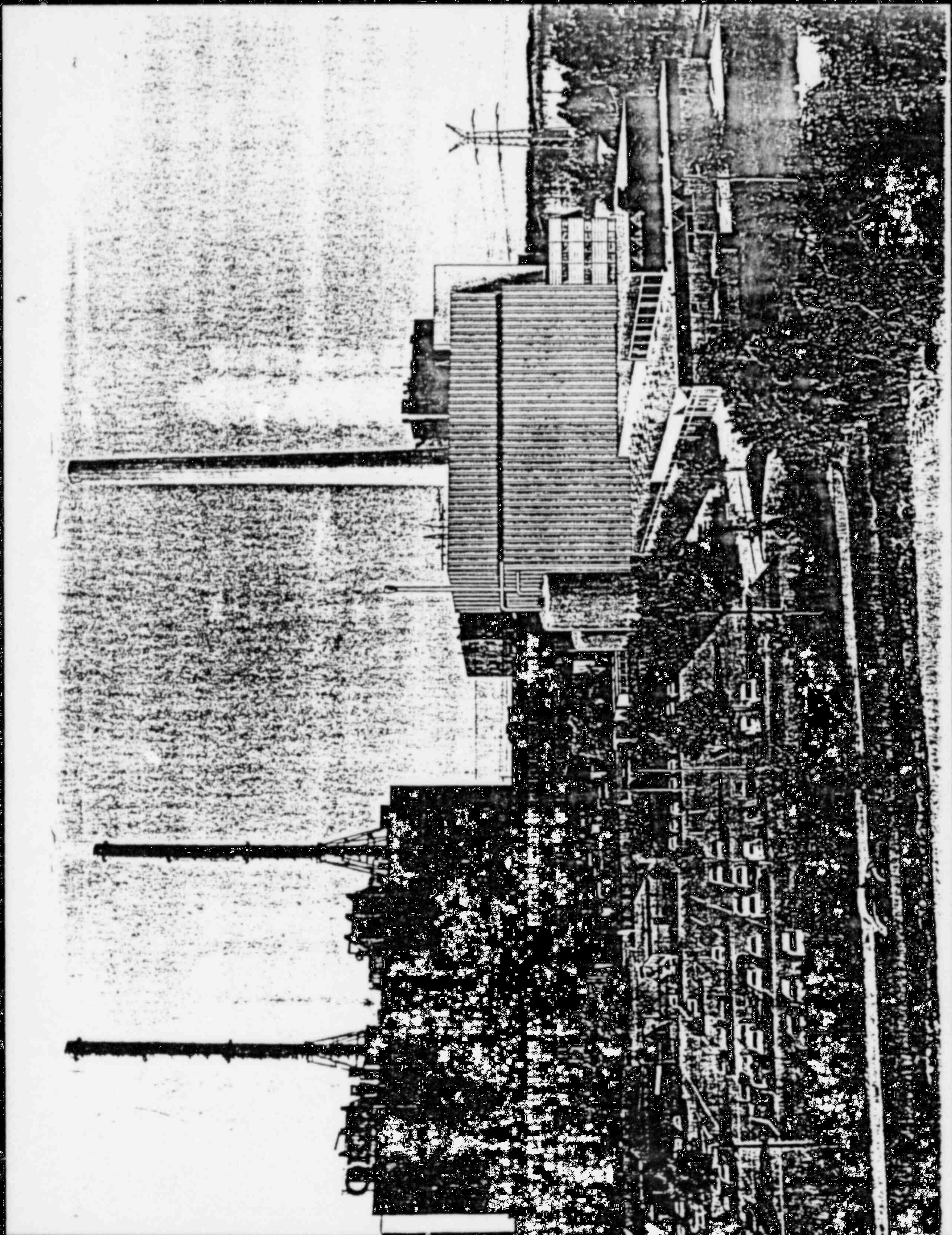
2D/3D PROJECT

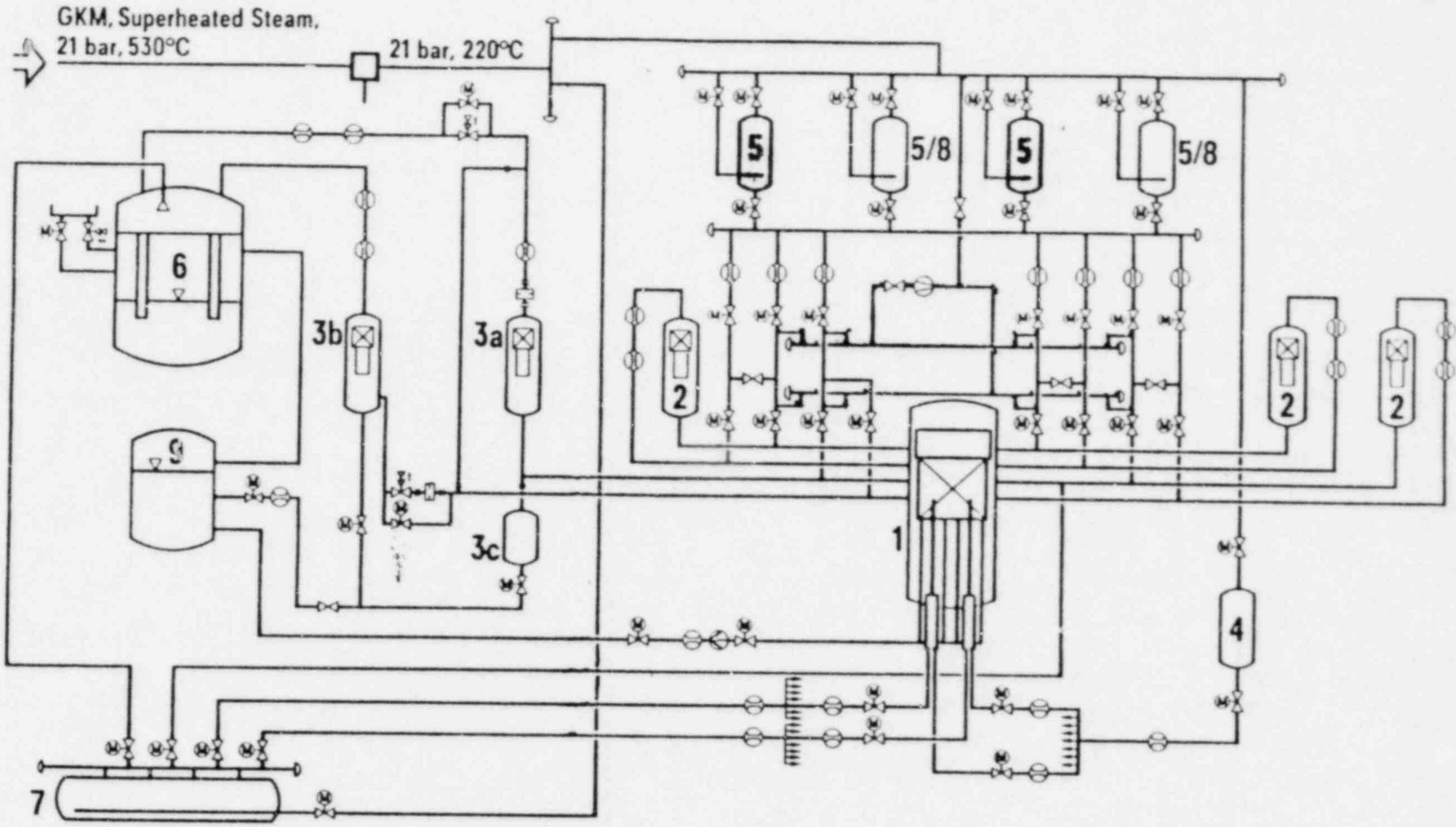
STEERING COMMITTEE MEETING

MARCH 10, 1982

JAERI, TOKYO

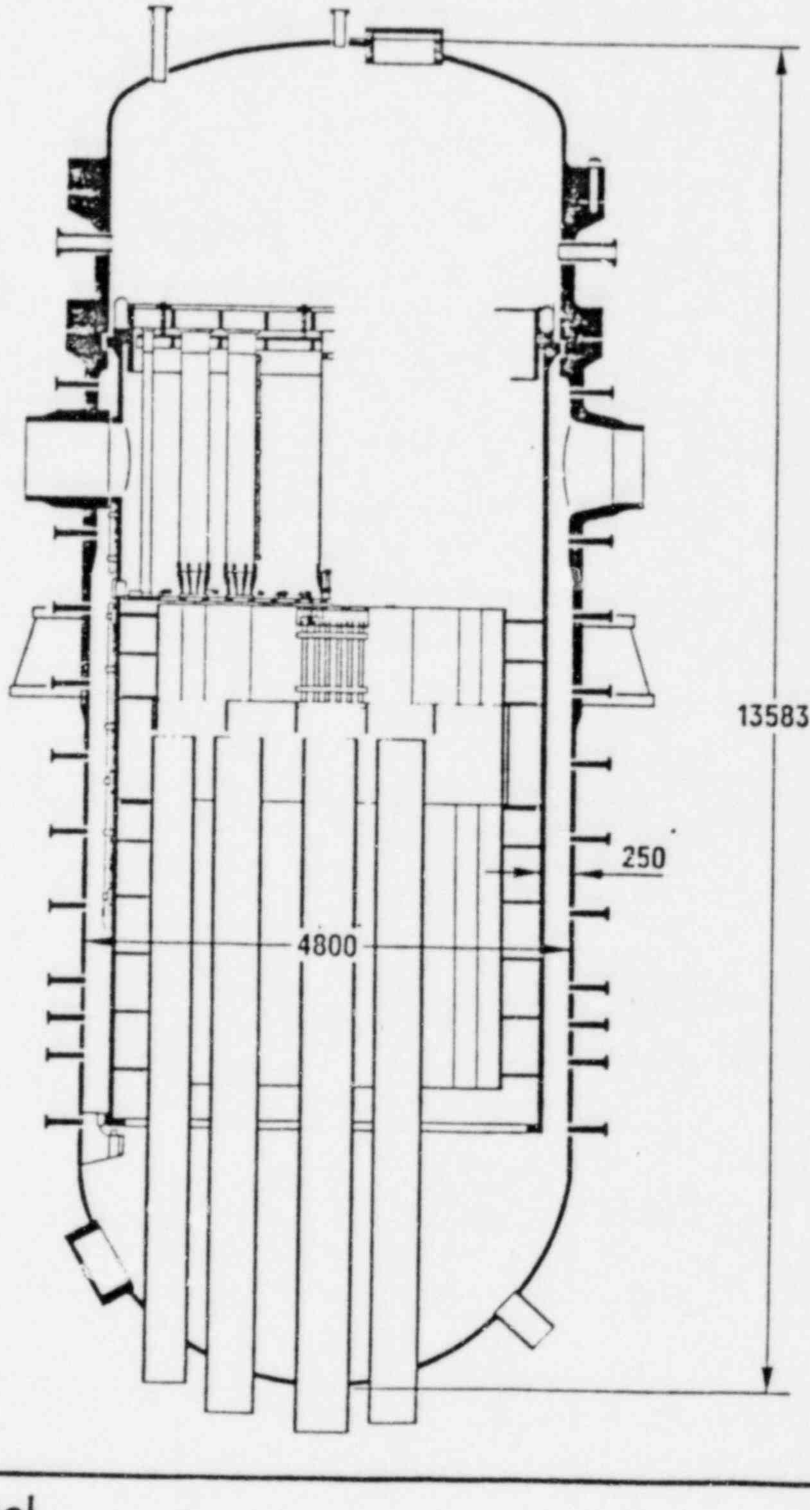
FRG HANDOUT



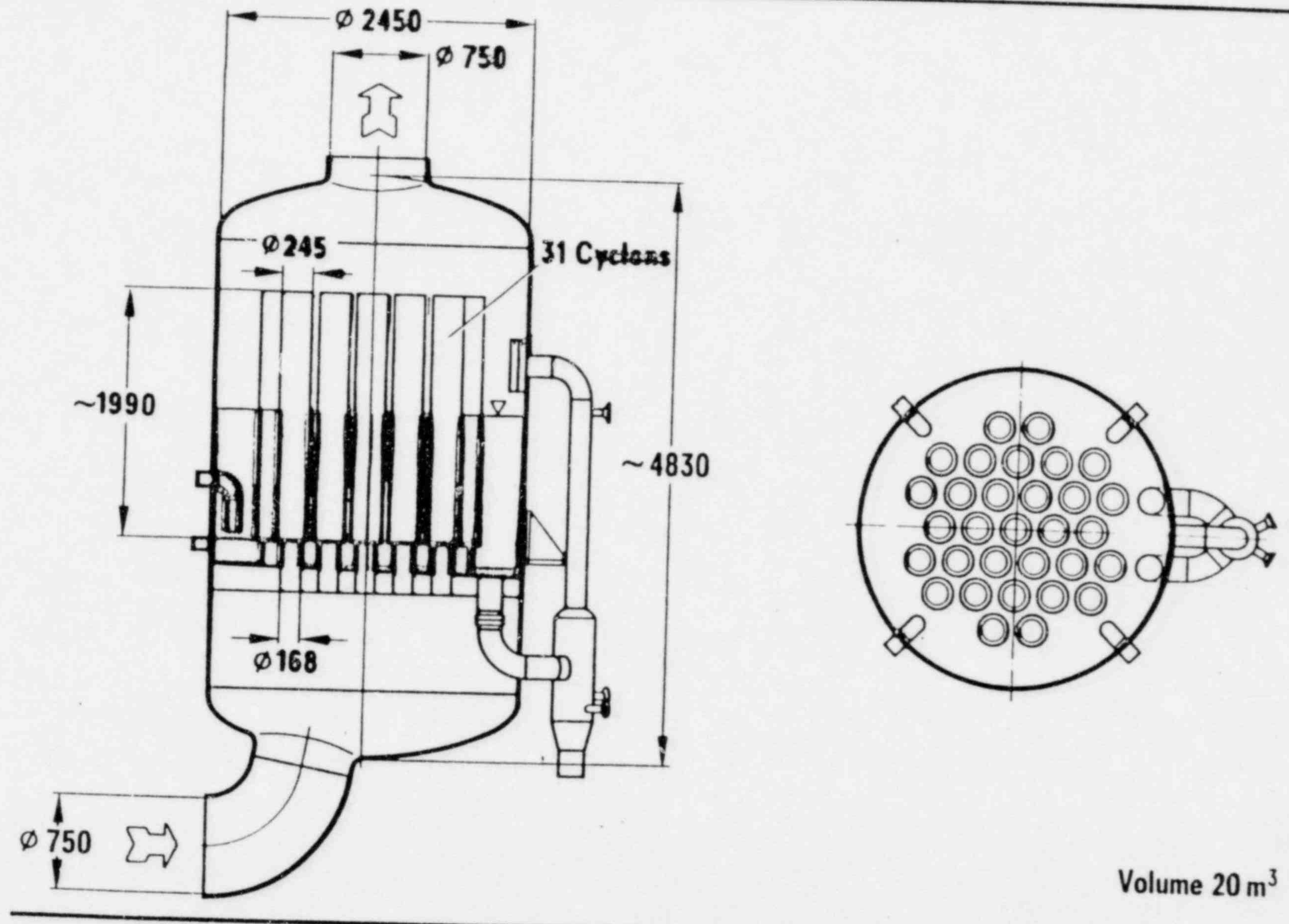


1 Test Vessel
2 Steam Generator Simulator (Intact Loop)
3a Water Separator (Broken Loop, Hot Leg)
3b Water Separator (Broken Loop, Cold Leg)
3c Drainage Vessel for Hot Leg Break
4 Hot Water Storage Tank
5 Accumulator
6 Containment Simulator
7 Steam Storage Tank
8 N_2 – Tank
9 Water Collecting Tank

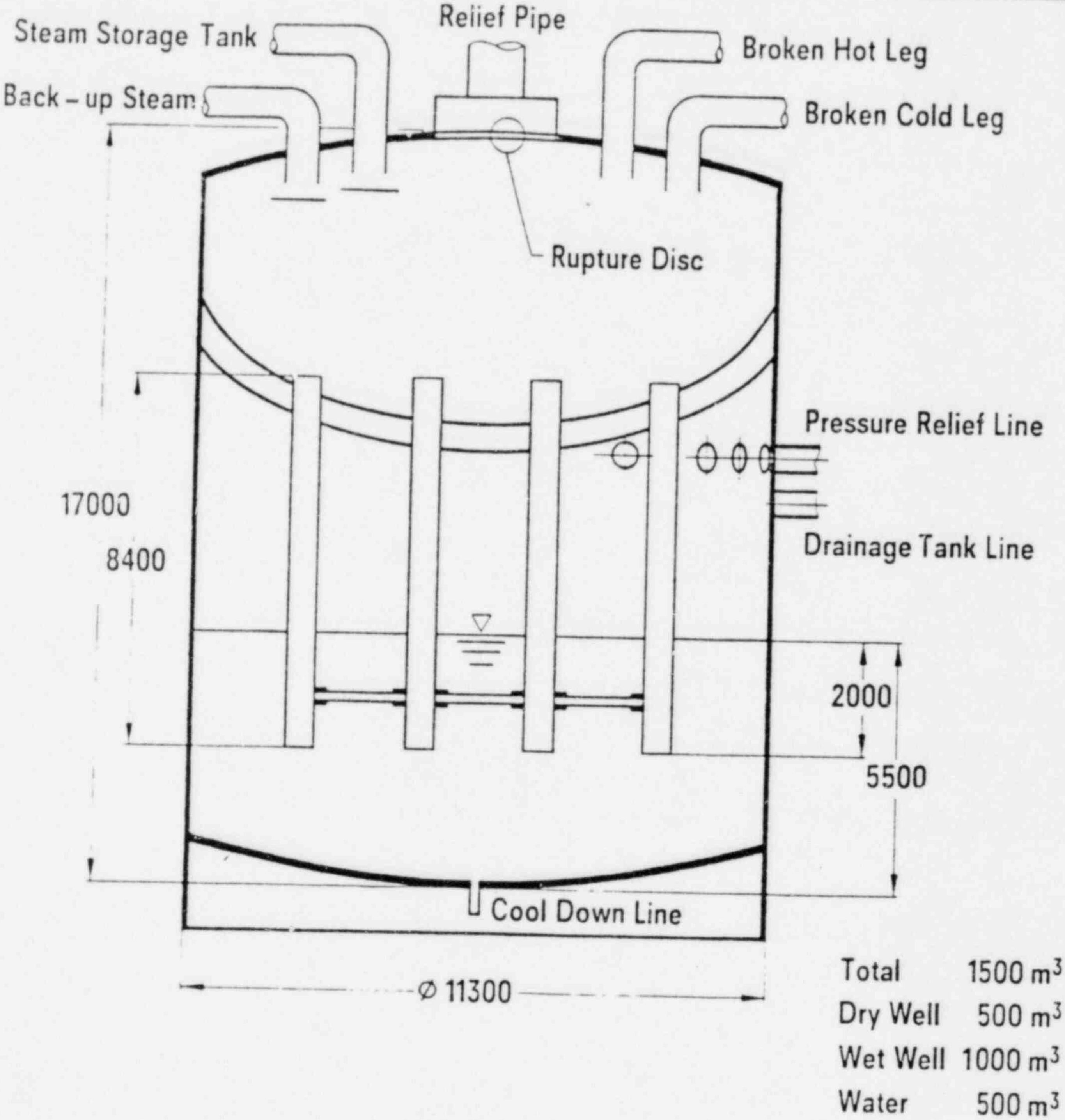
UPTF – Flow Diagram



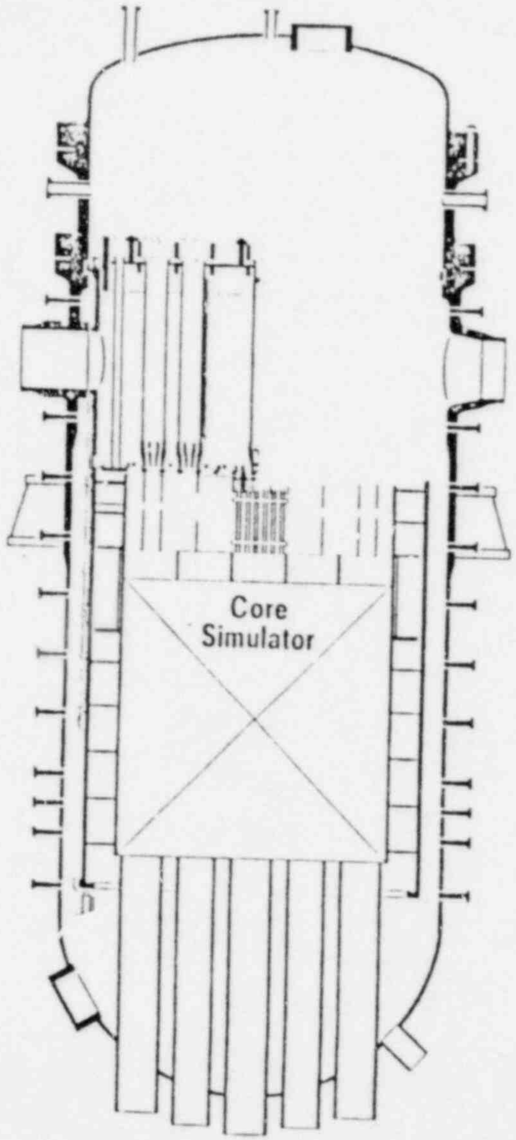
UPTF – Test Vessel



Steam Generator Simulator (UPTF)
Intact Loop

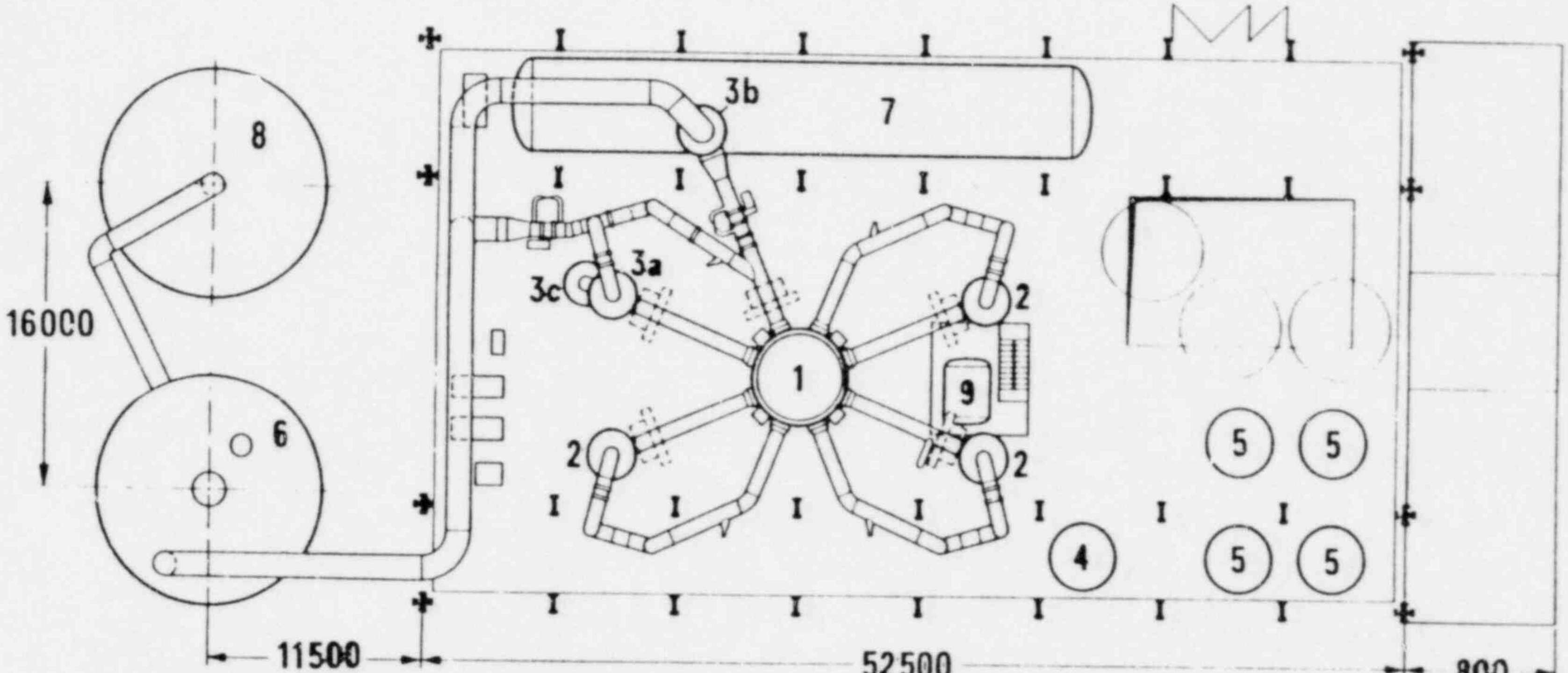


Containment Simulator (UPTF)



Instrumentation in Test Vessel	Upper Plenum	Core-Upper Plenum Interface	Core	Lower Plenum	Down-comer
Fluid Temperature	X	X		X	X
Fluid Temperature below End Box		X			
Wall Temperature					X
Pressure	X				
DP to Containment	X				X
DP Upper Plenum – Downcomer	X				X
DP Vent Valve	X				X
DP axial		X			X
DP horizontal					X
LLD	X		X	X	
FDG	X	X			X
Break Through Det.		X			
	X				
Video Probes	X				
Turbines vertical	X				X
Turbines horizontal	X	X			
Turbines & String Probes					X
Flow Modules		X			
Conductivity Probe				X	

Instrumentation in Test Vessel



1 Test Vessel
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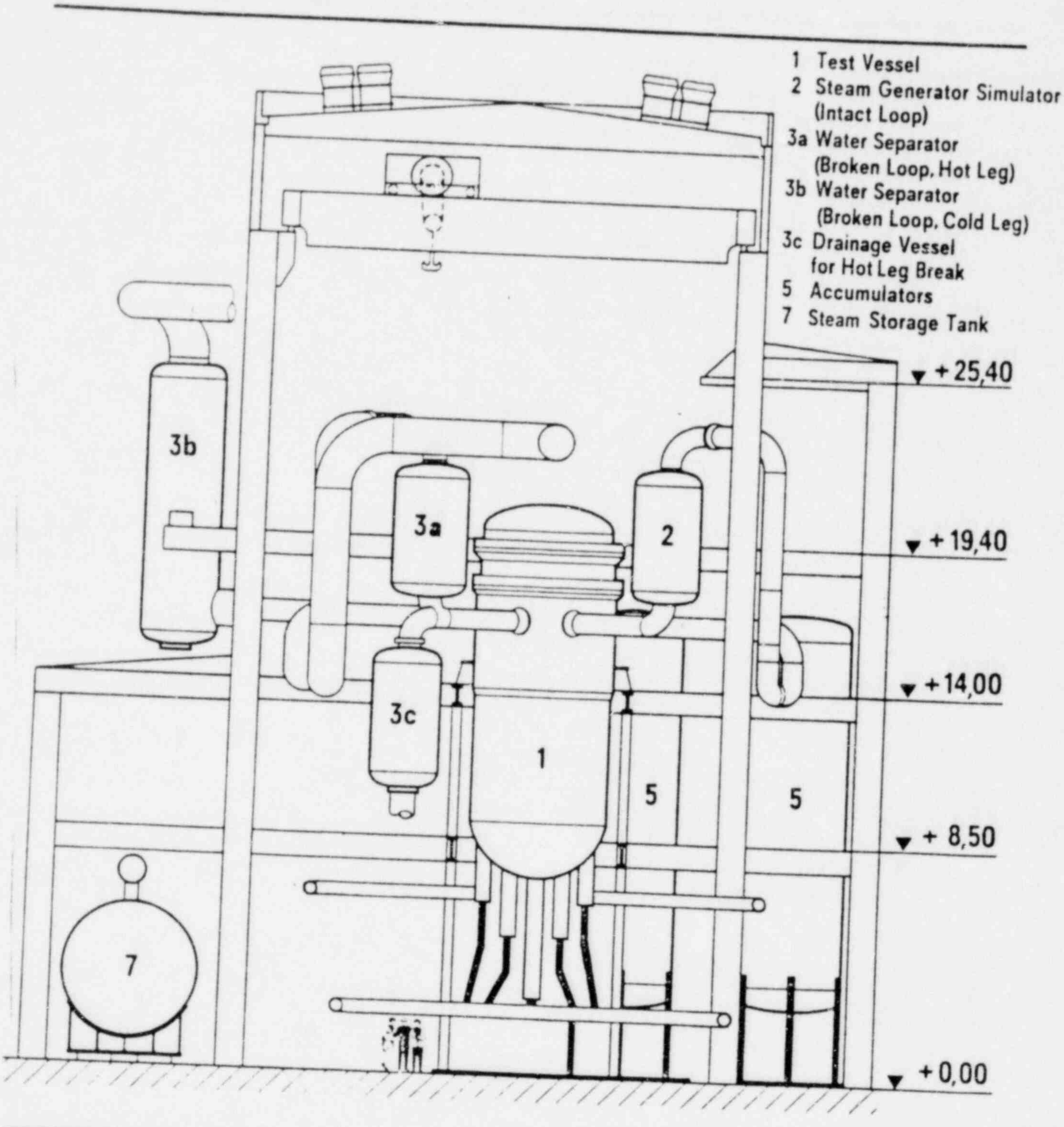
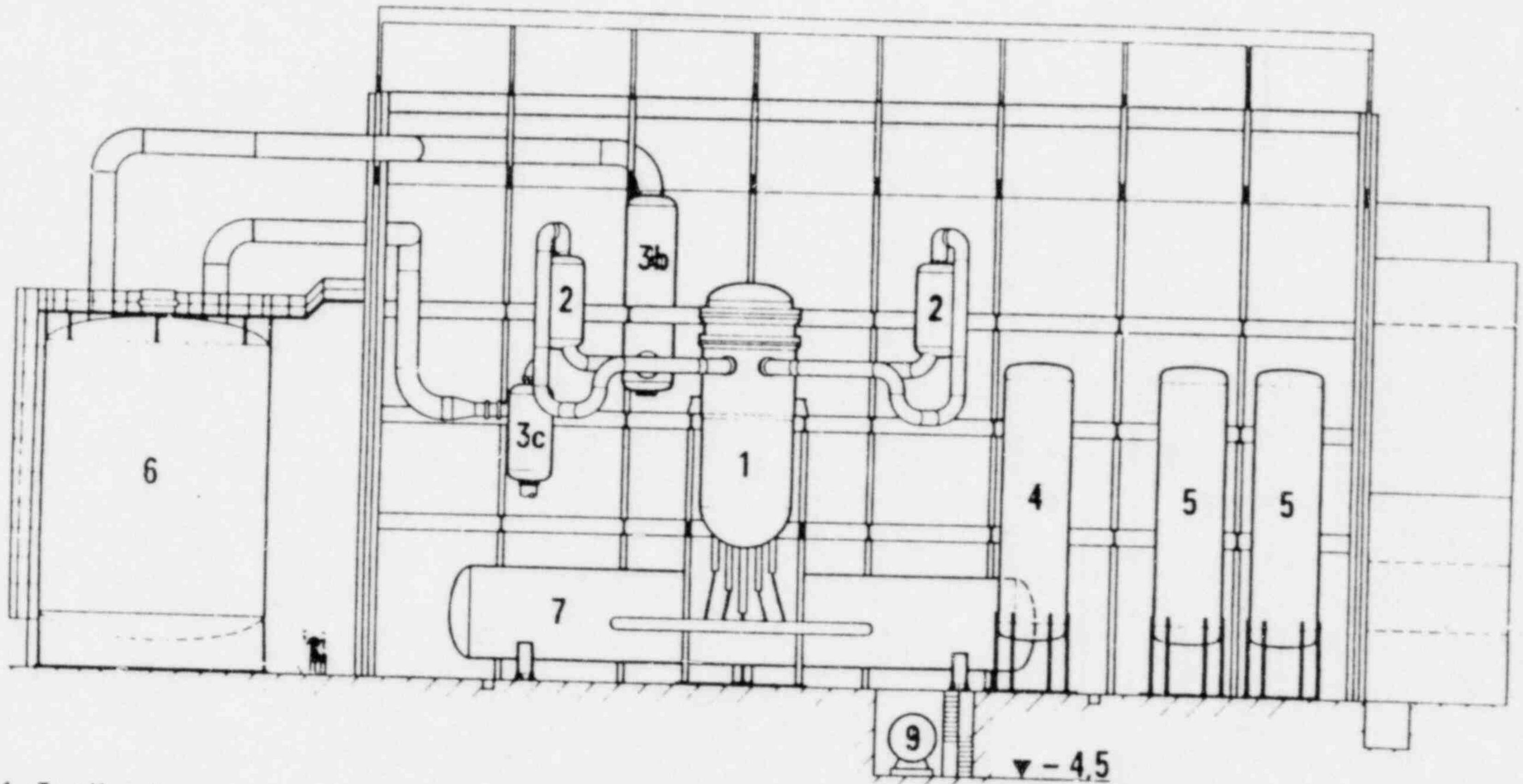
3c Drainage Vessel for Hot Leg Break
4 Hot Water Storage Tank
5 Accumulators
6 Containment Simulator
7 Steam Storage Tank
8 Water Drainage Tank
9 Drain Storage Tank

UPTF Layout
Top View



UPTF Layout
Side View



1 Test Vessel
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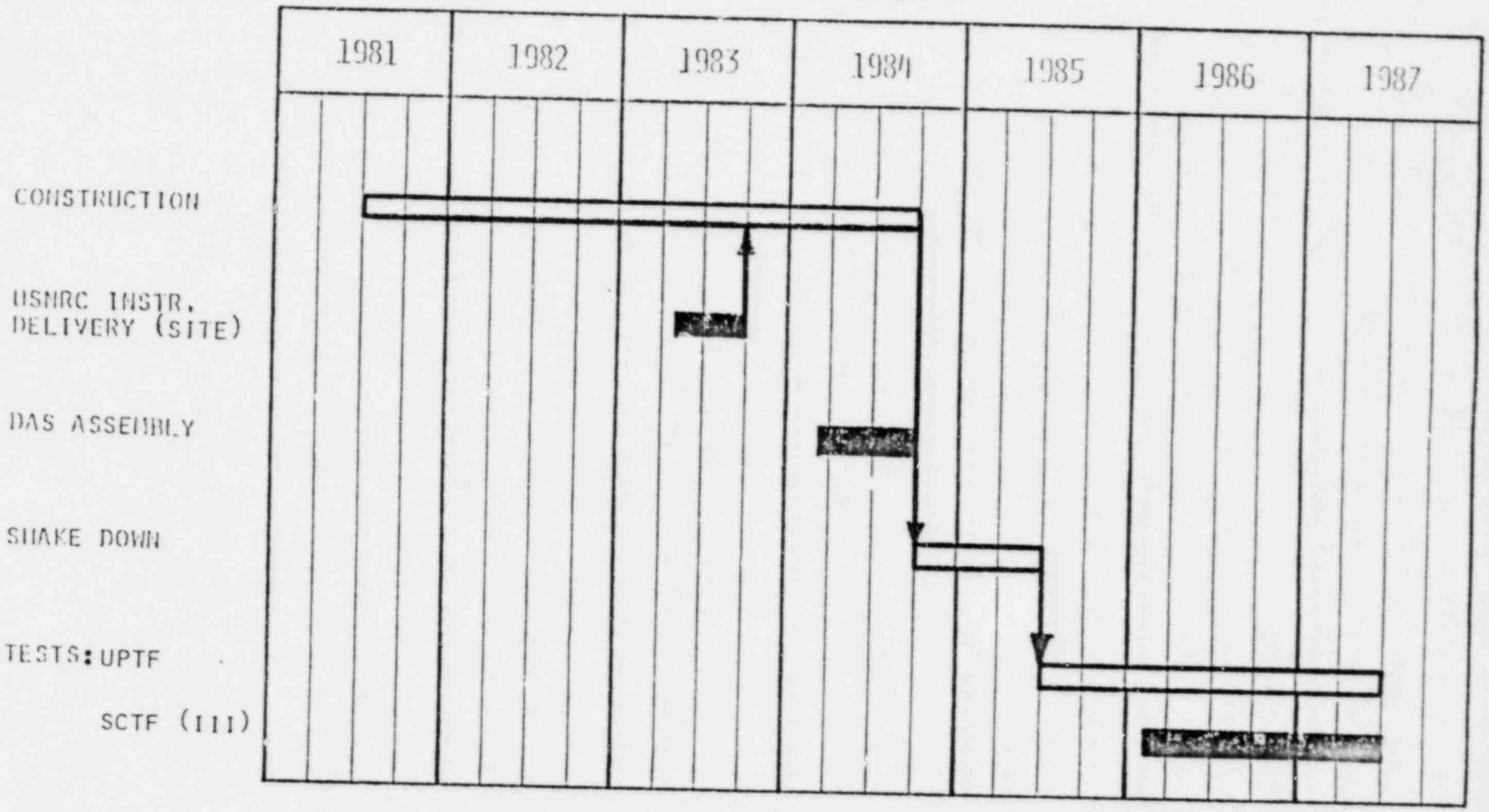
3c Drainage Vessel for Hot Leg Break
4 Hot Water Storage Tank
5 Accumulators
6 Containment
7 Steam Storage Tank
9 Drain Storage Tank

UPTF Layout
Front View



2D/3D PROJECT, UPTF SCHEDULE

December 1981

TYPE OF TEST	NUMBER OF TESTS	
A. SEPARATE EFFECTS TESTS	13	
1. DOWNCOMER		6
2. UPPER PLENUM		6
3. STEAM GENERATOR TUBE BREAK		1
B. INTEGRAL TESTS	17	
1. COMBINED INJECTION		8
2. COLD LEG INJECTION (INCL. B&W)		7
3. ALTERNATIVE ECCS		2
TOTAL NUMBER OF TESTS	30	

TABLE 3-1: PRELIMINARY TEST MATRIX FOR THE UPTF

STATUS OF UPTF

MARCH 1982

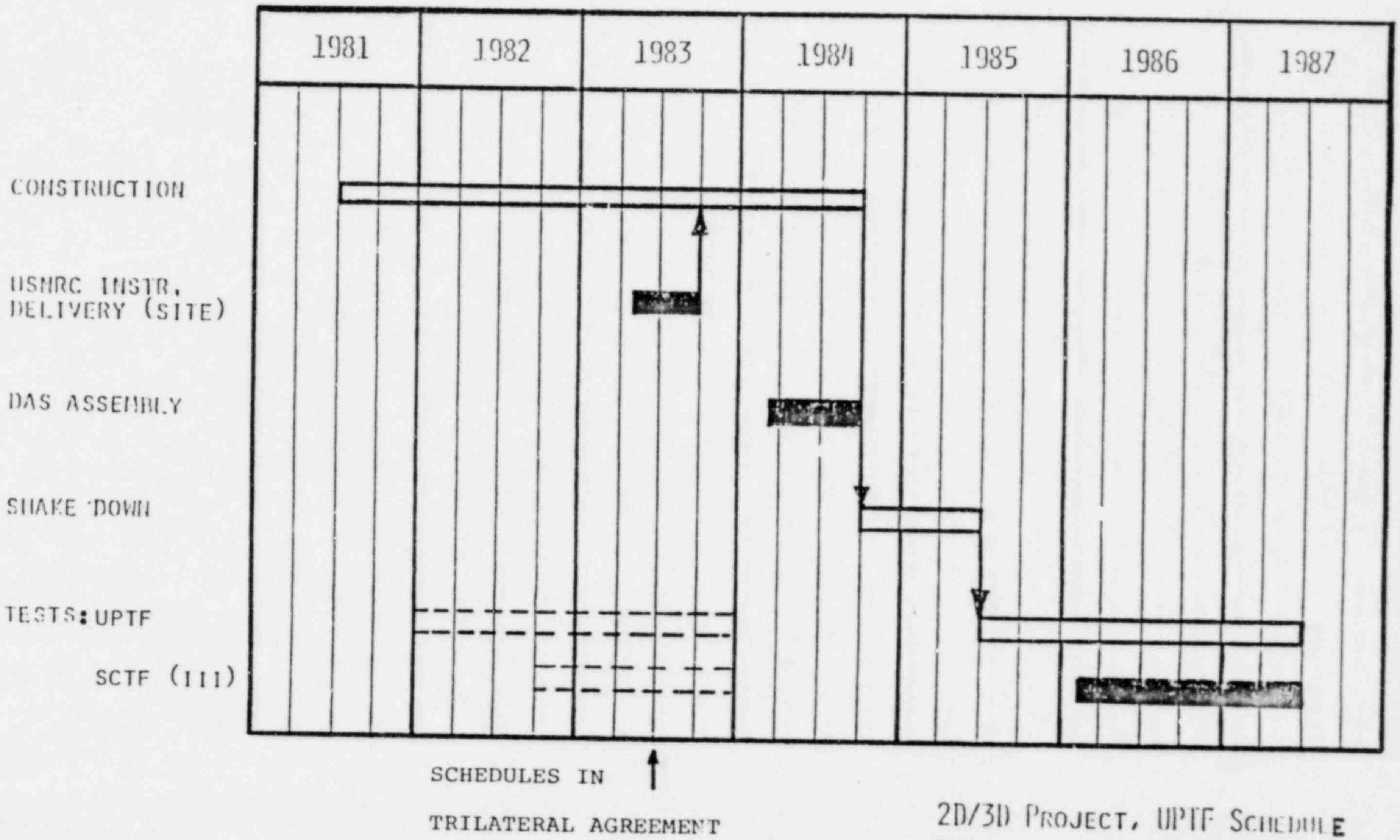
- TIME SCHEDULE UNCHANGED SINCE 1980
- CONTRACTS FOR UPTF CONSTRUCTION GIVEN TO KWU AND GKM IN SEPTEMBER 1981
- TIME LEADING COMPONENTS HAVE BEEN ORDERED
- CONSTRUCTION OF BUILDING STARTED MARCH 1, 1982
- BEGIN OF UPTF TESTING PLANNED FOR MID 1985 (2 YEARS TESTING)
- KWU WILL BE CONTRACTOR FOR UPTF TESTING
- TEST MATRIX HAS BEEN PROPOSED (DISCUSSION DURING 2D/3D MEETING IN APRIL)

UPTF PROJECT

PROGRAM CHANGES WITH RESPECT TO 2D/3D AGREEMENT

MARCH 1982

- SHIFT OF TIME SCHEDULE
- DELETION OF SUPERHEATED STEAM INJECTION
- DELETION OF ECC INJECTION IN DOWNCOMER
- DELETION OF CE TESTS
- REDUCTION OF UPTF TESTS (30)
- CAPABILITY TO PREHEAT ECC WATER ADDED
- CAPABILITY OF SMALL BREAK LOCA PHENOMENA INVESTIGATION ADDED
- CAPABILITY OF STEAM INJECTION INTO STEAM GENERATOR SIMULATORS ADDED
- CORE SIMULATOR FEEDBACK CONTROL SYSTEM ADDED



2D/3D PROJECT, UPTF SCHEDULE

December 1981

2D/3D USNRC PROGRAM

MARCH 10, 1982

L. H. SULLIVAN

1. 2D/3D NRC PROGRAM STATUS

2. SCOPE CHANGE SINCE 1980 AGREEMENT

3. PROGRAM PLAN

2D/3D USNRC PROGRAM STATUS

1. CCTF II INSTRUMENTATION COMPLETED.

2. SCTF II INSTRUMENTS UNDER FABRICATION. REFURBISHMENT OF SCTF I INSTRUMENTS BEING PLANNED FOR USE IN CORE II.

3. UPTF INSTRUMENTATION SCOPE AGREED.

4. SCTF III INSTRUMENTATION SCOPE BEING FINALIZED AS A RESULT OF CHANGE IN UPTF.

5. UPTF DAS SCOPE BEING FINALIZED.

6. TRAC-PF1 MODEL BEING USED IN POST TEST PREDICTION AND DESIGN ASSISTANCE CALCULATIONS. RECENTLY PERFORMED CALCULATIONS: CCTF I TESTS, SCTF I TESTS, UPTF SG AND LOOP STUDIES, GPWR AND W/J PWR BEHAVIOR.

NRC SCOPE CHANGE

SINCE FORMAL AGREEMENT SIGNED IN JANUARY 1980

FORMAL AGREEMENT	CURRENT PROGRAM PLAN	REASONS FOR CHANGE
STERO LENS IN CCTF, SCTF AND UPTF	VIDEO PROBE	TECHNICALLY NOT FEASIBLE WITHIN 3D SCHEDULE. NOT NEEDED BECAUSE ACTUAL FLOW EXPECTED DIFFERENT FROM SPHERICAL DROPLET FLOW
SCTF IN-CORE IMPEDANCE PROBE	IMP PROBE NOS. IN SCTF II AND III SWAPPED	TO ACCOMODATE UPTF SLIPPAGE
FLUID DIST. GRID IN CCTF AND SCTF	PROBE NO. INCREASED	TO EXTEND MEASURING RANGE
TV CAMERA AND RECORDER FOR SCTF	ELIMINATED	JAERI AGREED TO PROVIDE THESE.
TURBINE AND DRAG DISC IN CCTF LP	COOLED T/C SELECTED	TURBINE AND DRAG DISC NOT CAPABLE OF MEASURING REVISED LOW FLOW RANGE

NRC SCOPE CHANGE

SINCE FORMAL AGREEMENT SIGNED IN JANUARY 1980

(CONTINUED)

FORMAL AGREEMENT	CURRENT PROGRAM PLAN	REASONS FOR CHANGE
FILM PROBE IN CCTF II CORE WALL	ELIMINATED	PER JAERI REQUEST
DP'S AND PITOT TUBES IN UPTF END BOX	DRAG BODIES AND DP'S SELECTED	PITOT TUBES NOT SATISFACTORY. DRAG BODIES SUPERIOR TO DP'S
PRETEST AND POST-TEST PREDICTIONS AND POST-TEST ANALYSES PLANNED FOR EACH TEST	POST-TEST PREDICTION AND POST-TEST ANALYSIS (IF NECESSARY) PLANNED FOR EACH VALID TEST	NO NEED FOR ANALYSIS FOR REPEATED TESTS. USUALLY PRETEST PREDICTION NOT APPLICABLE TO DATA BECAUSE OF CHANGE IN TEST CONDITIONS

NRC SCOPE CHANGE

SINCE FORMAL AGREEMENT SIGNED IN JANUARY 1980

(CONTINUED)

FORMAL AGREEMENT	CURRENT PROGRAM PLAN	REASONS FOR CHANGE
FLUID DISTRIBUTION GRID IN UPTF	PROBE NO. DECREASED	REDUCED NO. TECHNICALLY SATISFACTORY
FILM PROBES IN UPTF & SCTF III	ELIMINATED	QUIESCENT FILM FLOW NOT EXPECTED
IMPEDANCE PROBES IN		
UPTF	ELIMINATED	VOID FRACTION INFO FROM DP & FDG
SCTF III	REDUCED	SOME ALREADY FABRICATED
SCTF II	INCREASED	PROTECTION AGAINST LOSS IN CORE I
STRING PROBES IN UPTF VENT VALVE	REPLACED WITH DP	MEASUREMENT REQUIREMENTS CHANGED
DRAG BODIES IN SCTF III TIE PLATE	ADDED	COMPATIBILITY WITH UPTF
BREAKTHROUGH DETECTORS IN SCTF III TIE PLATE	ADDED	COMPATIBILITY WITH UPTF

NRC SCOPE CHANGE SINCE SIGNING OF

THE FORMAL AGREEMENT IN JANUARY 1980

1. INSTRUMENT SUPPLY

ORIGINAL AGREEMENT	CURRENT PROGRAM PLAN	REASONS FOR CHANGE
Stereo Lens CCTF I 1 II 3 SCTF I 2 UPTF 4	Video Probe Quantity: no change	Technically not feasible within 2D/3D schedule. Also not needed because of inapplicability of highly idealized droplet flow.
In-core Impedance Probe SCTF II 8 III 4	SCTF II 4 III 8	SCTF Core II & III are swapped to accomodate UPTF schedule for coupling between UPTF and SCTF.
Fluid Distribution Grid SCTF I UP 8x7 DC 2x2x10 CCTF II UP 8x7 I UP(LLD) 3 II DC 5x3x10	SCTF I UP 8x8 DC 2x3x7 CCTF II UP 11x10 DC 6x3x7 6x1x6	Extension of measuring range. LLDs and FDGs are combined in CCTF II upper plenum.
TV Camera & Recorder SCTF I HL 2 CL 1	None None	JAERI agreed to provide these.
Turbine Meter CCTF II LP 4 Drag Disc CCTF II LP 4	Cooled Thermocouple CCTF II LP 4	Change of measurement requirements (seeking very low flow measurements below turbine & drag disc ranges).
Film Probe CCTF II Core Wall 4	None	Eliminated per JAERI request.
dP's and Pitot Tubes UPTF Core/UP 200	Drag Bodies 36 (end box) Narrow dP 9 (across tie plate) Wide dP 36 (end box water level) Breakthrough 100 Detecters	Pitot tubes are not satisfactory. Drag bodies are superior to dP's.

1. INSTURMENT SUPPLY (Continued)

ORIGINAL AGREEMENT	CURRENT PROGRAM PLAN	REASONS FOR CHANGE
Fluid Distribution Grid		
UPTF UP 100 X 7 DC 100 X 3	UPTF UP 63 X 7 DC 50 X 3 + 50 X 1	Reduced Number Technically Satisfactory
Film Probe		
UPTF UP 6 HL 2 SCTF III Core Tube 6	UPTF UP 0 HL 0 SCTF III Core Tube 0	Quiescent Film Flow not Expected
Impedance Probe		
UPTF UP 12 SCTF III Core 8 SCTF II UP 0	UPTF UP 0 SCTF III Core 4 SCTF II UP 4	α From DP & FDG " " Protection against Loss in Core II
String Probe		
UPTF Vent Valve 5	UPTF Vent Valve 0	Measurement Requirements Changed
DP		
UPTF Vent Valve 0	UPTF Vent Valve 5	Measurement Requirements Changed
Breakthrough Detectors		
SCTF III Tie Plate 0	SCTF III Tie Plate 2	Compatibility with UPTF
Drag Bodies		
SCTf III Tie Plate 0	SCTF III Tie Plate 4	Compatibility with UPTF

2. ANALYSIS SUPPORT

ORIGINAL AGREEMENT	CURRENT PROGRAM PLAN	REASONS FOR CHANGE
No. of calculations specified. For each experiment pre-test and post-test predictions and post-test analyses will be made.	No. of studies specified. For each valid experiment post-test prediction and post-test analysis (if necessary) will be made.	There is no need for calculations for the tests that are repeated for reproducibility check or for the tests that give essentially same results as previous tests. Pre-test predictions are eliminated because usually the actual test conditions are different from the previously planned ones, thus making pre-test predictions not directly applicable to the tests.

	No. of Calculations	No. of Studies
CCTF	184	39
SCTF	228	75
UPTF	221	60
PWR	141	32

STATUS OF JAERI ACTIVITIES

2D/3D STEERING COMMITTEE MEETING

JAERI, Tokyo

March 10, 1982

TEST FACILITIES

CCTF (Cylindrical Core Test Facility):

- The test facility was completed in March 1979.
- The second core was completed in March 1982.

SCTF (Slab Core Test Facility):

- The test facility was completed in March 1981.
- The second core is under construction and will be completed by March 1984.
- The third core will be completed around the end of 1985.

Steam Supply System:

- The steam boiler and the steam reservor tank were completed in January 1982.
- The connection between the steam reservoir tank and the test facilities will be completed by February 1983.

Combined Injection System:

- The system is under construction, and will be completed by Febraury 1983 for SCTF and by April 1983 for CCTF.

TEST PROGRAM

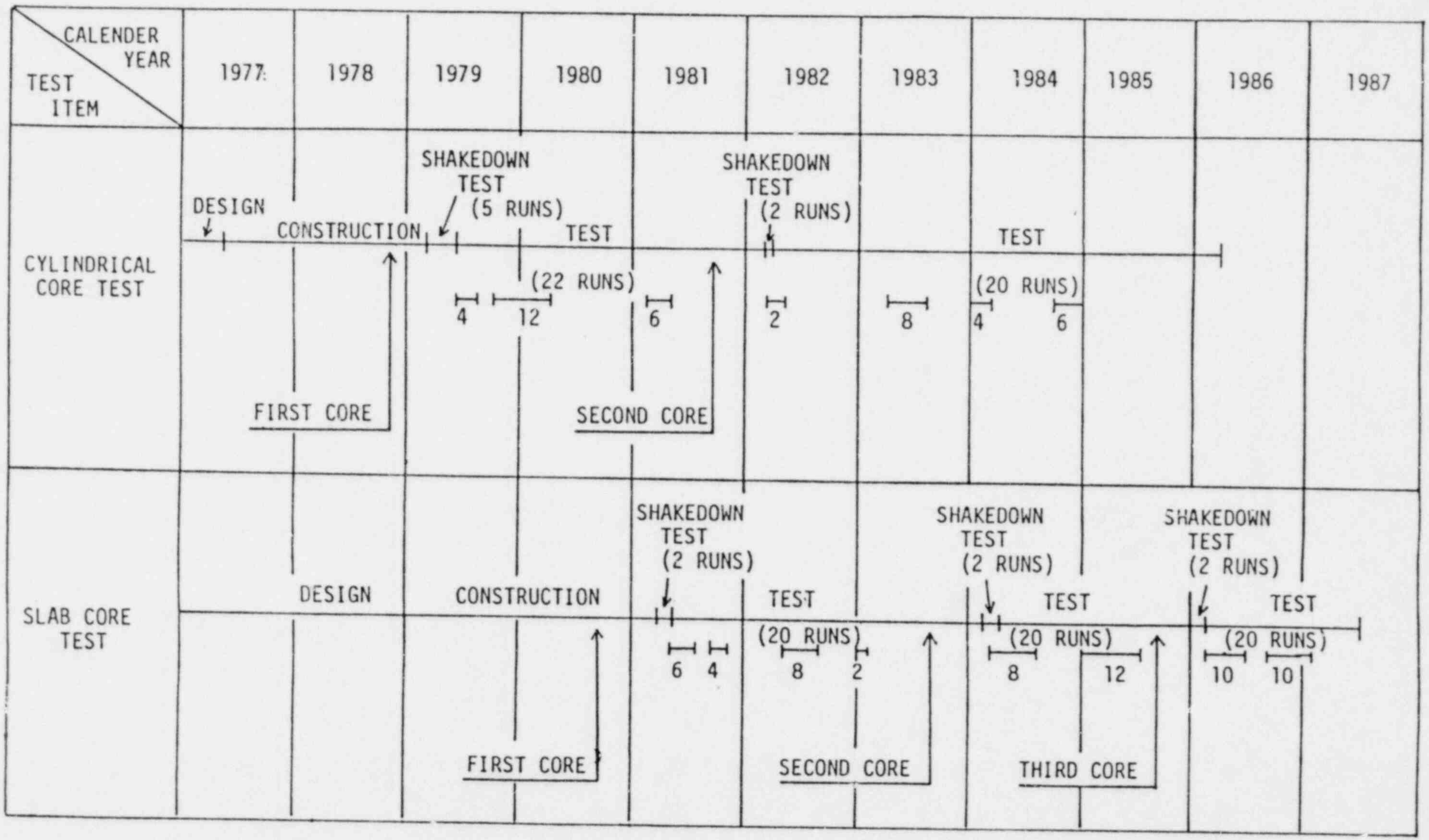
CCTF:

- Five shakedown tests and 22 main tests with the first core were finished in April 1981.
- The shakedown tests and main tests with the second core will be started in March and April, 1982, respectively.

SCTF:

- Two shakedown tests and 11 main tests with first core have been performed by directly injecting ECC water into the lower plenum.
- Eleven more main tests will be performed by injecting ECC water into the cold legs or the cold legs/upper plenum from April 1982 to February 1983.

TIME SCHEDULE OF JAERI LARGE SCALE REFLOOD TEST PROGRAM



Note: ⊢⊣ 4 denotes test period and number of tests.

TOTAL COST ESTIMATION

Beginning of program (1976)	4.4×10^{9} yen
1st revision (1977)	5.7×10^{9} yen
2nd revision (1978)	8.5×10^{9} yen
3rd revision (1979)	1.2×10^{10} yen
4th revision (1980)	1.4×10^{10} yen
5th revision (1981)	1.5×10^{10} yen

Note: Not included manpower cost and computer charge.

A COORDINATED ANALYTICAL AND EXPERIMENTAL STUDY OF THE THERMOHYDRAULIC BEHAVIOR OF EMERGENCY CORE COOLANT DURING THE REFILL AND REFLOOD PHASE OF A LOSS-OF-COOLANT ACCIDENT IN A PRESSURIZED WATER REACTOR

PROGRAM PLAN

MARCH 1982

APPROVED BY:

Dr. Wolf-J. SCHMIDT-KUESTER, FEDERAL REPUBLIC OF GERMANY

I. MIYANAGA, JAPAN

D. ROSS, UNITED STATES

CONTENTS:

CHAPTER 1

OBJECTIVES OF THE PROGRAM

I. General Reactor Safety Research Objectives

1. Resolve Licensing Concerns in Three Countries for Effectiveness of Core Cooling Provided by ECC Systems for Large and Medium Breaks in PWRs

   Reactor licensing concerns are similar in the US, FRG and Japan; safety issues do not differ across national boundaries. Some questions raised in the USAEC 1972-3 ECCS Rule Making Hearing are still not completely answered, such as steam binding, ECC bypass, and full-size effects. The 2D/3D Program will resolve these licensing concerns by providing data and analysis to quantify the safety margins embedded in the ECCS acceptance criteria and the associated prescriptions for evaluating the existing ECC systems as set forth in the ECCS hearings.

   Since it is too costly for one country to build and test a full-scale reactor vessel with a heated core, the program unites the ECC safety research efforts of three countries, with each party providing unique resources that can be coupled with the resources provided by the other two parties. Thus, FRG is supplying the Upper Plenum Test Facility to provide data for full-scale upper plenum and downcomer flow behavior; Japan is supplying the Slab Core Test Facility to provide data on the heated core effect in a full-height, full-radius geometry and the Cylindrical Core Test Facility to provide system behavior under conditions of steam binding; the US is providing instrumentation and analysis to couple all the experimental results.

2. Provide Full-Scale Data for Assessment of Scaling Capability of Computer Codes to Predict the Accident Response of Large Commercial PWRS During a Whole Spectrum of Breaks in LOCA

   At present, no experimental steam binding data in a well simulated upper plenum exists for large or medium break LOCAs during reflood. The ECC bypass data during refill is available only in small test facilities up to 1/5 scale of downcomer width. Separate effects data will be supplied by UPTF on scaling of de-entrainment models for upper plenum structures, scaling of flow modeling in the downcomer gap, on condensation-induced interactions between steam water in the upper plenum and on the modeling of liquid distribution in the upper plenum, including CCFL at the tie-plates. Separate effects data will be supplied by SCTF on radial scaling of flow regimes in the core and on 2D effects on quench front motion for both blocked and unblocked bundle geometries.

Coupling of test results between UPTF and SCTF will assess the codes' capability to predict liquid fallback from the upper plenum and subsequent steam generation in the core; both effects being assessed against full-scale data.

Data on integral system effects during end-of-blowdown, refill and reflood are provided by CCTF in a scaled full-loop geometry with electrically heated cores. This data will assess the codes' capability to predict liquid distribution in the system and core cooling under conditions of steam binding in the loops. Data during the end-of-blowdown and refill period will assess the codes' ability to predict the correct initial conditions for the start of reflood.

3. <u>Quantify the Safety Benefit of Hot Leg Injection (or Upper Plenum Injection) by Providing ECC Liquid Penetration Data for PWRs*</u>

The data and analysis from the 2D/3D Program will be used to help optimize the safety effectiveness of future improved ECCs with respect to medium and large break LOCAs.

ECCs employing hot leg injection (or upper plenum injection) has shown the capability of rapidly cooling the top of a partially uncovered core in small or large break LOCAs and could condense bubbles in the upper

* This data is complementary to that being provided for BWRs in the 30° Steam-Sector Test Facility (A joint USNRC/GE/EPRI effort).

plenum (TMI and St. Lucie). The possible condensation induced oscillation in a large upper plenum or the carryover of water into steam generators could aggravate steam binding. The 2D/3D facilities are to test the validity of these concerns and their consequences.

II. Specific Technical Objectives

There are four specific technical objectives for the 2D/3D Program:

1. To study the effectiveness of various ECCS during reflood for a large and medium break LOCA (including cold leg injection, combined hot and cold leg injection, lower plenum injection and vent valve) by measuring:

   - The liquid carry-over and fallback, and steam flow rate across core/upper plenum interface.

   - The entrainment/de-entrainment of liquid in upper plenum.

   - The pressure difference between the upper plenum and the top of downcomer.

   - The pressure drop across steam generators.

2. To study the effectiveness of various ECCS during refill for a large and medium break LOCA by measuring:

   - ECC penetration in downcomer and lower plenum filling during refill.

   - Downcomer upward steam flow transients induced by the condensation of steam by ECC water during refill.

   - U-tube flow oscillation during refill.

   - Pool height and temperature of water accumulated in upper plenum under combined injection during refill and reflood.

3. To study the core inventory and flow circulation related to severe accidents by measuring:

   - Net flow rate out of the vessel and circulation in the system.

   - Heat transfer in the steam generators.

- Phase separation in the upper plenum and hot leg.
- Local liquid-level and temperatures in the core, upper plenum, exit nozzle, downcomer and lower plenum.

4. To study the convective flow and temperature distributions inside a heated core under the following conditions:

   - During reflood for a large and medium break LOCA (chimney effect).
   - Under conditions of core flow blockage during reflood, by measuring:
     - density distribution in the core
     - velocity distribution in the core
     - location and clad temperatures at the hot spot.

CHAPTER 2

FACILITIES AND SUPPORT PROGRAMS

I. The German Upper Plenum Test Facility

1. Introduction

The Bundesminister fuer Forschung und Technologie (BMFT) of the Federal Republic of Germany funds the design, construction and operation of the Upper Plenum Test Facility (UPTF) to provide information on the three-dimensional thermo-hydraulic behavior of steam and water in the simulated upper plenum and downcomer of a pressurized water reactor during the last part of blowdown, the refill and reflood phases of a hypothetical loss-of-coolant accident. The last part of blowdown will be simulated to establish the initial conditions of the refill phase.

The UPTF facility represents a four-loop, approximately 1200 MWe size pressurized water reactor including reactor vessel, downcomer, lower plenum, upper plenum and simulators for the core, the loop systems and the containment.

For core flow simulation a steam/water injection device providing the proper thermo-hydraulic conditions and performance, especially at the core/upper plenum interface, is used.

The test facility will be built at Grosskraftwerk Mannheim (GKM), where a sufficient amount of steam for the operation of UPTF can be supplied by a conventional power plant.

2. Objectives of the Upper Plenum Test Facility

The objective of UPTF is to determine the three-dimensional thermal-hydraulic behavior of the fluid in the upper plenum and downcomer during the last part of blowdown, refill and reflood phases of the loss-of-coolant accident. The facility provides the capability of simulating the flow conditions from the time the upper plenum pressure reaches 9 bars absolute through the remaining transient.

The UPTF will primarily be used to:

- Study the separation effectiveness of upper structural components;
- Measure the liquid carryover through the hot leg nozzles out of the reactor vessel;
- Study the three-dimensional nature of the liquid fallback process from the upper structurals;
- Study water/steam interaction and liquid mass and liquid temperature distributions in the upper plenum for the case of hot leg injection;
- Study the influence of distribution of water level and subcooling on water penetration through the upper core support plate and upper tie-plate into the core;
- Study the effects of liquid level oscillations in the core, lower plenum and downcomer on carryover and fallback during reflood; and
- Study the fluid dynamic behavior in the downcomer during injection of ECC water and nitrogen.

In particular, the following phenomena are to be studied:

- Carryover to and fallback from the upper plenum during refill and reflood;
- Carryover to and backflow from the simulated hot legs during refill and reflood;
- Water distribution in the upper plenum for combined injection, cold leg injection only, and other ECCS defined in Section 3.8;
- Delivery of ECC water to the reactor vessel and the effects of condensation during the last part of blowdown, refill and reflood;
- Three-dimensional, two-phase flow redistribution inside the upper plenum;
- Flow across the core/upper plenum interfaces with local check of cross-flow between end boxes;

- Local pool height formation rate above the tie-plate, including frothing and re-entrainment;

- Liquid fallback to the core as a function of local steam flow rate and local liquid temperature;

- Entrainment, de-entrainment, and re-entrainment in the upper plenum and the upper portion of the core;

- Liquid film formation and flow in the upper plenum;

- Axial, azimuthal, and radial flow distribution in the upper plenum region;

- Heat removal from the structures of the upper plenum;

- Outlet nozzle flow split and flow regimes; and

- Countercurrent flow effects in the downcomer during the last part of blowdown and refill.

The UPTF will be capable of simulating both cold and hot leg breaks, and of simulating emergency core coolant injection into the intact and broken cold legs and hot legs, upper plenum, downcomer and lower plenum.

3. UPTF Design Features

The UPTF models a four-loop, approximately 1200 MWe pressurized water reactor, including the reactor vessel, downcomer, lower plenum, upper plenum and simulators for the core, containment and loop components. Fig. 2-1 shows the schematic flow diagram of the facility.

The UPTF system is based on German reactor design with compromises of plant features, such that results from various specific tests will be applicable to German, Japanese and U.S. vendor designs.

The portion of the reactor vessel to be simulated is of full-height, with four full-scale hot leg and cold leg nozzles, simulated equivalent to three intact loops and one broken loop. The orientation of the nozzles is shown in Fig. 2-2. The core barrel is also of full-size and accommodates eight vent valves.

Materials used are selected so that the water chemistry is satisfactory for USNRC and BMFT instrumentation.

3.1 Reactor Vessel (Fig. 2-3)

- The vessel ID is 4800 mm. This value is the sum of core barrel OD (full-size) and 250 mm downcomer gap. The downcomer upper annulus in the region of cold and hot leg nozzles is 210 mm;

- The hot and cold leg nozzle ID is 750 mm;

- The vessel is of full-height of the simulated PWR.

3.2 Core Barrel

- The core barrel OD is of full-size;

- The core barrel is of full-length of the simulated PWR. The distance between the bottom of the cold leg and the lower end of the core barrel is 6300 mm;

- The core barrel provides eight vent valves, as in a B&W plant. The valves are capable of being kept closed as desired from outside the vessel.

3.3 Lower Plenum Internals

- The size and structure is based on a typical simulated PWR design, compromised for experimental results. Desired features of the lower plenum structure to be maintained are flow resistance, effect of lower plenum level sloshing, obtaining correct temperature in lower plenum at the start of the test.

3.4 Downcomer

- The downcomer is of full-length;

- The downcomer width is 250 mm in the lower region; the upper annulus just below the cold legs is 210 mm;

- Realistic flow restrictions such as neutron shielding pads, reactor vessel surveillance sample tube holders, etc., are simulated to the degree practicable.

3.5 Upper Plenum Internals (Fig. 2-2, Fig. 2-3)

- The upper structure is of the KWU type which are similar to those of the new Westinghouse design, and includes core barrel vent valves for B&W simulation.

  The effect of the inner barrel in the B&W design is accounted for by the height of the hot leg nozzle above the upper core support plate;

- Distance from the upper edge of the upper core support plate (UCSP) to the bottom of the hot leg nozzle is about 985 mm;

- Distance from the lower edge of the UCSP to the lower edge of the top plate of upper structurals is about 2500 mm.

3.6 Reactor Coolant Loops

- Cold and hot leg breaks can be simulated;

- Active loop components are not provided; sufficient auxiliary systems to deliver or remove flows from vessel nozzles typical of the performance of the intact and broken loops are provided (see Fig. 2-1);

- Number and orientation of the cold leg and hot leg nozzles are shown in Fig. 2-2;

- The connection to the containment is shown in Fig. 2-1, which is in accordance with the experimental requirements;

- Five steam/water separators are provided in accordance with Fig. 2-1 (steam generator simulation);

- Steam generator hot leg drainage is simulated;
- Pump simulators are provided in each loop.

3.7 Containment Simulator

- The containment is a pressure suppression system with vent lines between the upper and lower chamber;
- The system design permits control of the containment pressure during the test;
- The volume of the upper chamber (pressure chamber) is 500 m^3, of the lower chamber (condensation chamber) 1000 m^3;
- The capability of steam backflow from the containment to the reactor coolant system is provided.

3.8 ECC System (Fig. 2-1)

- Capability is provided to allow the following ECC injections into:

  a. intact and broken cold legs

  b. intact and broken hot legs

- Capability is provided for ECC injection for 10 seconds of saturated water at initial test conditions and with or without delayed hot leg injection;
- Appropriate arrangements are provided for possible upper plenum, lower plenum and downcomer injection.

3.9 Auxiliary Systems

- Auxiliary systems for steam, water and nitrogen injection and extraction needed to simulate PWR performance, e.g., accumulator nitrogen are provided in accordance with Fig. 2-1.

3.10 Core Simulator (Fig. 2-4)

On the basis of the following functional requirements a steam/water injection and mixing device has been developed and experimentally tested:

- To the degree practicable, provide for the correct flow resistance in the vertical direction during the blowdown and refill phases;

- The flow paths at the upper end of the core shall be geometrically similar to the PWR. The end boxes and upper core support plate will be of original KWU geometry (Figs. 2-5a and 2-5b). Flow resistance at the lower end of the core has to be simulated;

- A two-phase fluid source will be provided for the last part of blowdown, and the refill and reflood portions of the test. The USNRC will provide analytical assistance;

- The fuel configuration to be simulated is the KWU 16 x 16 fuel bundle;

- The core simulator shall provide for 17 zones to simulate various heat/steam generation rate regions within the core; (Fig. 2-4)

- To the degree practicable a capability will be provided to vary operation parameters about nominal conditions without changing the hardware.

The concept consists of 193 injection nozzles, one beneath each fuel assembly dummy to provide the appropriate steam/water flow conditions at the core/upper plenum interface. Capability is provided to inject saturated steam at up to 220°C.

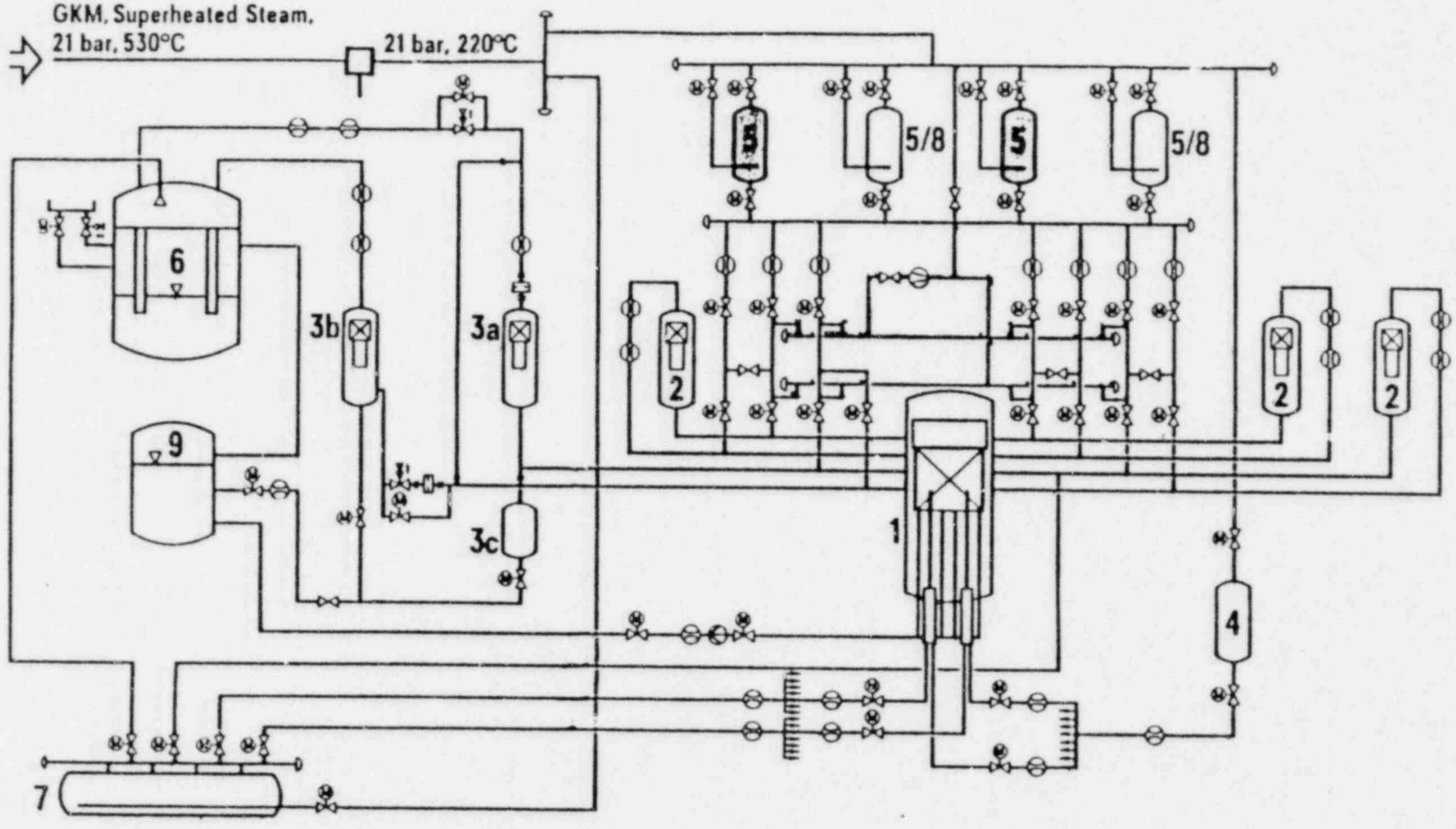
Fig. 2-4 shows the 17 injection zones, which are to provide control of mass flow rates independently.

Provisions will be made to simulate steam generation in the core whenever water break through from the upper plenum is detected (core simulator feedback)

4. Instrumentation and Control

To the extent practicable, the same instrumentation type and location shall be used in the UPTF as is used in the JAERI CCTF and JAERI SCTF, to facilitate the experimental and analytical coupling of the test results obtained in the different test facilities. Instrumentation for the UPTF is to be provided by both the BMFT and the USNRC. The BMFT is responsible for all control systems. The USNRC-supplied advanced two-phase flow instrumentation is listed in Appendix 3 of the Trilateral Arrangement.

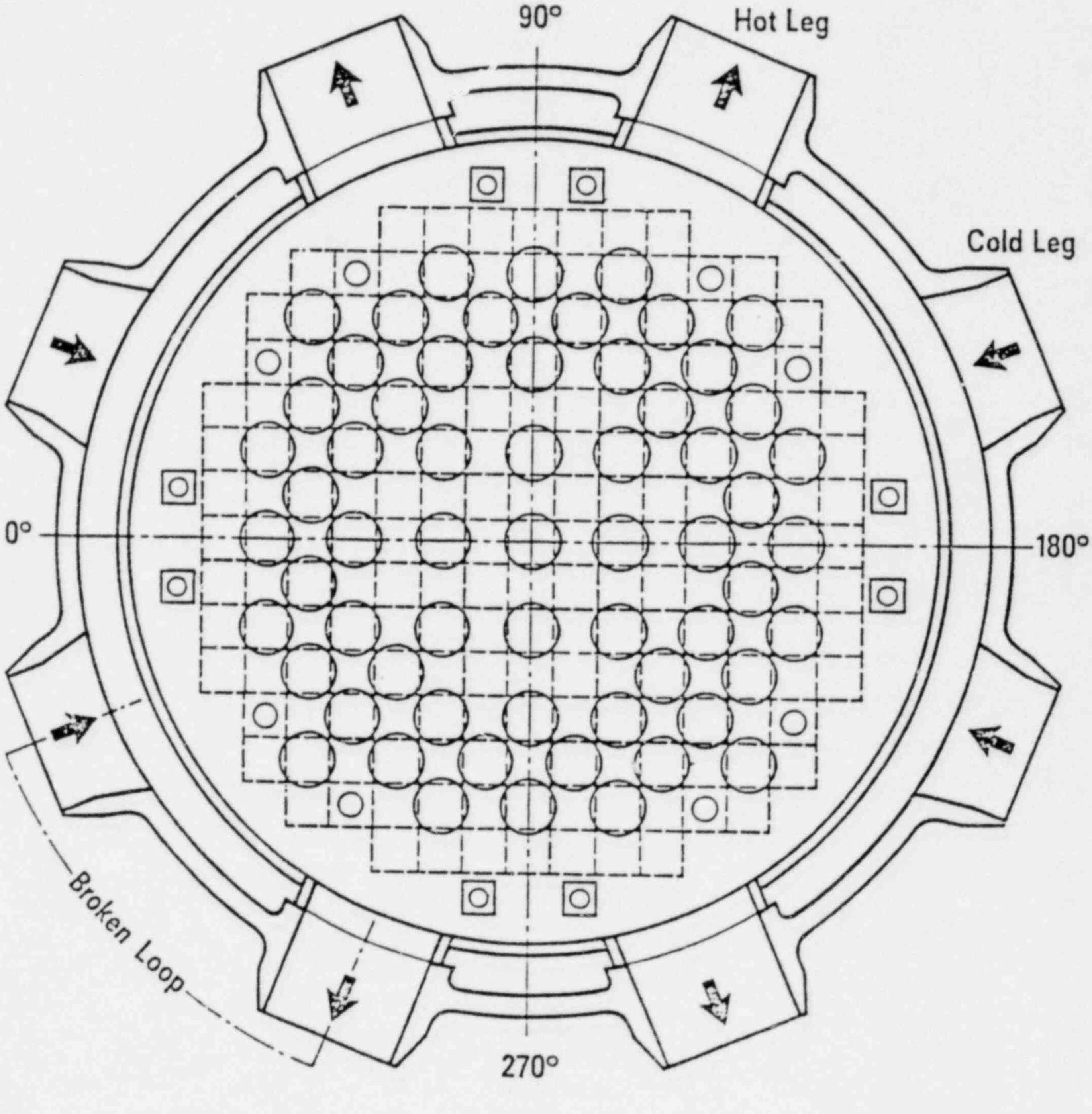
Fig. 2-6 shows the experimental instrumentation in the test vessel.



1 Test Vessel
2 Steam Generator Simulator (Intact Loop)
3a Water Separator (Broken Loop, Hot Leg)
3b Water Separator (Broken Loop, Cold Leg)
3c Drainage Vessel for Hot Leg Break
4 Hot Water Storage Tank
5 Accumulator
6 Containment Simulator
7 Steam Storage Tank
8 N_2 – Tank
9 Water Collecting Tank

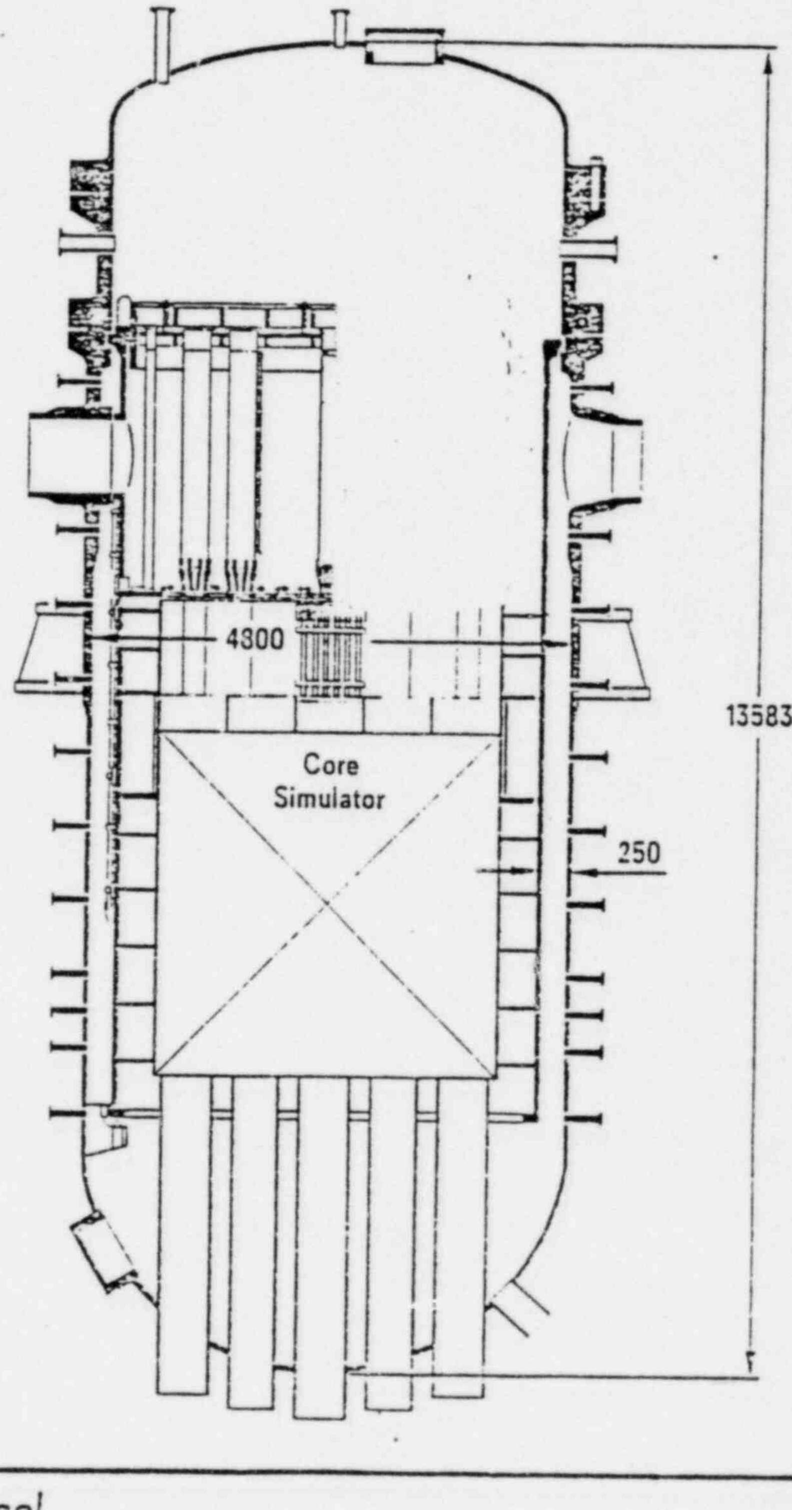
UPTF – Flow Diagram

Fig. 2-1



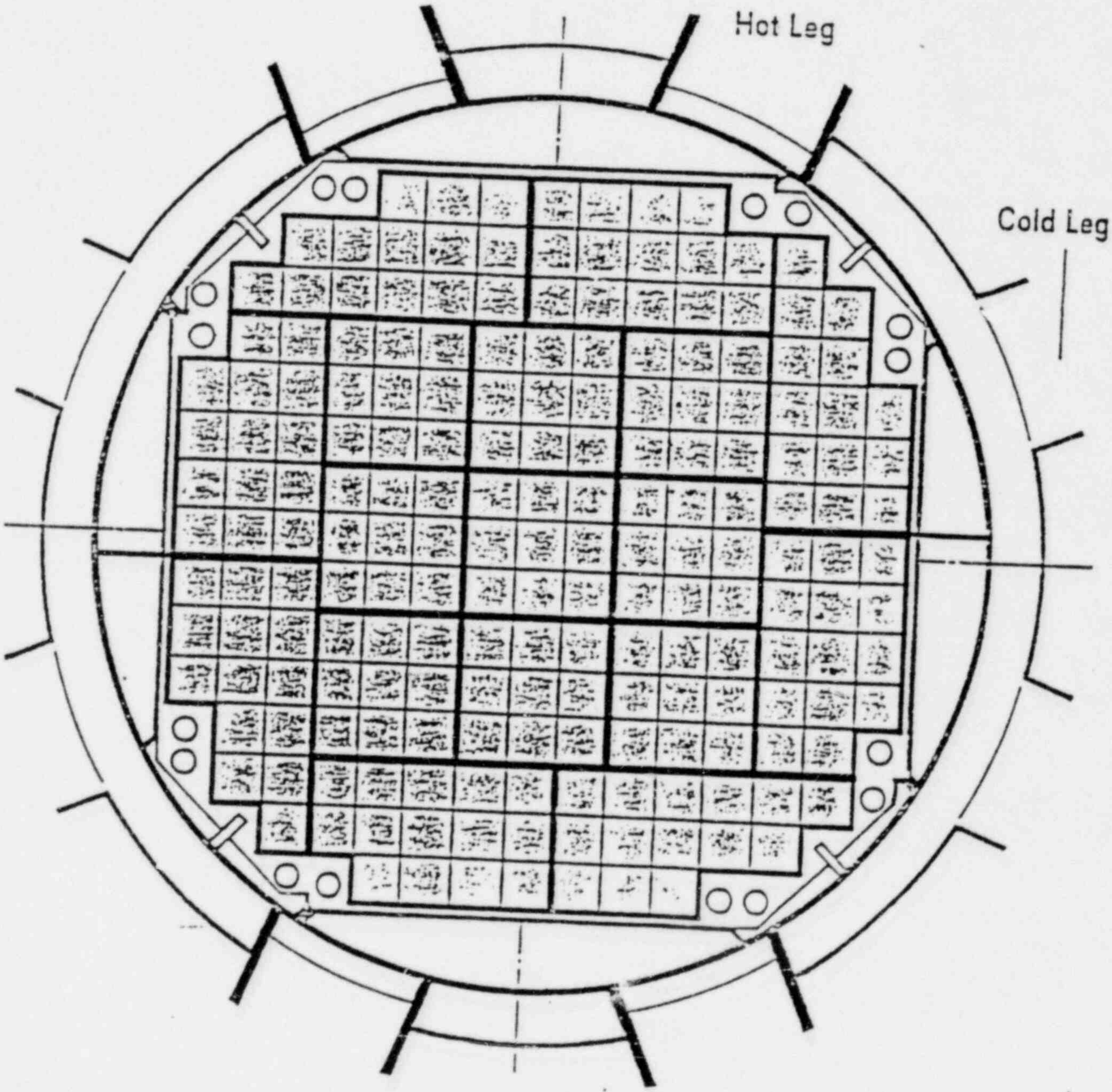
Upper Plenum (UPTF)
Cross Section

Fig. 2-2



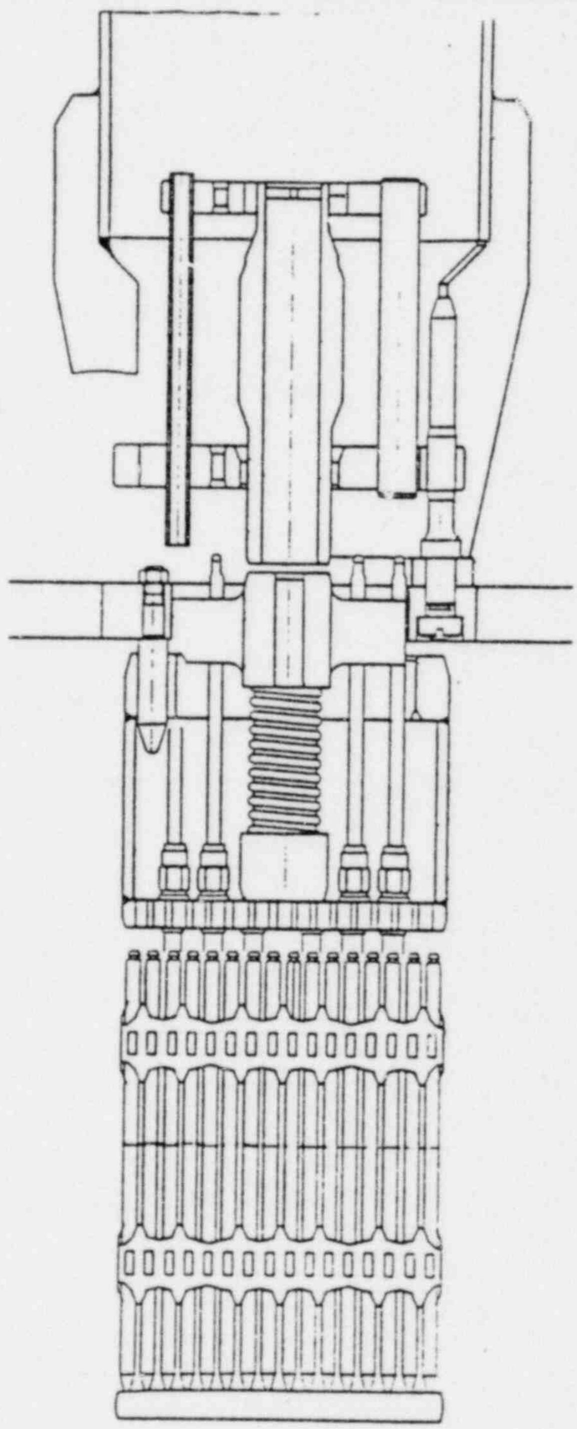
UPTF – Test Vessel

Fig. 2-3



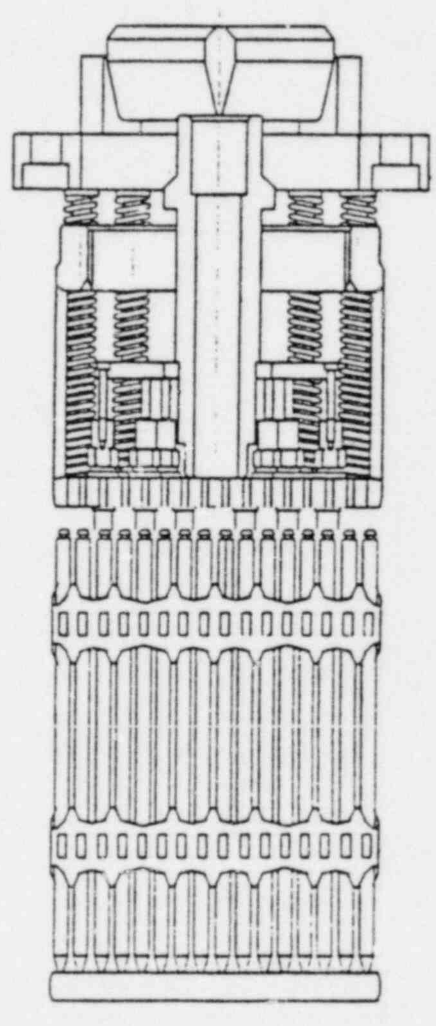
Reactor Core
Cross Section
CORE SIMULATOR INJECTION ZONES

Fig. 2-4



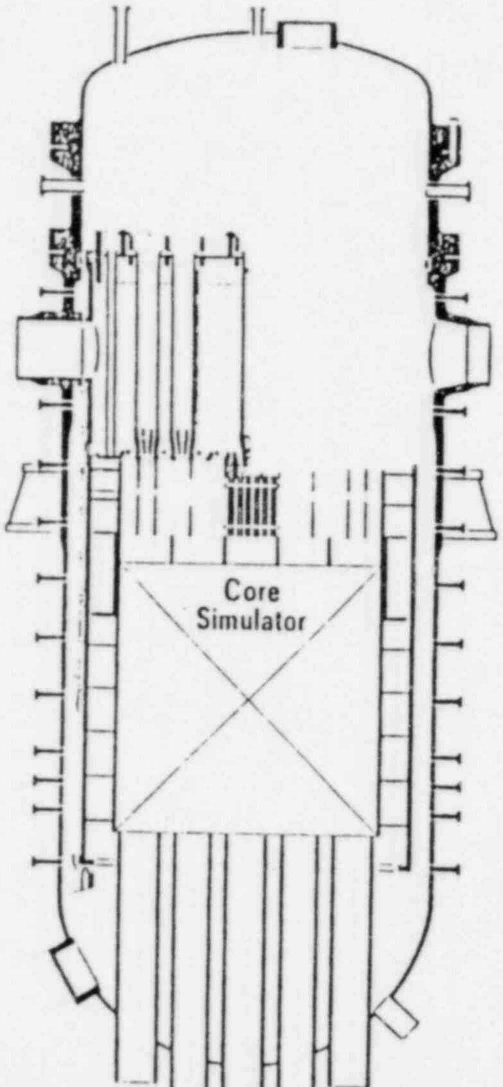
End Box (UPTF)
Fuel Element with CRA Spider

Fig. 2-5a



End Box (UPTF)
Fuel Element with Flow Restrictor

Fig. 2-5b



Instrumentation in Test Vessel					
	Upper Plenum	Core-Upper Plenum Interface	Core	Lower Plenum	Down-comer
Fluid Temperature	X	X		X	X
Fluid Temperature below End Box		X			
Wall Temperature					X
Pressure	X				
DP to Containment	X				X
DP Upper Plenum – Downcomer	X				X
DP Vent Valve	X				X
DP axial		X			X
DP horizontal					X
LLD	X		X	X	
FDG	X	X			X
Break Through Det.		X			
Video Probes	X				
Turbines vertical	X				X
Turbines horizontal	X	X			
Turbines & String Probes					X
Flow Modules		X			
Conductivity Probe				X	

Instrumentation in Test Vessel

Fig. 2-6

II. The Japanese Cylindrical Core Test Facility and Slab Core Test Facility

1. Introduction

The Japan Atomic Energy Research Institute will fund the design, construction and operation of two experimental facilities:

- The Cylindrical Core Test Facility--To provide information on coolant behavior in the core and upper plenum, including steam and water carryover (steam binding) and integral system (steam generator and pump simulated) effects during the refill and reflood phases of a simulated LOCA. The latter part of blowdown would be simulated to establish the initial conditions for refill.

- The Slab Core Test Facility--To provide information on the two-dimensional, thermal-hydraulic behavior and core flow within the reactor vessel during the refill and reflood phases of a simulated LOCA for a pressurized water reactor. The last part of blowdown would be simulated to establish the initial conditions for refill.

2. Objectives

2.1 Cylindrical Core Test Facility Program Objectives

The objectives of the Cylindrical Core Test Facility are:

- Demonstration of emergency core cooling system behavior during refill and reflood period.

- Verification of reflood analysis codes.

- Collection of the following information to improve the thermohydrodynamic model in the analysis codes, i.e., (a) multi-dimensional core thermohydrodynamics including the radial power distribution effect, fallback effect and spatial oscillatory behavior, (b) flow behavior in the upper plenum and the hot legs, (c) behavior of accumulated water at the bottom of the upper plenum including possible counter-current flow and sputtering effect,

(d) hydrodynamic behavior of the injected ECC water and the water passing through the steam generator, (e) multi-dimensional thermo-hydrodynamic behavior in the hot annular downcomer, and (f) overall oscillatory behavior in the system.

- The reference plant for the simulation is based on a compromise of plant features such that results from specific tests will be .pplicable to German, Japanese, and United States vendor designs.

2.2 Slab Core Test Facility Program Objectives

The purpose of the facility is to study core heat transfer, core hydrodynamics and ECCS performance. In particular, the following phenomena are to be studied:

- Carryover to and fallback from the upper plenum during refill and reflood, including countercurrent flow in the tie-plate and upper core support plate and near the quench front, and also including possible sputtering effects;

- Carryover to and fallback from the simulated hot legs during refill and reflood;

- Water distribution in the reactor vessel for combined injection, cold leg-only injection, and other ECCS defined in Section 3.1.8.;

- Liquid level oscillations in the core and downcomer and their effect on carryover and fallback during reflood;

- Delivery of ECC water to the reactor vessel and the effects of condensation during the last part of blowdown, refill and reflood;

- Core heat transfer, heater rod temperatures and fluid flow phenomena including flow redistribution, and quench front propagation; both blocked and unblocked-bundled tests should be included;

- Effect of downcomer flows. including condensation, during the refill period;

- Entrainment, de-entrainment, re-entrainment, and distribution of water droplets in the core and upper plenum; and

- Pool formation above the tie-plate and upper core support plate including water subcooling and frothing effects.

3. JAERI Facility Design Features

3.2 Cylindrical Core Test Facility

The Cylindrical Core Test Facility is an experimental test facility designed to model a fuel-height core section of a pressurized water reactor. This facility will be used to provide information on the refill and reflood phase of a hypothetical loss-of-coolant accident. The last part of blowdown would be simulated to establish the initial conditions for refill. The overall schematic diagram of the facility is shown in Figure 2-7. The central part of the test facility will be a non-nuclear core of 2000 electrically heated rods arranged in a cylindrical array. The core will be housed in a test vessel which includes a downcomer, lower plenum and upper plenum as well as a core region. The core design is based on 32, 8 × 8 rod assemblies which model typical PWR 15 × 15 assemblies.

The facility shall provide the capability to reasonably simulate the flow conditions of a PWR in a LOCA from the time the upper plenum reaches 6 bars absolute (6 Kg/cm^2 absolute) through the last part of blowdown, refill and the crucial part of reflood. Volumetric scaling shall be used based on core area scaling.

3.1.1 Reactor Vessel

- The vessel is sized to accommodate the 2000-rod core.

- Wall thickness is based on pressure rating. The stored heat energy is simulated.

- The simulated portion of the vessel is full-height.

- Four hot leg nozzles are provided. The nozzle height above the core is a compromise representative of current PWR designs of interest to the parties.

- Cold leg nozzles are provided equivalent to three intact loops and one broken loop.

3.1.2 Core Barrel

- A simulated core barrel is provided. Wall thickness and other typical features are based on various PWR designs.

- Core barrel is full-length.

- Core barrel and upper annulus design must provide for simulation of core barrel vent valves in at least some tests in Core-II.

3.1.3 Lower Plenum Internals

The size and structure of the lower plenum and its internal structures are based on a simulated PWR design, compromised as necessary for experimental results. Desired features of the lwoer structure to be maintained are volume, flow resistance, and obtaining the correct temperature in the fluid in the lower plenum during the test.

3.1.4 Core

- The core consists of a cylindrical configuration of 32, 8 × 8 bundles simulating 15 × 15 array fuel, including unheated rods.

- Flow paths at the upper end of the core are geometrically similar to the PWR end boxes and upper core support plates. In the remainder of the core, flow paths and geometry reasonably simulate the fuel in single- and two-phase flow.

- Core bypass flow area is included in the downcomer flow area.

- Power to the core is controlled to vary the power distribution to achieve the experimental requirements.

- The core housing is designed to minimize flow perturbations and heat release.

- The heater rod design simulates the heat capacity of a fuel rod to the degree practicable.

3.1.5 Downcomer

- The downcomer is full-length.

- The downcomer is designed to provide a flow resistance representative of a PWR downcomer.

- The volume is determined based on the core area scaling.

- The downcomer is designed to provide ECC flow behavior throughout the test which is reasonably representative of that of a PWR downcomer.

3.1.6 Upper Plenum Intervals

- In the CCTF tests of the 2D/3D Cooperative Program, two sets of upper structurals are used. One type includes a model of the slotted-type support columns and the other type includes a model of solid-type support columns.

- Distance from the upper core support plate (UCSP) to the bottom of the hot leg nozzle is as shown in Fig. 2-8.

- Distance from UCSP to top plate of upper structurals is as shown in Fig. 2-8.

3.1.7 Reactor Coolant Loops

- Cold leg break is simulated.

- Actual loop components, e.g., steam generators and pimps are simulated.

- Connection to containment and simulation required of containment are based on experimental requirements, particularly considering last part blowdown and refill phase effects.

3.1.8 ECC Injection

Capability is provided to simulate the following

ECC systems with subcooled and near-saturated water:

- Intact and broken cold leg injection;
- Intact and broken hot leg injection (not in Core-I but in Core-II);
- Downcomer injection;
- Upper plenum injection to simulate hot leg injection; and
- Lower plenum injection.

3.1.9 Auxiliary Systems

Auxiliary systems including steam, water and nitrogen needed to simulate PWR performance, e.q., accumulator nitrogen, shall be identified and sized, if possible.

3.1.10 Containment System

The containment design shall permit the containment pressure to be controlled during the test based on experimental requirements.

3.1.11 Instrumentation

To the extent practicable, the same instrumentation (type and location) is used in the 2000-rod CCTF as is used in the 2000-rod SCTF and the UPTF to facilitate experimental and analytical coupling of the test results obtained in different test facilities. Instrumentation for the CCTF is provided by both the JAERI and the USNRC.

3.2 Slab Core Test Facility

The Slab Core Facility is an experimental facility designed to model a full-scale radial and axial section of a pressurized water reactor, a single bundle in width. This facility will be used to study the end-of-blowdoen, refill and reflood phases of a hypothetical loss-of-coolant accident. The overall schematic diagram of the facility is shown in Figure 2-9. The central part of the facility will be a non-nuclear core of 2000 electrically-heated rods, arranged in a row of eight simulated fuel assemblies. This core will be housed in a test vessel, which includes a downcomer, lower plenum and upper plenum. The slab design will be based on eight, 16 × 16 fuel assemblies. Othe components shall be sized based on core area scaling, unless otherwise specified by an expert group.

The facility shall provide the capability to reasonably simulate the flow conditions in a PWR during a LOCA from the time the upper plenum pressure reaches six bars absolute (6 kg/cm² absolute) through the last part of blowdown, refill and the crucial portion of reflood.

The reference plant for the simulation is based on a compromise of plant features, such that results from specific tests will be applicable to German, Japanese, and United States vendor designs.

3.2.1 Reactor Vessel

- Vessel is sized to accommodation slab core of eight assemblies with 16 × 16 rod configuration. At least two such cores plus appropriate spare assemblies will be built.

- The simulated portion of the vessel is full-height.

- A hot leg nozzle is provided and located at the end of the slab corresponding to the edge of the core. The nozzle height above the core is a compromise representative of current PWR designs of interest to the parties.

- Cold leg nozzles are simulated equivalent to three intact loops and one broken loop.

- Nozzles are provided on the upper plenum, lower plenum and downcomer of the vessel to facilitate water injection for proper simulation of conditions for testing ECC systems listed in Section 3.2.8.

3.2.2 Core Barrel

- A simulated core barrel is provided. Wall thickness and other typical features are based on various PWR designs.

- Core barrel is full-length.

- External piping is used for simulation of core barrel vent valves.

3.2.3 Lower Plenum Internals

The size and structure of the lower plenum and its internal structures are based on a simulated PWR design, compromised as necessary for experimental results.

3.2.4 Core

- The core consists of a slab configuration of eight assemblies with 16 × 16 rod configuration corresponding to the upper plenum internals, including unheated rods.

- Flow paths at the upper end of the core are geometrically similar to the PWR end boxes including simulation of internals as dummy control rod spiders, throttling spiders and upper core support plates. In the remainder of the core flow paths and geometry reasonably simulate the fuel in single- and two-phase flow.

- To the degree practicable, the core baffle bypass region is simulated. The features are the correct flow resistance and scaled volume. The flow bypass region is simulated PWR designs that have either up-or-down flow in the baffle region during normal operation.

- Power to each bundle is individually controlled to vary the power distribution.

- The core housing is designed to minimize flow perturbations and heat release.

- The heater rod design simulates the heat capacity of a fuel rod to the degree practicable.

3.2.5 Downcomer

- The downcomer is full-length.

- The downcomer is designed to provide a flow resistance representative of a PWR downcomer.

- The volume is based on the core area scaling.

- The downcomer design provides ECC flow behavior throughout the test which is reasonably representative of that of a PWR downcomer. Flexibility, such as provision for a vertical partition in the downcomer, is provided to achieve acceptable performance under countercurrent steam/water flow conditions. An in-line downcomer such as that shown in Fig. 2-10 is used.

3.2.6 Upper Plenum Internals

- In the presently planned slab core tests of the 2D/3D Cooperative Program, two types of upper structurals are used. One type is representative of the Westinghouse PWR design and of the same type as used in the CCTF; the other type is of the same type as used in the UPTF.

- The distance from the UCSP to the bottom of the hot leg nozzle is approximately 1035 mm.

- The distance from UCSP to top plate of upper structurals is approximately 2200 mm.

- The upper plenum volume is based on the core area scaling.

- Provisions are made to permit accounting for the effects of flow to and from that portion of the upper structurals not directly simulated. The design is based on the injection and drain system for simulation of specified flow and temperature distribution.

3.2.7 Reactor Coolant Loops

- Cold leg and hot leg breaks are simulated.

- Actual loop components are not provided. Rather, sufficient systems are provided to deliver or remove flows from the vessel nozzles typical of the performance of the broken and intact loops (see Fig. 2-9).

- Piping size and shape are determined so as to simulate PWR characteristics.

- Connection to containment, and simulation required of containment is based on experimental requirements, particularly considering end-of-blowdonw and refill pahse effects.

3.2.8 ECC Injection

Capability is provided to simulate the follwoing ECC systems with subcooled and near-saturated water:

- Intact and broken cold leg injection;
- Intact and broken hot leg injection;
- Downcomer injection;
- Upper plenum injection; and
- Lower plenum injection.

The SCTF ECC system is designed to maximize mutual benefit and coupling of the UPTF and SCTF tests.

3.2.9 Auxiliary Systems

- Auxiliary systems including steam, water and nitrogen needed to simulate PWR performance, e.g., accumulator nitrogen, are identified and sized.
- A supplemental steam supply shall be provided to fulfill the requirements for proper simulation of conditions for testing ECC systems listed in Section 3.2.8.

3.2.10 Containment System

- The containment system design permits the containment pressure to be controlled during the test based on experimental requirements.
- Containment tanks for CCTF are also used in SCTF tests.
- A nozzle shall be provided on the containment vessel to facilitate steam introduction for proper simulation of conditions for testing ECC systems listed in Seciton 3.2.8.

3.2.11 Instrumentation

To the extent practicable, the same instrumentation (type and location) is used in the 2000-rod SCTF as is used in the 2000-rod CCTF and the UPTF to facilitate experimental and analytical coupling of the test results obtained in different test facilities. Instrumentation for the SCTF is provided by both the JAERI and the USNRC.

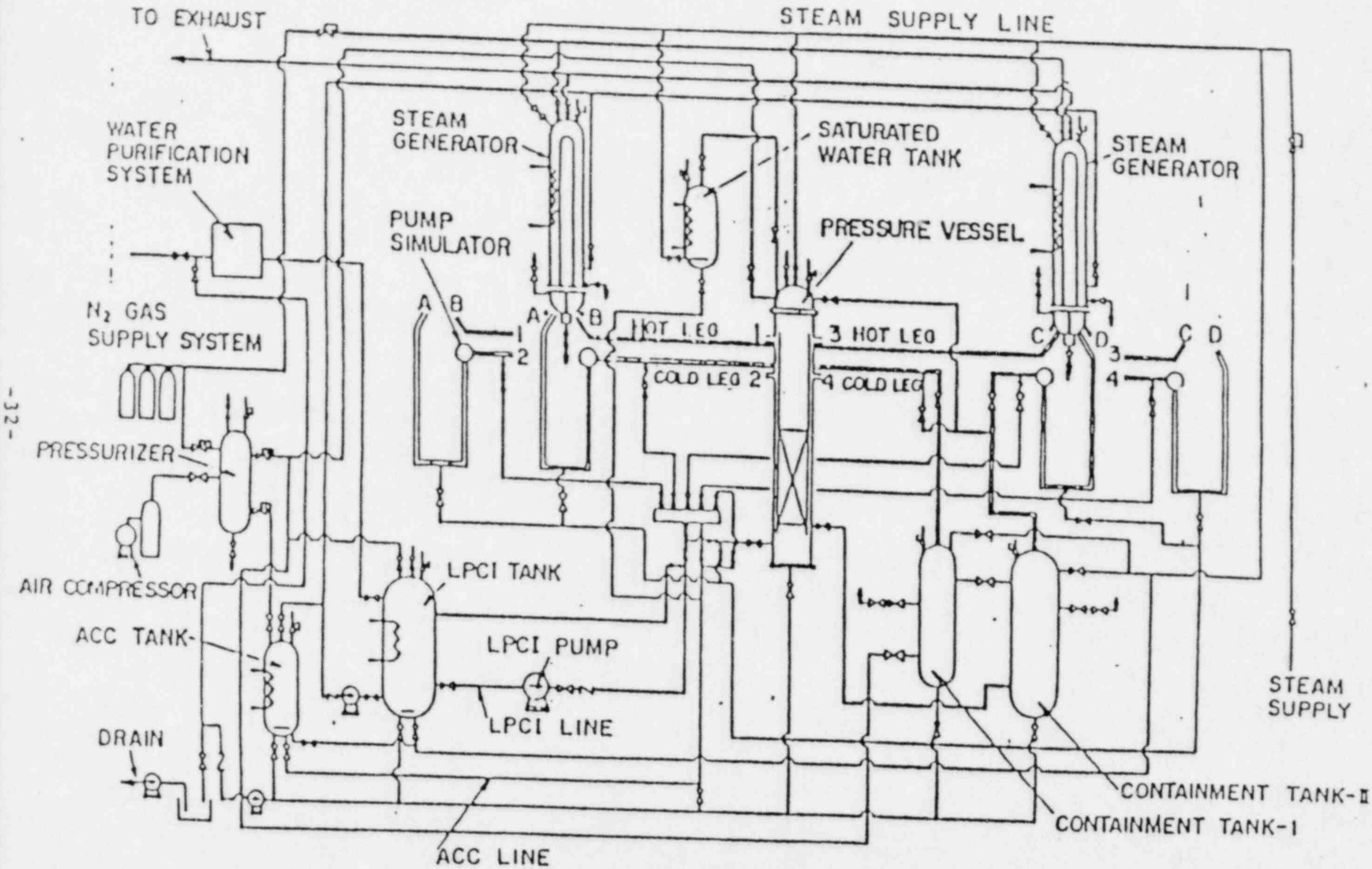
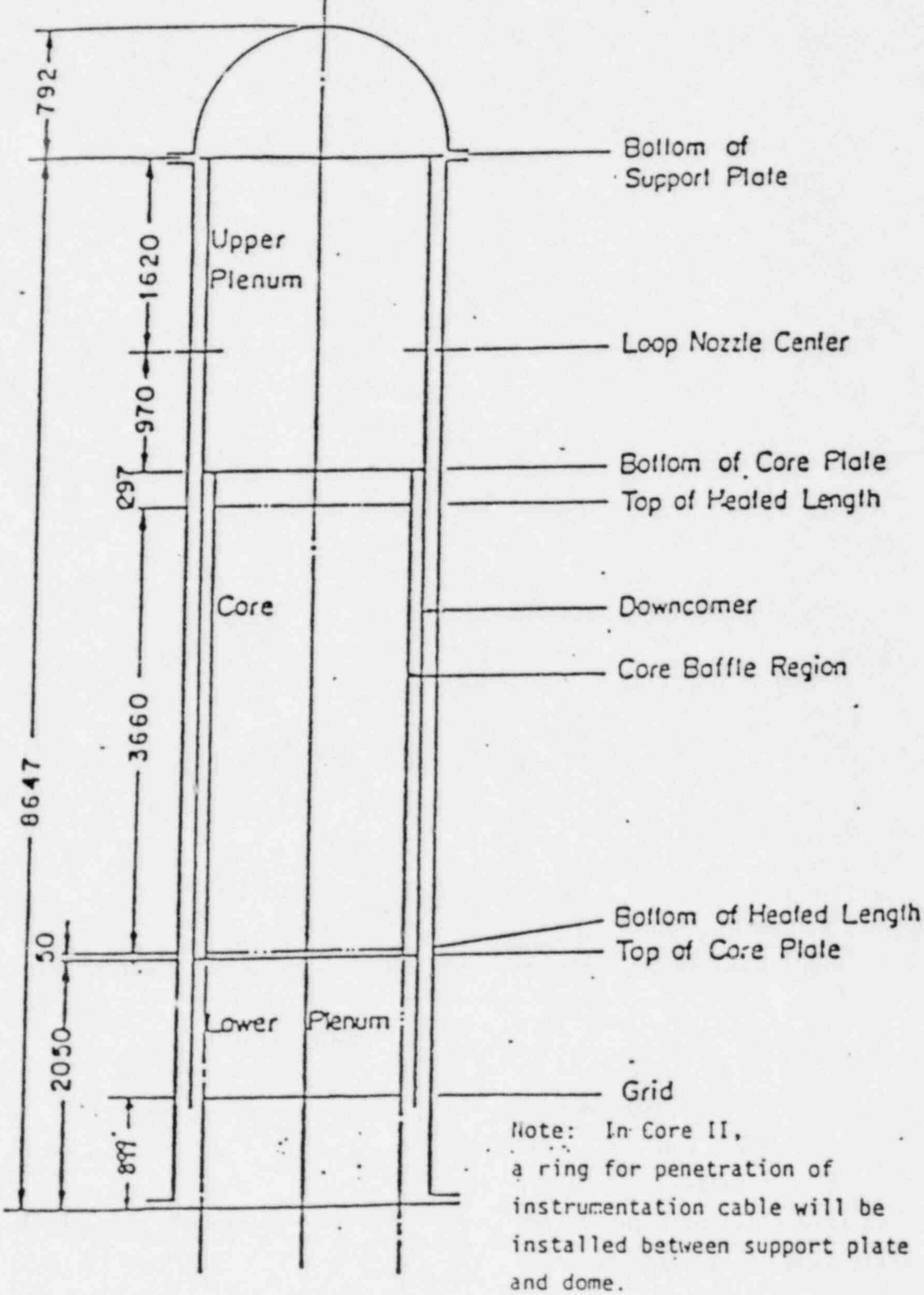


Fig. 2-7 Schematic diagram of cylindrical core test facility



Note: In Core II, a ring for penetration of instrumentation cable will be installed between support plate and dome. The height is 760 mm.

Fig. 2-8 - Dimensions of the pressure vessel

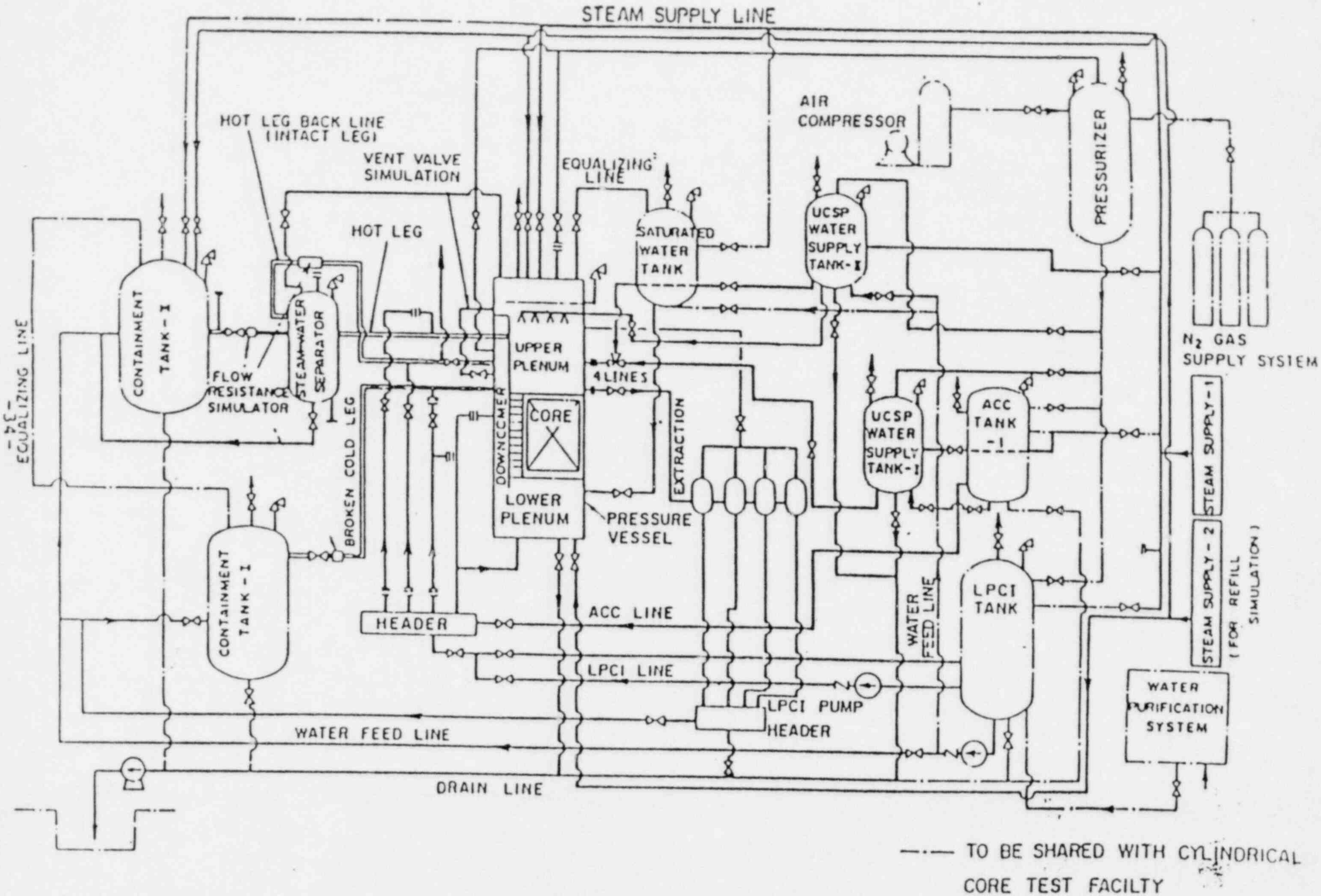
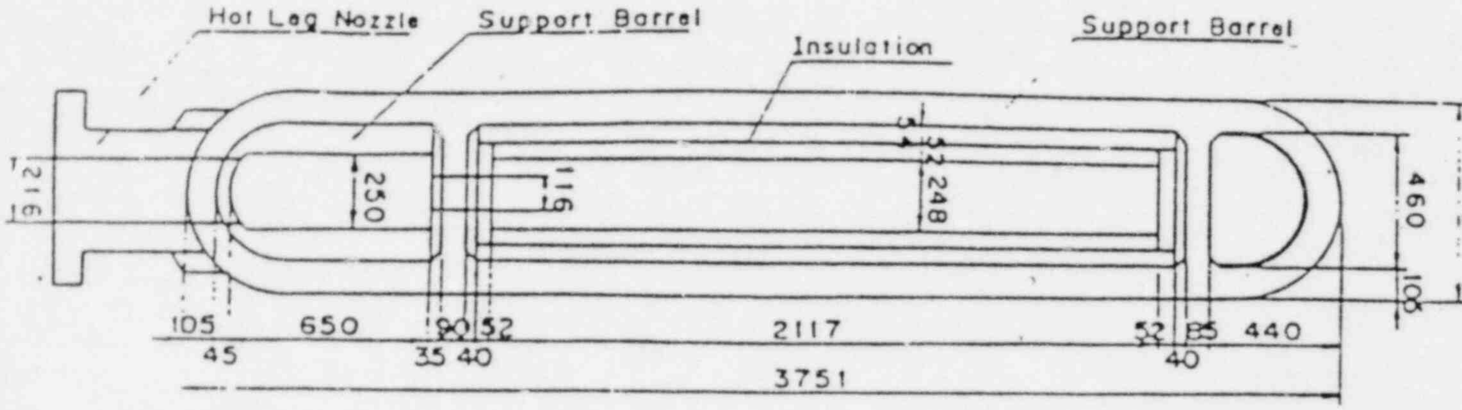
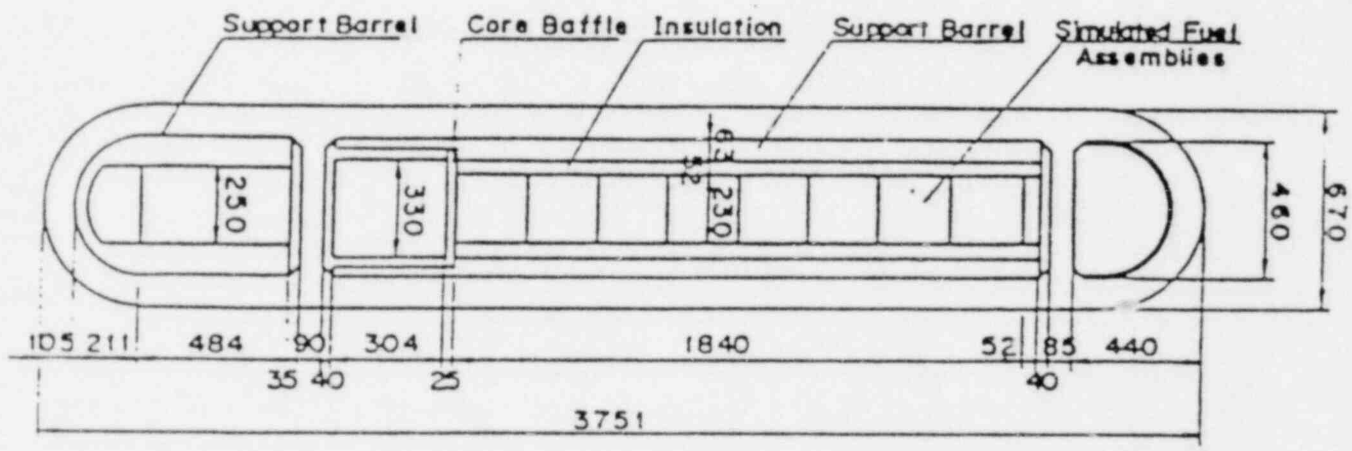


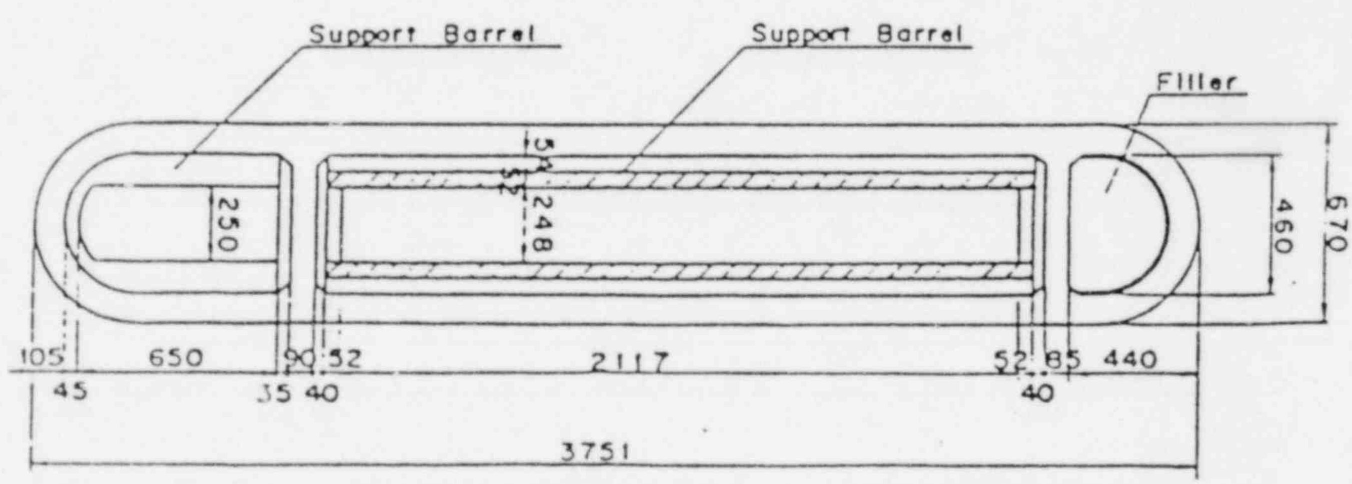
Fig. 2-9 SCHEMATIC DIAGRAM OF SLAB CORE TEST FACILTY



Upper Plenum Cross Section



Core Cross Section



Lower Plenum Cross Section

Fig. 2-10 In-Line Downcomer Design for SCTF

III. Plan for Instrument Development and Supply and Calculational Support for the 2D/3D Program by the USNRC

1. Introduction

In support of the JAERI and BMFT experimental refill and reflood test facilities, the USNRC will:

- Fund, develop, fabricate, deliver and provide operational support for advanced two-phase flow instrumentation to be installed in the JAERI and BMFT facilities (all instruments provided will meet written technical requirements, including accuracy jointly agreed upon by the parties), and
- Fund, develop and perform multi-dimensional TRAC computer code calculations for design analysis, pretest predictions and post-test analysis required for the test program.

2. USNRC 2D/3D Instrumentation

2.1 Measurement Requirements

The objective of the USNRC 2D/3D Instrumentation Program is the measurement of the two-phase behavior of steam and water at the boundaries of and locally within the core, upper plenum, downcomer and lower plenum of the test vessel in experiments at the UPTF, CCTF and SCTF, simulating the last part of blowdown, and the refill and reflood phases of a postulated loss-of-coolant accident (LOCA) in a pressurized water reactor (PWR).

The advanced instrumentation to be provided will supplement the conventional instrumentation provided by JAERI and the BMFT and be used to:

- Measure the velocity, mass flow and direction of steam and water in the nozzles of the test vessel;
- Measure the de-entrainment and entrainment of moisture in the upper plenum and in the vicinity of the upper core support plate and tie-plate;

- Measure film thickness and velocity in the core, on the baffle walls and on the upper plenum structures;

- Measure local void fraction in the core, upper plenum and downcomer;

- Measure liquid level in the downcomer, core, upper plenum and lower plenum;

- Measure steam and water distribution in the downcomer and upper plenum;

- Measure two-phase velocities in the downcomer, core and upper plenum; and

- Measure the mass flow between the core and upper plenum.

A table listing the suggested measurements to meet the objectives of the 2D/3D Refill/Reflood Program is attached to this Program Plan. This table also includes some of the facility-provided instrumentation where pertinent to the measurement objectives.

2.2 Instrument Development

To measure the mass flow and void fraction in the nozzles and loops, and between the core and the upper plenum of the CCTF, SCTF and UPTF, several types of instruments will be provided by the USNRC. The loops of the CCTF are to be provided with spool pieces. The spool pieces are short, flanged pipe sections which contain a drag disk, turbine meter, three-beam gamma densitometer, pressure cell and temperature measuring device. The spool pieces will be installed in the cold and hot leg piping of the CCTF to measure fluid density, velocity, mass flux and direction of flow to and from the cold and hot leg loops during the end-of-blowdown, refill and reflood phases.

The early CCTF Core-I tests were run without spool piece measurements. An NRC analysis of these data show that the measurements obtained without the spool pieces were not sufficient to perform an unambiguous mass balance over all time periods. It was found that assumptions had to be used to obtain the mass flow rate in the hot legs, the steam generator and the pump simulator. These assumptions affected the overall mass balance. Hot leg spool pieces now operational in CCTF will provide the mass balance information in the future. The cold leg spool pieces in CCTF will help remove ambiguity about the amount of ECC injection which flows from the vessel to the containment, through the broken cold leg, during both refill and reflood.

The second series of CCTF tests will include a downcomer to upper plenum core barrel vent valve simulation. Mass flow and void fraction will be measured. The velocity will be measured by a turbine meter and the void fraction by a string probe.

Mass flow and void fraction measurements are needed for the hot and cold leg nozzles of the SCTF and UPTF, which only have simulated loops. These measurements are needed to define the direction, velocity and steam/water flow to and from the test vessel. Because of the size of these nozzles, it is generally not practical to use conventional spool pieces. Therefore, isotopic multi-beam gamma densitometers to measure voids in conjunction with a drag disk rake will be used for the UPTF and for the hot leg nozzle of the SCTF. A spool piece will be used for the smaller SCTF cold leg nozzle. These will give information on mass flow, density and flow direction.

For the end-of-blowdown, refill and reflood phases, it is necessary to be able to measure the liquid level in the downcomer, lower plenum, core, and upper plenum. Liquid level detectors will be provided in appropriate quantities to follow these levels during the course of each test in the CCTF, SCTF and UPTF.

A newly developed NRC optical probe with extremely fast response identified as "Fluid Distribution" grids are to be provided in the downcomer and upper plenum of the CCTF and UPTF to measure the distribution of water and steam. The fluid distribution grids for SCTF consist of electrical conductivity probes and were developed before improved optical probes were available. These sensors will be able to detect whether or not a significant flow oscillation exists between the downcomer and the core during the reflood phase.

It is also necessary to measure the steam/water mass flow and direction in the downcomer during the end-of-blowdown and refill phases. To accomplish the latter objective, fluid distribution grids coupled with drag discs or turbine flowmeters are to be placed in the downcomer of CCTF Core-II, SCTF and UPTF. These instruments are placed in such a manner that axial, azimuthal, and radial differences in the flow behavior can be detected.

In order to evaluate the local mass flow rate and follow the flow direction and velocity of both steam and water within the core, the upper core support plate and the upper plenum, it is necessary to make local measurements at specified locations. The USNRC has developed several instrument types for making local film, void and velocity measurements. These include film and impedance probes and string probes to measure the velocity and void fraction in crucial two-phase flow locations.

Cross-correlation of probe signal pairs can be used to derive local velocities. The USNRC will provide film and impedance probes for the 2D/3D test facilities as given in the Scope of Supply Section. Film and impedance probes have measured void fraction and velocity in two-phase flow tests at ORNL and PKL.

The USNRC has developed a visual system using miniature TV cameras and rod lenses (video optical probe) to be used for viewing the space inside the experimental test vessels. The temperature limitation of current lens material requires the use of a cooling system. The resultant probe is too large to install in the core bundle but can be used for viewing structures and flow phenomena in the upper plenum, downcomer, and the hot leg of the JAERI test facility and in the upper plenum in the UPTF during refill and reflood. Several video optical probe systems have been provided to JAERI for use in the CCTF and SCTF and additional systems will be provided to the BMFT for testing in the UPTF.

2.3 USNRC Instrumentation, Fabrication, and Scope of Supply

The USNRC plans to provide the quantity and type of instruments given in the following tables for the JAERI and BMFT facilities noted. The USNRC will use its best efforts to meet the proposed schedule for delivering these instruments, which is based on meeting the preliminary facility design, construction and test schedule requirements provided by the BMFT and JAERI. The USNRC will provide all necessary preconditioning electronics required for the instruments. These electronics will nominally provide a suitable interface signal for recording in the data acquisition system. Cable between the sensor and preconditioning electronics will be provided by USNRC. Installation and checkout assistance will be provided, as well as a supply of spare parts for the test program. Follow-on assistance in correcting unusual malfunctions and data interpretation will be provided as stated further on in the text.

The NRC instrumentation provided for the JAERI CCTF Core-I delivery is given below. The instrumentation has been delivered and utilized by this facility.

JAERI CCTF Core-I

8 - instrumented spool pieces

3 - upper plenum liquid level detectors (LLDs)

4 - downcomer drag disks (DDs)

6 - core LLDs

3 - downcomer LLDs

3 - lower plenum LLDs

1 - video lens system

The instrumentation to be provided by the USNRC for the SCTF Core-I, the CCTF Core-II and the UPTF are given in Tables 2-1, 2-2, and 2-3. The quantities for reference purposes are listed in the tables. The scope of the USNRC instrument supply for all facilities including SCTF II and III is shown in the table attached to this Program Plan.

The DDs and core and lower plenum LLDs shown above as delivered for CCTF Core-I are to be refurbished for CCTF Core-II. Film and impedance probe modules were not included in CCTF Core-I. Film and impedance modules will be designed, fabricated and delivered by USNRC for installation in the CCTF Core-II heater bundle and vessel internals. As in the case of Core-II of the CCTF, Cores-II and III of the SCTF will reuse, to the extent possible, the same instrumentation in each successive core test series.

The SCTF Core-II will be supplied with several new film probes and impedance probes and as spares to cover possible loss in transfer from one core to the next. The film and impedance probes are installed during bundle assembly and are generally inaccessible thereafter. Hence, the USNRC would not expect to provide spare probes in event of failure in use. The responsibility of the USNRC in the case of the isotopic sources, electronics, spool piece turbine meters, spool piece drag disks and downcomer drag disks will be to provide replacement parts for maintenance and repair in the event of failure in normal use. One of the multi-beam sources has a relatively short half-life and will require replacement every 12 to 18 months. The USNRC would provide replacement sources during test intervals. Failure of an individual sensor in an LLD during a single core test series would normally not require replacing the sensor or justify removal of the LLD. Required spare parts would be provided by the USNRC for refurbishment or repair of the LLDs following removal from one core and prior to insertion in the next core.

The USNRC will provide the instrumentation support to PKL ii tests, as agreed upon by USNRC and BMFT.

JAERI and the BMFT will be responsible for providing craft support labor, hoists, rigs, and other equipment for installing USNRC-supplied instruments and electronics in the test facilities. Installation and maintenance instructions will be provided to JAERI and BMFT by the USNRC for each instrument. Each facility will be expected to follow these instructions and be responsible for routine maintenance. The USNRC will provide assistance in resolving unusual failure or readout problems and assist in interpretation of the signals. Special tools for the installation will be supplied by the USNRC.

Technical supervision will be provided by USNRC contractors on-site at the facilities during initial installation and checkout of USNRC-provided instrumentation. USNRC will provide personnel to assist in the maintenance of instrumentation and the USNRC-supplied DAS equipment when necessary, as mutually agreed by project managers, and also will assist in checking the instrumentation to assure the validity of the data. JAERI and the BMFT will be responsible for providing service requirements, such as electrical power, cooling water, etc., needed for the operation of the USNRC instruments.

TABLE 2-1

INSTRUMENTATION FOR SLAB CORE-I TO BE PROVIDED BY USNRC

Phenomena	Instrument and Location	Quantity
I. Upper Plenum		
1. De-entrainment	Film probes (Wall)	6
	Film probes (Structure)	6
2. Local flow pattern	Video optical probe	1
3. Local fluid, α	Prong probe	8
	Gamma densitometer	4
4. Local fluid velocity	Turbine meter (horizontal and vertical)	4
5. Pool formation	Fluid distribution grid	8x8
II. Core - Upper Plenum Interface		
1. Upward flow vel. between core and upper plenum*	Turbine meter (UCSP)	8
2. Fluid level in end box	Fluid distribution grid	Included in I.5
3. Local flow pattern	Video optical probe	1
III. Core		
1. Chimney effect	Impedance probe (α & V)	8
2. Bundle, α	Gamma densitometer grid	15
3. Liquid level	LLD	4
4. Lower plenum/core vel.	Turbine meter	4
5. Fallback on walls and tubes	Film probes (Wall)	8
	Film probes (Tube)	6
IV. Hot Leg		
1. Mass flow rate	Spool piece (w/o turbine)	1
V. Cold Leg		
1. Velocity, density, α	Spool piece	1
VI. Downcomer		
1. Flow patterns	Fluid distribution grid	2x3x7
2. Void fraction	String probe	3
3. Velocity (momentum)	Drag disc	3

*Provisions will be made to the extent practical by the USNRC to have the measurement method at the interface between the core and upper plenum be consistent in both the SCTF III and UPTF

TABLE 2-1 - Continued

Phenomena	Instrument and Location	Quantity
VII. Vent Line		
1. Mass flow rate	Spool piece (w/o Gamma)	1
VIII. Lower Plenum		
ORNL reference conductivity probe		1

TABLE 2-2

INSTRUMENTATION FOR CYLYINDRICAL CORE-II TO BE PROVIDED BY USNRC*

	Phenomena	Instrument And Location	Quantity
I.	Upper Plenum		
	1. De-entrainment	Film probes	4
	2. Local flow patterns	Optical probe	1
	3. Local fluid, α	Prong probe	4
	4. Local fluid velocity	Turbine meters (3V, 1H)	4
	5. Vent flow	Turbine meter (2H)	2
		String probe	2
	6. Pool formation	Fluid distribution grid	11x10
II.	Core - Upper Plenum Interface		
	1. Upward flow velocity	Turbine meter (UCSP)	8
	2. Fluid level in end box	Fluid distribution grid	Included in I.6
III.	Core		
	1. Chimney effect	Impedance probe (α & V)	24
IV.	Core - Lower Plenum Interface		
	1. Liquid flow	Cooled T/C	4
V.	Hot Leg		
	1. Liquid Flow	Film probe (α & V)	4
	2. Local flow pattern	Optical probe	1
VI.	Downcomer		
	1. Flow patterns	Fluid distribution grid	6x3x7 6x1x6
	2. Local flow patterns	Optical probe	1
VII.	Lower Plenum		
	ORNL reference conductivity probe		1

*(1) The instrumented spool pieces supplied for Core-I of the CCTF would be required for use with Core-II.

(2) The DDs and LLDs from Core-I would be refurbished for use with Core-II.

TABLE 2-3

INSTRUMENTATION FOR THE UPPER PLENUM TEST FACILITY TO BE PROVIDED BY USNRC

Phenomena	Instrument	Quantity
I. Upper Plenum		
1. Local flow patterns	Video optical probe	3
		12
2. Local fluid velocity	Turb. meters (6V, 6H)	12
3. Pool formation	LLD	8
4. Vent flow	Turbine meter	5
	dP**	5
5. Pool formation	Fluid dist. grid	63 x 7
II. Core - Upper Plenum Interface		
1. Upward flow velocity	Turbine meter	36 5
2. Fluid level in end box	Fluid dist. grid	Included in I.5
3. Mass flow	Drag bodies	36
	Narrow dP*	9
	Wide dP*	36
	Breakthrough detectors	100
4. Cross flow between end boxes	Turbine meter	6
III. Core		
1. Liquid level	LLD	2
IV. Hot Leg		
1. Density, α	Multi-beam gamma densitometer	4
2. Velocity (momentum)	Drag rake (bidirectional)	4
V. Cold Leg		
1. Density, α	Multi-beam gamma densitometer	1
2. Velocity (momentum)	Drag rake (bidirectional)	1
VI. Lower Plenum		
1. Liquid Level	LLD	EXT. of III.1
2. ORNL reference conductivity probe		1

* Transducers, signal conditioners, and purge contorl system, to be provided by USNRC; and tubes, plumbing, and bleeding to be provided by BMFT.

** Transducers and signal conditioners to be provided by USNRC, and tubes, plumbing, purge control system, and bleeding to be provided by BMFT.

TABLE 2-3 Continued

	Phenomena	Instrument	Quantity
VII.	Downcomer		
	1. Flow patterns	Fluid distribution grid	50x3+50x1
	2. Local fluid velocity	Turbine meter	8

2.4 Data Handling System

In order to assure proper processing and handling of the data, the function of each data handling subsystem, the interface between them, and the responsible party for each has been defined as follows (see Table 2-4a for the JAERI test facilities and Table 2-4b for the UPTF).

- Data-taking system: This includes the sensors, with associated electronics, up to and including the signal conditioners. The USNRC has responsibility for this work for USNRC-provided instrumentation.

- Data acquisition system: This consists of equipment downstream of the signal conditioners, including recording devices, simple conversion and calibration. This is the responsibility of the facility except for UPTF in which the USNRC will loan DAS equipment obtained from US suppliers and will provide technical support services. The USNRC will perform design studies for the supply of the UPTF DAS with the aim of utilizing to the fullest extent practicable equipment currently owned by the US government. The program plan is based on the assumption that the process will lead to a satisfactory solution. Should against present expectations, the necessity arises to develop alternative proposals, the three parties would jointly discuss such alternatives, taking into account the obligation and responsibilities of each party as described in the agreement.

- Data processing: This will be performed by the facility and includes conversion of signals from the DAS into engineering units and display and print out in forms useful for data report and data analysis by each party. Appropriate algorithms will be provided to each facility for data reduction of signals recorded from USNRC-provided instrumentation. Test facilities will be responsible for integration of the USNRC-provided software into a data processing system and will be responsible for processing the instrument signals for each test, unless otherwise specified.

- Data analysis: Data, after processing by the facility will be supplied to each party in forms useful for code analysis.

2.4 Data Handling System

In order to assure proper processing and handling of the data, the function of each data handling subsystem, the interface between them, and the responsible party for each has been defined as follows (see Table 2-4a for the JAERI test facilities and Table 2-4b for the UPTF).

- Data-taking system: This includes the sensors, with associated electronics, up to and including the signal conditioners. The USNRC has responsibility for this work for USNRC-provided instrumentation.

- Data acquisition system: This consists of equipment downstream of the signal conditioners, including recording devices, simple conversion and calibration. This is the responsibility of the facility, except for the UPTF for which USNRC will be responsible for design software and supply of the DAS consistent with the conditions agreed upon by BMFT/USNRC in the telephone conversation on February 26, 1982.

- Data processing: This will be performed by the facility and includes conversion of signals from the DAS into engineering units and display and printout in forms useful for data report and data analysis by each party. Appropriate algorithms will be provided to each facility for data reduction of signals recorded from USNRC-provided instrumentation. Test facilities will be responsible for integration of the USNRC-provided software into a data processing system and will be responsible for processing the instrument signals for each test, unless otherwise specified.

- Data analysis: Data, after processing by the facility will be supplied to each party in forms useful for code analysis.

TABLE 2-4a

DATA-HANDLING SUBSYSTEMS, INTERFACE AND RESPONSIBILITY FOR ____ TEST FACILITIES

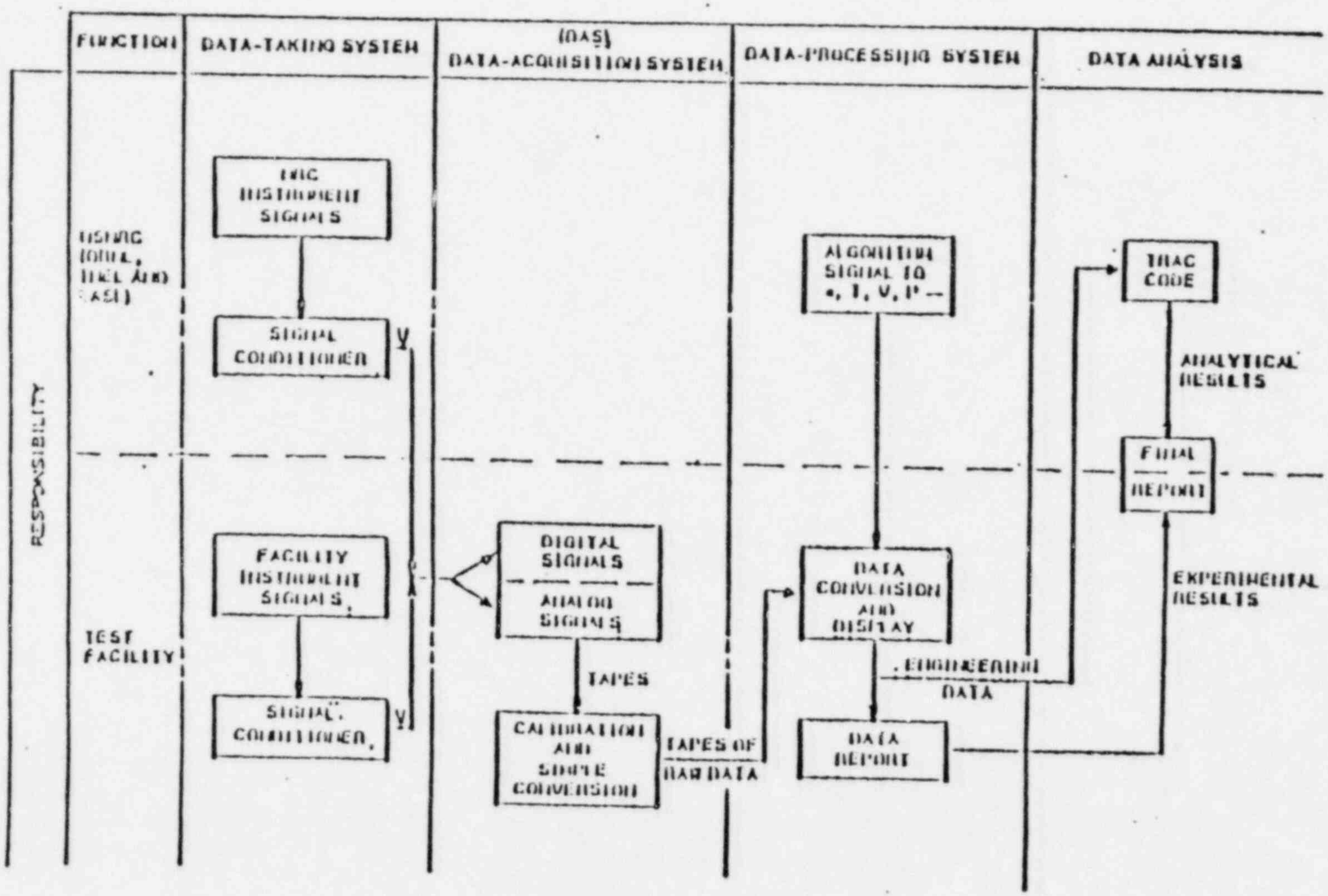
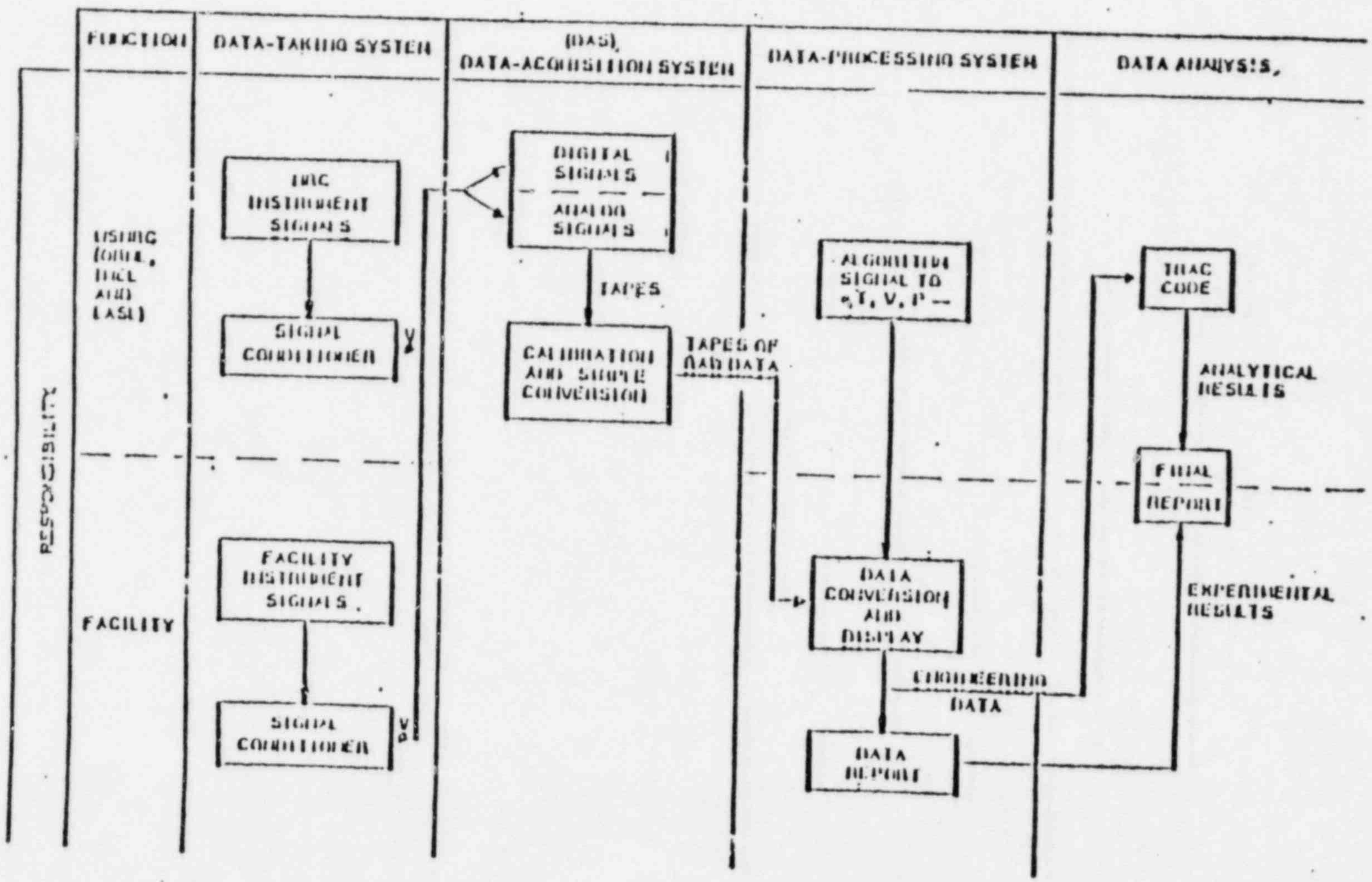


TABLE 2-4b

DATA-HANDLING SUBSYSTEMS, INTERFACE, AND RESPONSIBILITY FOR THE UPTF.



3. USNRC Analytical Support

3.1 Objective

The objectives of the USNRC analytical support program are to utilize the TRAC code to:

- Provide analysis support during the design phase of the UPTF and SCTF;

- Evaluate the location and type of instrumentation, and desired accuracy in UPTF, SCTF and CCTF;

- Provide analysis support in the testing phase to help specify the boundary conditions and initial conditions of each experiment;

- Perform post-test prediction for each valid experiment; (See Table 6). Post-test analyses will be performed if necessary (See Section 3.4).

- Provide analytical coupling between the two separate-effects test facilities, UPTF and SCTF; and

- Using integral system data from PKL* and CCTF and large-scale separate-effects data from UPTF and SCTF, checkout and validate the multi-dimensional best-estimate code TRAC to form a basis for credible predictions of the behavior of a full-size PWR during the last part of blowdown, refill and reflood phases of a postulated loss-of-coolant accident.

TRAC (Transient Reactor Analysis Code) has been developed with the objective of improving capabilities for analyzing postulated transients in full-scale reactors. The improvements focus on the following areas: (1) a modular structure to allow flexibility in code organization and problem setup and to facilitate introduction of improved models; (2) simulation of multi-dimensional flow within the reactor vessel to allow investigation of radial and azimuthal flow, in addition to axial variations; (3) dynamic dimensioning to allow the maximum number of computational cells and hence better simulation of local flows with local models; and (4) ability of the separate phases to have separate temperatures and to move with different velocities in order to properly simulate postulated flow transients.

3.2 Integration of Test Results with Full-Scale Simulation

Of the three test facilities included in this test program, the JAERI CCTF use full system tests with a heated core and external loops with steam generators. The JAERI SCTF has a full-radius and full-height heated core, with upper and lower plena, all in slab geometry. There is only limited hardware in the SCTF to explicitly mock-up the external loops. The UPTF is a full-scale 360° sector of a reactor vessel without a heated core, and uses steam/water flow from nozzles located below the upper core plate to simulate core flow. In contrast with SCTF, there is simulated hardware for the ex-vessel system. Thus, each facility concentrates on specialized aspects of multi-dimensional flow within the vessel.

The three participating countries produce PWRs of differing designs and dimensions. Thus, the geometry of the test facilities is to be a composite which is a compromise reflecting the main features of the individual designs. The CCTF has vessel internals scaled down from a Westinghouse design (similar to Japanese plants). The UPTF will have full-size internals based on the German (KWU) design which are similar to those of the new Westinghouse PWR designs, while the SCTF will have internals based on the US/Japan design in Cores I and II and the KWU design in Core-III to provide for coupling to UPTF. All three facilities will incorporate core barrel vent valves in order to test this feature of the B&W design.

Thus, each of the three facilities will give important, but geometrically specialized, information which must be integrated together with a simulation of a full-scale LWR system for each of the various PWR designs. The TRAC code will perform this integrated simulation (See Figure 2-11).

In addition to providing computer simulations of each of the three test facilities, TRAC will, in parallel, provide a computer simulation for one representative design of each of the full-scale PWR systems supplied by the participating countries. Thus the measured results from each test with particular geometry, boundary, and initial conditions can be directly integrated with the full-scale PWR simulation which the test represents (see Figure 2-12).

To aid in extrapolating the 3D test results to different designs, small-scale tests have been performed in the US to develop local geometry-dependent models for countercurrent flow and flooding at the upper end box and net entrainment on upper plenum structurals.

3.3 TRAC Coupling of Tests

In addition to integrating the individual test results into full-scale PWR simulations, TRAC will be used, along with engineering judgment, to couple the individual tests (see Figures 2-11, 2-12, 2-13, and 2-14). It is understood that, in Figure 2-14, there is to be generally one iteration between facilities in order to confirm the boundary conditions. This coupling will be of two forms: analytic coupling between test facilities not being run in parallel, and experimental coupling between test facilities being run in parallel. The schedule provides for SCTF Core-III and UPTF to be run in parallel so that experimental coupling can be achieved. Figure 2-12 emphasizes the method for the case where the two facilities (UPTF and SCTF) are run as two separate-effects tests with only analytical coupling. A paper which describes the coupling of experiments in UPTF and SCTF Core-III (Reference 1) has been prepared and accepted as a working document by the three parties at a meeting in November 1979.

Reference: 1. "Coupling of Experiments in the Upper Plenum Test Facility and the Slab Core Test Facility," October 30, 1979.

In this regard, the SCTF plays a pivotal role in the geometric coupling because it will have a set of Westinghouse/Japanese (W/J) internals in Cores I and II and a set of KWU internals in Core-III. The CCTF is currently planned to have only W/J internals while the UPTF will only have KWU internals. The first CCTF test series will be finished before the first SCTF tests start, so the coupling between the W/J geometry tests in these two facilities will require analytic coupling by TRAC. The KWU geometry tests in the SCTF Core-III and UPTF will be run somewhat in parallel in time so that coupling can be obtained experimentally, using a combination of TRAC and engineering judgment. For these latter tests, TRAC will supply initial and boundary conditions for the next test in one facility based on the results of the previous tests in the other facility. Specifically, for the UPTF, TRAC will supply the conditions of the two-phase flows to be formed by the core simulator during the test, the initial water level in the lower plenum and the pressure conditons at the hot leg nozzles. For the SCTF, TRAC will supply the side injection flows into the upper plenum and the liquid temperature distribution above the upper core support plate in the case of combined injection, the initial power and temperature distribution within the core, the initial water level in the lower plenum and the pressure conditions at the hot leg nozzle.

Coupling between the core and upper plenum will be automatically accounted for in both the CCTF system test and the SCTF facility, since both have heated cores. In this regard, the CCTF facility plays a key role in determining the system effects feedback on this coupling. In SCTF, the liquid feedback from the upper plenum to the core will be measured, as well as the feedback effect of this fallback. Thus, increased steam generation within the core, as well as liquid "sputtering" from the hot rods, leading to possible plugging of the subchannels with saturated water, will be explicitly observed using JAERI-supplied thermocouples. These measured observations will be used to test the TRAC prediction of this feedback phenomenon between the core and upper plenum. Based on an analysis of these test results from CCTF and

SCTF, TRAC will be in a position to calculate the steam/water spray injection necessary at the lower boundary of the upper plenum during testing in the UPTF.

The current understanding is that saturated ECC water will be injected for up to 10 seconds to form a layer of saturated water above the upper core support plate to simulate the potential plugging phenomena in a heated reactor case.

TRAC analysis will be provided for tests with cold leg injection, combined cold leg and hot leg injection, as well as alternate ECC injection locations. Necessary model improvements to TRAC are being made so as to be ready in time to accurately predict the phenomena expected to occur during the diverse tests compromising the 2D/3D Program. For those facilities to be built after this arrangement takes effect, TRAC will be used to assist in design studies.

3.4 Scope of Calculations

For valid experiments, code calculations for the specific geometry of the test facility will be made for:

- Post-test prediction (with measured initial and boundary conditions) will be made when the initial and boundary conditions are available.

- Post-test analyses will be made for improvement of analytical model, based on physical finding from experiments, if necessary.

For tests which may be selected as international standard problems, pretest prediction will be calculated.

For valid tests, the calculations and experiments are to be coordinated as follows:

- Test performed.

- Actual boundary and initial conditions transmitted to LANL for post-test prediction; data access to LANL will be restricted until post-test prediction is documented.

- Post-test prediction transmitted to facility and Quick-Look Report issued.

- Test data transmitted to LANL. Post-test analysis performed if necessary.

The responsibility and report preparation and interaction between analysis and experiment is contained in Table 2-5.

TABLE 2-5

SPECIFICATION OF RESPONSIBILITIES FOR INTERACTIONS BETWEEN ANALSIS AND EXPERIMENTS

	Objective	USNRC	JAERI	BMFT
1.	Thermal-hydraulic design assistance calculations	R	A	A
2.	Facility hardware design	A	R	R
3.	Location and type of instrumentation	R	R	R
4.	Data acquisition and processing	A*	R	R
5.	Experimental Operation	[illegible]	R	R
6.	Uncertainty analysis of instrumentation and measurements	[illegible]	[illegible]	[illegible]
7.	Specification and analysis of model test[3]	R	A	A
8.	A. Specification of startup tests	A	R	R
8.	B. Analysis of startup tests	R	A	A
9.	Analytic predictions for tests	R	A	A
10.	Quick-Look Data Report*	A	R	R
10.	A. Report of comparison between data and prediction*	A	R	R
11.	Experimental Data Report*	A	R	R
12.	Post-test analysis for each experiment	R	R	R
13.	Analysis of computer behavior[3]			
14.	Empirical correlation of data and comparison with existing correlations[3]			
15.	Final Analysis Report for test series	R	R	R
16.	Specification of accuracy of measurement	R	A	A

Legend for Table 2-5

R - Primary Responsibility
A - Assistance

[1] approval by analysis
[2] R: instrument developer in all facilities
[3] New model tests: decision by Technical Coordination Committee
[4] Within a specified time period (see Appendix 7) reports will be released to the public following a review by the TCC to ensure correctness of data and calculation results.
[5] depending on interest of party

* unless specified otherwise

Table 2-6 summarizes the approximate number of documented studies to be performed.

As improved versions of TRAC become available they will be used in the 2D/3D Program.

TRAC-P1A Faster-running than TRAC-P1

TRAC-PD2 New reflood modeling; error corrections

TRAC-PF1 Fast-running; non-condensible gas

TRAC-PD3 Multi-D kinetics with feedback, ATWS, restructured with improved modeling (if development is authorized by NRC)

Initial calculations were performed using TRAC-P1A. During calendar year 1980 and 1981 most calculations were performed using PD2. Beginning in calendar year 1982, TRAC-PF1 will be used for most calculations.

All versions will be released promptly for 2D/3D use after completion. The IBM version if available will be released when requested.

Information about development and calculations will be exchanged between parties in advance of completion of the codes. USNRC will keep the BMFT and JAERI and their contractors informed of details of the model development of the TRAC code and will provide, upon request, copies of the latest released version of the TRAC code for their own use.

3.5 Assessment of Test Results

In support of the JAERI and BMFT reflood and refill program experiments, the USNRC will conduct systematic assessment of the test results. This assessment will be carried out for several purposes:

- In support of the TRAC development activities, a thorough understanding of the physical phenomena and the sequence which they occur is needed. Assessment of the test data will be performed to meet this need.
- In support of test facility operation and in evaluating the performance of the instrumentation, consistency checks will be performed on the data. This intent is to assure the test results and the output from the instrumentation are consistent and sensible.

TABLE 2-6

TRAC Calculations for 2D/3D
Minimum Set of Documented Studies

	FISCAL YEAR	78	79	80	81	82	83	84	85	86	87	88	TOTALS	
FULL-SCALE PWR	GERMAN	0	1	3	1	2**	2**	2**	~~1~~ 0	~~1~~ 0	~~1~~ 0	1	~~15~~ 12	
	W/J	4	2	0	1	1	1	1	0	1	1	1	13	
	B&W	0	0	0	0	0	1	0	1	1	1	0	4	
UPTF *	TESTS	0	0	0	0	0	0	0	~~10~~ 6	~~20~~ 18	~~10~~ 5			~~40~~ 30
	CALCULATIONS:													
	DESIGN/OPERATION	2	2	1	7	6	6	6	0	0	0	0	30	
	PREDICTION/ANALYSIS	0	0	0	0	0	0	0	~~10~~ 6	10	~~10~~ 14	0	30	
CCTF	TESTS	0	4	16	4	12	8	4	4	2	0	0		44
	CALCULATIONS:													
	DESIGN/OPERATION	1	0	0	0	2	0	0	0	0	0	0	3	
	PREDICTION/ANALYSIS	0	2	4	9	3	8	4	4	2	0	0	36	
SCTF	TESTS	0	0	0	6	12	2	8	12	10	10	0		60
	CALCULATIONS:													
	DESIGN/ OPERATION	3	4	4	0	0	2	0	0	0	0	0	13	
	PREDICTION/ANALYSIS	0	0	0	8	10	4	8	12	10	5	5	62	
TOTALS	TESTS	0	4	16	10	14	10	12	~~26~~ 22	~~32~~ 30	~~20~~ 16	0		~~144~~ 134
	CALCULATIONS	10	11	12	26	24	24	21	~~28~~ 23	~~25~~ 24	~~18~~ 21	7	~~206~~ 203	

1. Several test calculations may be combined into one write-up as one documented study, such as tests which vary only by one parameter; but each valid test will have one calculation as part of the documented study.
2. No more pre-test predictions, as agreed to by the TCC in March 1981.
3. In Design/Operation calculations, a documented study may consist of several calculations.
4. The calculation numbers listed in the table of Appendix III of the Agreement are individual calculations, but not documented studies.

* Number of UPTF calculations to be discussed when test matrix is decided.

** FRG resident engineer(s) at LANL to ~~perform most of the calculations with LANL assistance.~~ assist LANL to perform calculations

- In support of application of the test data in improving the TRAC analysis, simple analyses of separate aspects of the test facility will be performed. This intent is to emphasize understanding of the basic physics involved and to explore the importance of various parameters before incorporating these into the larger, more complex and complete computer codes such as TRAC.

- In support of applying the test results to other facilities (coupling) or to full-scale PWRs, test data assessment will be performed to assess the effects of characteristics unique to particular test facilities and to address the problem of applying the results to PWRs. Thus, the applicability of 2D/3D test results to the licensing process will be considered in a timely manner. This work will also be used to feed back to test planning to assure maximum usefulness of tests to be performed.

The test results analysis activities will be coordinated with similar activities conducted by JAERI and FRG personnel and will be documented, as appropriate, using the normal 2D/3D documentation procedures.

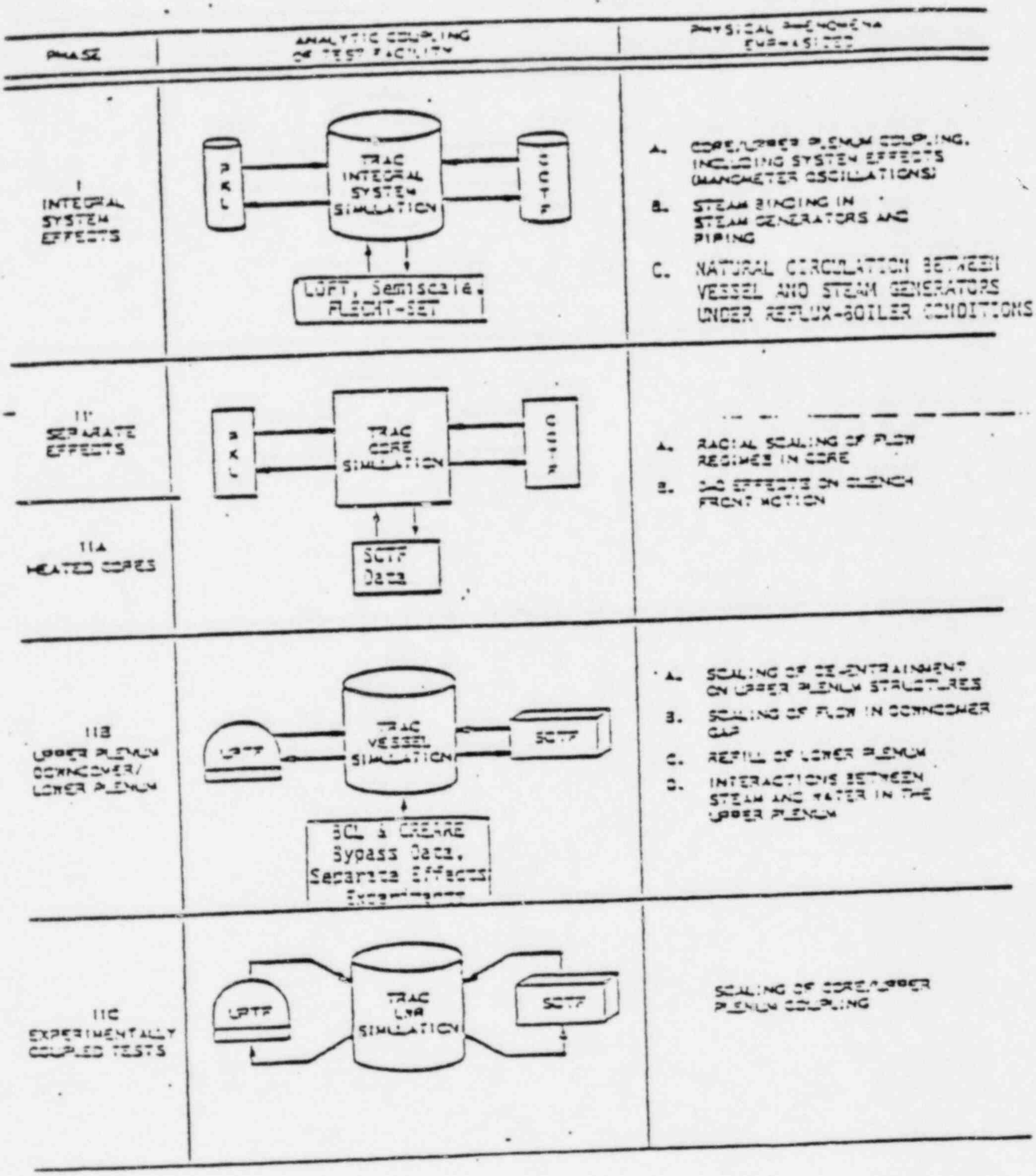


Fig. 2-11 - Phases of analytic checkout in the 2-D/3-D program

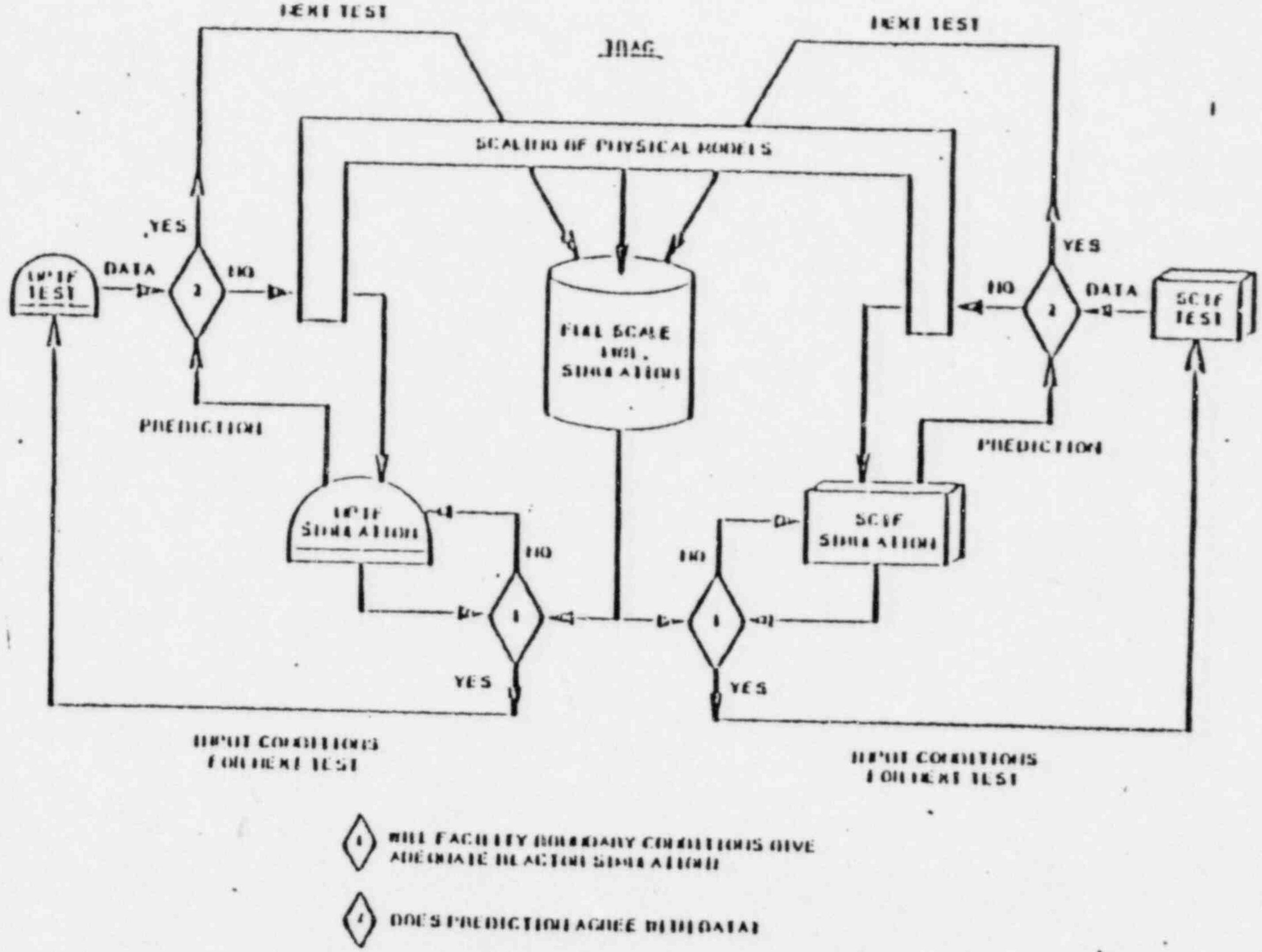
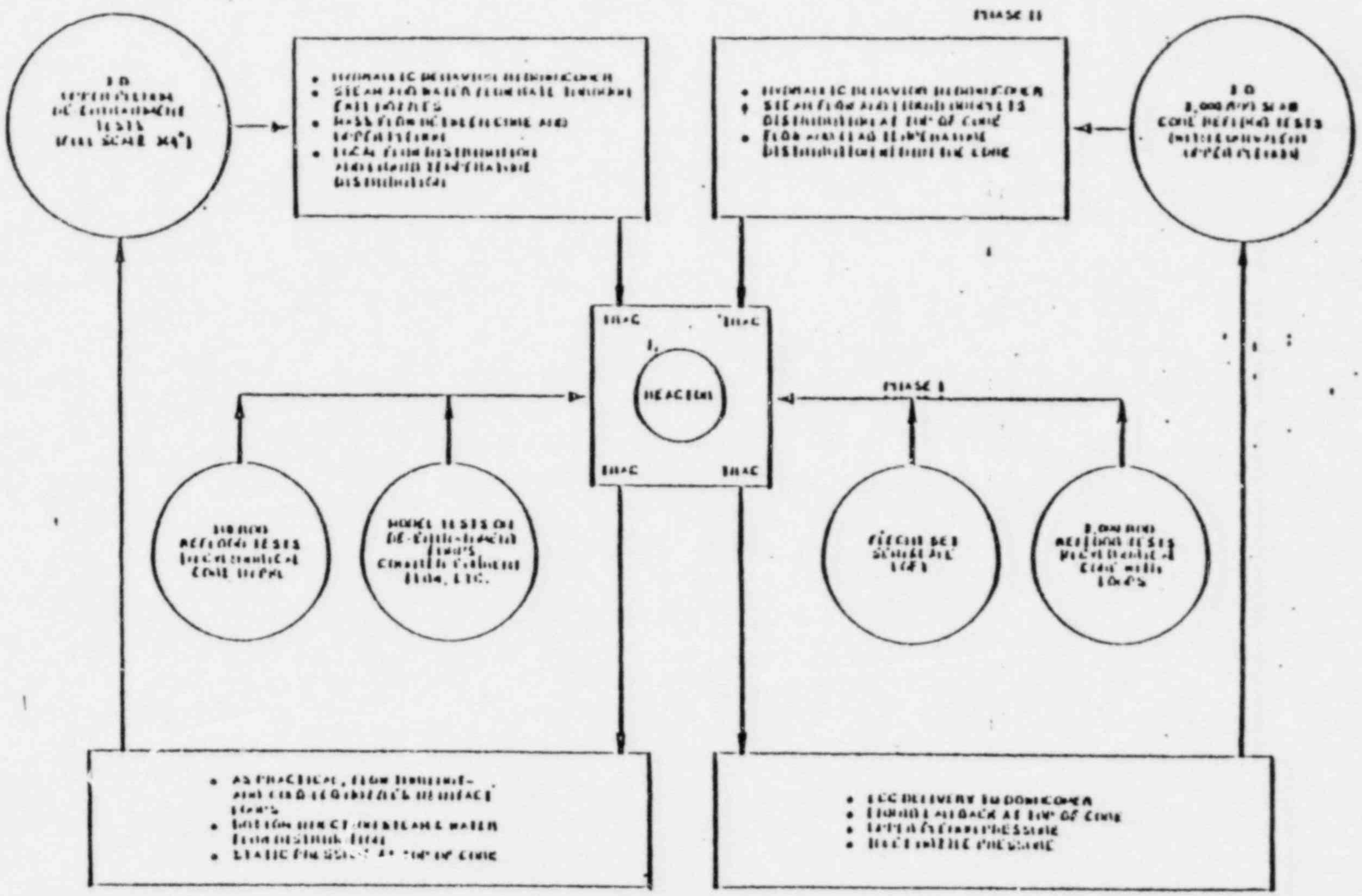
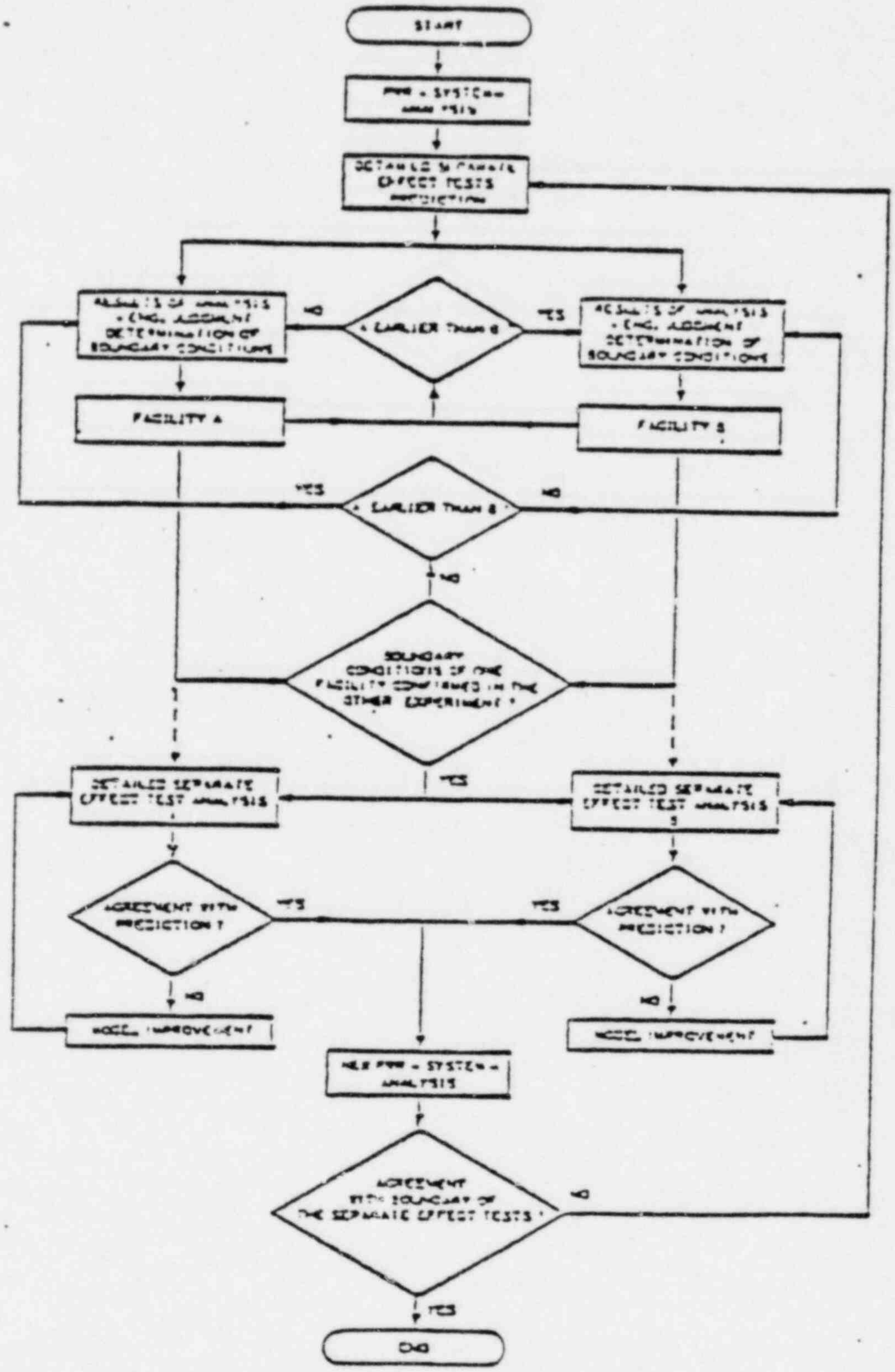


Fig. 2-12 - - SCTF-UPTF Interconnection with only analytic coupling



COORDINATED REFLOOD & DE-ENTRAINMENT TESTS

Figure 2-13



- Fig. 2-14 - Flow chart for the interconnection of the SCTF and UPTF experiments and analyses

CHAPTER 3

TEST PLANS

I. UPTF Test Plans and Schedule

The basic test to be performed is a reasonable simulation of a PWR LOCA from the time the upper plenum reaches 9 bars absolute through the last part of blowdown (to establish the initial conditions of the refill phase), and through the refill phase and the crucial part of reflood. A real-time simulation is preferred unless substantial cost savings or other benefits can be obtained without adversely affecting the experimental data. Emphasis and temporal priority will be given in the preliminary test matrix (Table 3-1) to existing ECC systems.

The test period will be two years. A total number of 30 tests shall be performed. If achievable, a larger number of tests will be performed within the specified test period.

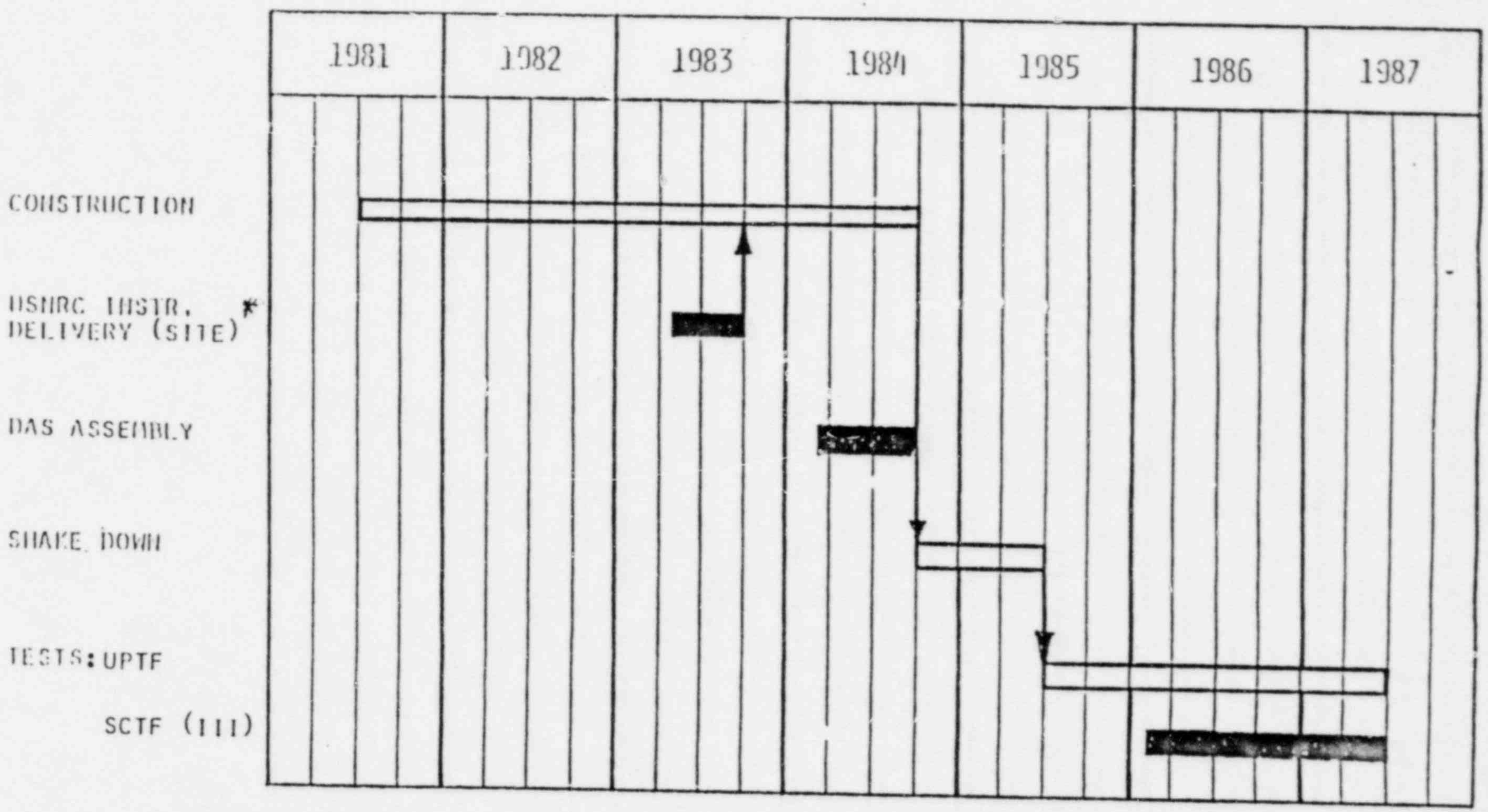
Hot and cold leg breaks and different break sizes will be simulated.

Provisions will be made to perform separate effect tests. One part of the tests will be coupled tests to interconnect the 2D and 3D test facilities. Another part of the tests will be parametric tests.

The UPTF schedule is shown in Fig. 3-1.

TYPE OF TEST	NUMBER OF TESTS	
A. SEPARATE EFFECTS TEST	13	
1. DOWNCOMER		6
2. UPPER PLENUM		6
3. STEAM GENERATOR TUBE BREAK		1
B. INTEGRAL TESTS	17	
1. COMBINED INJECTION		8
2. COLD LEG INJECTION (INCL. B&W)		7
3. ALTERNATIVE ECCS		2
TOTAL NUMBER OF TESTS	30	

TABLE 3-1: PRELIMINARY TEST MATRIX FOR THE UPTF



2D/3D PROJECT, UPTF SCHEDULE

* This schedule proposed by FRG

Fig. 3-1

II. JAERI Test Facility Test Plans and Schedule

1. Cylindrical Core Test Facility

1.1 Test Program

The main part of the test series to be performed is a direct, continuous simulation of a PWR LOCA from 6 bars absolute through the last part of blowdown, refill and crucial portion of reflood. A real time simulation is preferred unless substantial cost savings or other benefits can be obtained without adversely affecting the experimental data. Emphasis and temporal priority will be given in the test matrix to existing ECC systems.

The test period shall be as shown in Fig. 3-2 for Core-I and Core-II. A minimum of 20 tests will be performed with each of the two cores (see Table 3-2).

Provisions shall also be made to perform separate effects tests. These separate effects tests are to be used to understand the performance of particular portions of the integral tests, e.g., downcomer penetration, and to test effects of particular interest or unility in coupling the SCTF and UPTF. These tests will also be used to conduct parametric tests as required.

1.2 Schedule

The overall schedule shall be as shown in Fig. 3-2.

2. Slab Core Test Facility

2.1 Test Program

The main part of the test series to be performed involves a direct, continuous simulation of a PWR LOCA from 6 bars absolute through the last part of blowdown, refill and crucial portion of reflood. A real-time simulation is preferred unless substantial cost savings or other benefits can be obtained without adversely affecting the experimental data. Emphasis and temporal priority will be given in the test matrix to existing ECC systems. The test period will be as shown in Fig. 3-2 for Core-I and Core-II.

Core-III will follow. A minimum of 20 tests will be performed with each core (see Table 3-3). If achievable, a larger number will be performed, and, if practicable, within the same time period.

Provisions shall also be made to perform separate effects tests. These separate effects tests are to be used to understand the performance of particular portions of the integral test, e.g., downcomer penetration, and to test effects of particular interest or utility in coupling the UPTF and SCTF. These tests will also be used to conduct parametric tests as required.

2.2 Schedule

The overall schedule shall be as shown in Fig. 3-2.

TABLE 3-2

Cylindrical Core Test Matrix

	1st Core	2nd Core
Fuel Assemblies	15 x 15 W	15 x 15 W
Peaking Factor	1.49	1.40
Upper Plenum Internals	17 x 17 W	17 x 17 W new design
Type of Tests	Cold leg Injection: 20 runs	Refill/Reflood tests with cold leg injection: 10 runs Alternative ECCS tests: 5 runs Coupling tests with SCTF: 1 run Others: 4 runs

Figure 3-2 TIME SCHEDULE OF JAERI LARGE SCALE REFLOOD TEST PROGRAM

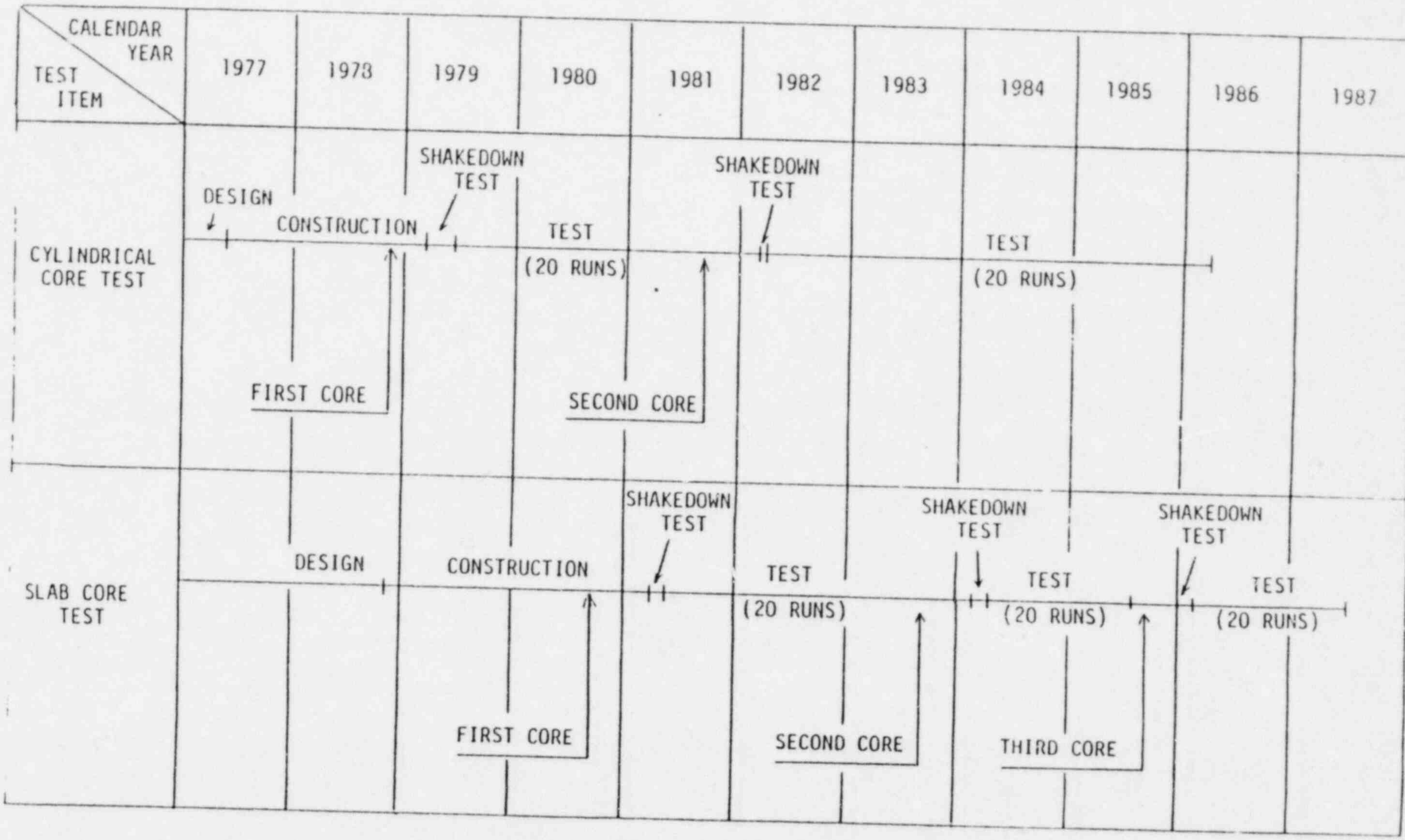


TABLE 3-3

Slab Core Test Matrix

Core	I		II		III	
Upper Structure	CCTF Core-II Coupling		CCTF Core-II Coupling		UPTF Coupling	
Core	W, Blockage		W, Normal		KWU, Normal	
Test	Forced Inj.	10	Cold Leg Inj.	16	Combined Inj.	15
	Gravity Inj.	1	Vent Valve	2	Cold Leg Inj.	4
	Cold Leg Inj.	7	Alternative ECC	2	Hot Leg Inj.	1
	Combined Inj.	2				
Total		20		20		20

APPENDIX I

TABLE OF MEASUREMENTS TO MEET THE OBJECTIVES OF THE 2D/3D REFILL/REFLOOD PROGRAM

MEASUREMENTS TO MEET OBJECTIVES OF 2D/3D REFILL/REFLOOD PROGRAM

COMPONENT	PHYSICAL PROCESS	MEASUREMENT REQUIRED	PRI-OR-ITY (1)	INSTRUMENT AVAIL-ABLE	SUP-PLI-ER (2)	NUMBER/FACILITY[8] CCTF I	CCTF II	UPTF	SCTF I	SCTF II	SCTF III
Core	Quench Front Motion	Axial Distribution of Rod Temperature	P	T/C (Metal)	F	168/6 (5)		— —	60/8 12/8 (5)		
						840		N.A.	662		
	Chimney Effect (including entrained drops)	Local Fluid α and V	S 1	Impedance Probe	N	—	24	N.A. ↓	8	6*	4*
		Fluid Temperature	S 1	T/C (Fluid)	F	49			102		
		Steam Temperature	P	Superheat Probe	F	—			16[9]		
		Bundle-Averaged α	P	γ-Densitometer	N	—	—		16[10]	(12)	(12)
		Radial ΔP	P	ΔP Gauge	F	—			6[11]		
	Liquid Level (Oscillations)	Axial ΔP	P	ΔP Gauge	F	28		—	67		
		Liquid Level	P	Liquid Level Detector	N	6[15]	(12)	2[52]	4[51]	4*	(12)
				ΔP, Level	F	—		—	—		
				Level Detector	F	—		—	17[16]		
	Core/Lower-Plenum Flow During Reflood	Liquid Velocity At Bottom of Downcomer	S 1	Turbine Meter	N	—	—	(17)	4	(12)	(12)
		Liquid Velocity near LCSP	S 1 S 1	Drag Disc Cooled T/C	N H	4[1?]	4	—	3[18]		
	Fallback on Walls and Unheated Tubes	Liquid Film Thickness and Velocity	S 1	Film Probe Modules Wall Tube	N N	— —	— —	— —	8 6	6 6	(14) —
		Wall Temperature	-	T/C (Metal)	E	37			42		
	Sputtering Measurements	Liquid/Vapor Discrimination	B 1	T/C (Fluid) (13)	P	-	-	-	-	64*	(12)

MEASUREMENTS TO MEET OBJECTIVES OF 2D/3D REFILL/REFLOOD PROGRAM (Continued)

COMPONENT	PHYSICAL PROCESS	MEASUREMENT REQUIRED	PRI-OR-ITY (1)	INSTRUMENT AVAILABLE	SUP-PLI-ER (2)	NUMBER/FACILITY CCTF I	CCTF II	UPTF	SCTF I	SCTF II	SCTF III
Core/ Upper-Plenum Interface	Mass Flow Rate Across UCSP, From Core to Upper Plenum (41)	Mixture Velocity	P	Turbine Meter	M	—	8	36	8	8†	(12)
		ρ_m in End-box with Froth: (42), (48)									
		1) ΔP between tie-plate and Upper-Plenum	P	ΔP Gauge	F	"Upper Plenum; Pool Formation"					
		2) Fluid Level in End-Box	P	Extension of Upper-Plenum FD Grid(21)	M	—	11x10	63-7†	8x8	(12)	(12)
		Steam Superheat	S 1	Superheat Probe	F	—	—	17	—	—	—
	Mass Flow Rate Across End-Box Tie-Plate, From Upper Plenum to Core(46)	Liquid Velocity, from ΔP Across End-Box Tie-Plate(43)	P	ΔP Gauge	F	4(18)	8(19)	—	8(19)	—	—
		Fluid Temperature in End-Box(44)	P	T/C Fluid	F	—	—	100(65)	48(23)	—	—
	Spatial Distribution of Liquid Penetration Across Tie-Plate (Radial and Azimuthal Distribution from Upper-Plenum)	Liquid Penetration Below End-Box Tie-Plate	P	Pitot Tube		—	8	—	8	—	—
			P	UCSP Instrument	F						
				Drag Body	H(61)	-	-	36	-	-	4
				Narrow dP	H(61)	-	-	9	-	-	-
				Wide dP	H	-	-	3	-	-	-
			P	Breakthrough Detector	H	-	-	36*	-	-	-
			P	Thermocouples	F	-	-	100* 193*	-	-	2* -
	Upflow Below End-Box(45)	Flow Velocity at Bottom of End-Box	S 1	Air Pitot Tube	F	—	—	—	16	—	—
	Cross flow between end boxes	Horizontal velocity of water	S 1	Turbine	M	—	—	6	—	—	—

MEASUREMENTS TO MEET OBJECTIVES OF 2D/3D REFILL/REFLOOD PROGRAM (Continued)

COMPONENT	PHYSICAL PROCESS	MEASUREMENT REQUIRED	PRIORITY (1)	INSTRUMENT AVAILABLE	SUPPLIER (2)	NUMBER/FACILITY CCTF I	CCTF II	UPTF	SCTF I	SCTF II	SCTF III
Upper Plenum	De-entrainment	Film Flow on Structures on Walls	S 2	Film Probe	M	—	4	—*	6 (24	—*	—
			S 2	Film Probe	M	—	—	—	6	3	(14)
		Local Flow Patterns	S 1	Video Optical Probe	M	—	[illegible](60)	3+	1	(12)	(12)
		Local Fluid α Between Structures	S 3	Flag/Prong Probe	M (25)	—	4 (27)	0*	8 (27	4	—
			P	γ-Densitometer	M	—	—	—	4 (28)	(12)	(12)
		Local Fluid Velocity Between Structures	S 1	Turbine Meter	M						
				Horizontal		—	3	6	2	(12)	(12)
				Vertical		—	1	6	2		
				Air Pitot Tube	F	—	—	—	12		
	Pool Formation	Liquid Level; Froth Level	P	Liquid Level Detector	M	3	—	8	—	—	—
				LLD	F	—	—	—	4		
			P	ΔP Gauge	F	4	—	—	12		
		Fluid Distribution	P	FD Grid (47)	M	—	11x10	63* x 7	8x8	(12)	(12)
		Temperature Distribution	P	T/C (Fluid)	F	4	—	60 (30)	12		
				T/C (Walls)	F	—	—	60	24		
				Superheat Probe	F	—	—	—	8		

MEASUREMENTS TO MEET OBJECTIVES OF 2D/3D REFILL/REFLOOD PROGRAM (Continued)

COMPONENT	PHYSICAL PROCESS	MEASUREMENT REQUIRED	PRIORITY (1)	INSTRUMENT AVAILABLE	SUPPLIER (2)	NUMBER/FACILITY CCTF I	CCTF II	UPTF	SCTF I	SCTF II	SCTF III
Upper Plenum Cont'	Vent Flow (B&W Design)	Flow Rate and Pressure Drop	P	Turbine/DP (66)	M	—	—	5/5*	—	—	—
			P	Turbine-Meter/String Probe (26)	M (31)	—	2/2	0*	—	—	—
			P	Spool Piece (w/o [illegible])	M	—	—	—	1 (29)	(12)	(14)
			P	ΔP Gauge (33)	F (32)	—		8	1	—	—
Hot Legs	Droplet Carryover	V, ρ, m	P	Spool Piece	M	4	(12)	—	1 (20)	—	—
			P	3-Beam γ-Densitometer	M	—	—	4	—	—	—
			P	Drag Rake (DTT)	M	—	—	4	—	—	—
		Local Flow Pattern	S1	Video Optical Probe	M	1	1	0*	—	—	—
			S 2	TV Cameras	F	—	—	—	2		—
		Fluid Temperature		T/C (Fluid)	F	31	—	4 (57)	4		—
				Superheat Probe	F	—	—	—	2	—	—
		Wall Temperature		T/C (Metal)	F	—	—	—	2	—	—
		Liquid Level	S 1	Semi-Conductor	F	—	—	—	2	—	—
				ΔP	F	—	—	4	—	—	—
	Steam-Generator Drainage	Film Thickness and Velocity	S 1	Film Probe	M	—	4	—*	—	—	—
Cold Legs	ECC Injection	V, ρ, m	P	Spool Piece	M	3	(12)	—	—	—	—
		Fluid Temperature		T/C (Fluid) (35)	F	21	—	—	4	—	—
		Wall Temperature		T/C (Metal)	F	—	—	—	2	—	—
		Liquid Level	S 1	Semi-Conductor	F	—	—	—	2	—	—
				ΔP	F	—	—	4	—	—	—

MEASUREMENTS TO MEET OBJECTIVES OF 2D/3D REFILL/REFLOOD PROGRAM (Continued)

COMPONENT	PHYSICAL PROCESS	MEASUREMENT REQUIRED	PRIORITY (1)	INSTRUMENT AVAILABLE	SUPPLIER (2)	NUMBER/FACILITY CCTF I	CCTF II	UPTF	SCTF I	SCTF II	SCTF III
Cold Legs Cont'	Break Flow (Refill)	$V, \rho, \dot{m}$	P	Spool Piece	N	—	—	—	1	(12)	(12)
			P	3-Beam γ-Densitometer	N	—	—	1	—	—	—
			P	Drag Rake (DTT)	N	—	—	1	—	—	—
			S 2	TV Camera	F	—	—	—	1	—	—
Steam Generator	Steam Binding	Droplet Vaporization in Steam Generator	P	ΔP Gauge	F	4		N.A.	N.A.	N.A.	N.A.
				T/C (Fluid):				↓	↓	↓	↓
				Primary	F	24		↓	↓	↓	↓
				Secondary	F	—		↓	↓	↓	↓
				T/C (Metal)	F	16(3)		↓	↓	↓	↓
		Exit Flow(38)	P	Spool Piece	N	1	(12)	↓	↓	↓	↓
		Level in Steam Generator Inlet Plenum		Level Transducer	F	4		↓	↓	↓	↓
		Steam Flow to IL & CL	S1	ΔP-gauge	F	—	—	7	—	—	—
Lower Plenum	Refill/Sloshing	Liquid Level	P	Liquid Level Detector (Same as in lower core)	N	3	(12)	2(62)	—	—	—
			P	ΔP Gauge	F	6		4	1	—	—
				T/C (Fluid)	F	3		16	10	—	—
				T/C (Metal)	F	—		—	4	—	—

MEASUREMENTS TO MEET OBJECTIVES OF 2D/3D REFILL/REFLOOD PROGRAM (Continued)

COMPONENT	PHYSICAL PROCESS	MEASUREMENT REQUIRED	PRIORITY (1)	INSTRUMENT AVAILABLE	SUPPLIER (2)	NUMBER/FACILITY CCTF I	CCTF II	UPTF	SCTF I	SCTF II	SCTF III
Downcomer	Condensation-Induced Flow	Local Flow Patterns	P	FD Grid (39)	N	—	6x3x7 6x1x6	50X3x50X1+	2x3x7	(12)	(12)
			S 2	Turbine Meter	N	—	—	8	—	—	—
	AND		S 2	Drag Disc	N	4(18)			3(18)		
		Pressure Forces:	S 1	Video Optical Probes	N	—	1	—		(12)	(12)
		Axial	P	ΔP Gauge	F	20		4	3	—	—
		Azimuthal	P	ΔP Gauge (40)	F	—	8	8(69)	—	—	—
	ECC Penetration (CCFL; Channeling)	Liquid Subcooling	P	T/C (Fluid)	F	20	—	50	8	—	—
		Wall Superheat	P	T/C (Metal)	F	40	—	40	4	—	—
				String Probe (26)	N	—	—	—	1	(12)	(12)
	Level Oscillations	Liquid Level	S 2	Liquid Level Detector	N	3	—	—	—	—	—
			P	LLD	F	—	—	—	14	—	—
UPTF Injection Zone	Injection Flows	Flow Rate									
		Liquid			F	—	—	17(60)	—	—	—
		Vapor			F	—	—	17	—	—	—
		Temperature		T/C (Fluid)	F	—	—	17	—	—	—
				Superheat Probe	F	—	—	17	—	—	—

Notes and Comments Relating to Attachment 1

1) P = primary measurement (mandatory, to measure key phenomena necessary for code validation and coupling of results between facilities),

   S = secondary measurement (optional and backup to primary measurement; useful in adding understanding of primary measurement),

   S-1 = high secondary priority,
   S-2 = medium secondary priority,
   S-3 = low secondary priority.

2) N = NRC,
   F = Facility.

3) Deleted

4) Total number of T/C per core; not all may be recorded during test.

5) Includes 6 pairs of staggered rods.

6) 12 unheated rods.

7) Actual placement of instrumentation determined by TRAC noding.

8) Facility information based on documents dated:

CCTF-I:	11/77
UPTF:	Design meetings and telexes, 1978-1980
SCTF-I:	5/78

   The NRC instrumentation support for PKL facility was terminated in October 1981 because of facility schedule delay.

9) Located near top of core.

10) 1/bundle located just below tie plate; the rest movable vertically.

11) 3 across 4 assemblies and 3 across 8 assemblies.

12) Reusable for the next core with refurbishment.

13) These thermocouples should be as small as possible in order to improve the response time.

14) To be reused if working without refurbishment.

15) 3 wide-range LLDs with probes spaced 20 cm apart, and 3 narrow-range LLDs with probes spaced 10 cm apart.

16) 6 vertical probes/LLD, with 2 LLDs/bundle near the side walls and 1 LLD in the core baffle region.

17) See downcomer.

18) Same instruments are entered in two different places: the core/lower plenum and the downcomer.

19) Additional ΔPs requested by NRC across tie plate:

CCTF-II:	8
UPTF (360°):	22
SCTF-I:	4

20) Turbine not included.

21) This is the same FD Grid as entered under "Upper Plenum Pool Formation."

22) The USNRC recommends that only a few end boxes have multiple T/C measurements, with the rest spread out to have at least one T/C measurement per end box.

23) Includes T/C near UCSP holes.

24) Probes located at 2 levels.

25) Deleted.

26) Void measurement only.

27) Both void and velocity measurement.

28) Locate gamma-densitometer in froth region.

29) Gamma densitometer not included.

30) T/Cs above UCSP.

31) If pipe is used for vent flow.

32) If flap valve is used for vent flow.

33) Not applicable in these early facilities.

34) These instruments fill most of pipe.

35) Locate T/C on either side of injection tee.

36) Not applicable in 1/78 UPTF design.

37) T/C to measure metal temperature on secondary side of steam generator.

38) Inlet flow from hot leg spool pieces.

39) Covers entire height of downcomer; $N_1 \times N_2 \times N_3$ = azimuthal x radial x axial

40) NRC requests these azimuthal ΔP measurements in the downcomer at 2 axial levels.

41) Mass flow $G_m = \rho_m V_m$ (across UCSP); m denotes two-phase mixture

42) Mixture density $\rho_m = \frac{\Delta P \text{ measurement in end box}}{\text{LLD measurement in end box}} = \rho_L \frac{h_L}{h_m}$

43) Liquid velocity across tie plate $V_L = \frac{\sqrt{2g \, \Delta P}}{K_{33} \rho_L}$ (correlation constant K_{33} will be determined from ORNL experiments)

44) Knowledge of liquid pressure and temperature permits determining ρ_L.

45) In UPTF, Q_1 and Q_2 will be injected from below (see under "UPTF Injection Zone") and it will be possible to check the ORNL correlation for bounce-back.

46) The core/upper-plenum interface scheme is now being tested at the ORNL IDL. See footnote (54). The final measurement scheme, including modelling, will be developed from these test results.

47) This is the same FDG as entered under Core/UP interface.

48) When there is negligible liquid in the end box for high upflow, the mixture mass flow rate can be determined from:

$$\Delta P \text{ (across tie plate)} = K_{23} \, G_m \, V_M$$

where the velocity of the center of momentum of the two phases, V_M, is measured by the turbine meter.

The assumption used to interpret these measurements is that the cross flow is negligible between end boxes, so that it is possible to relate the tie plate ΔP with UCSP velocity. Justification of these relations has been discussed in a separate writeup.

49) ΔP_{23} denotes the ΔP across the end box tie plate, and

ΔP_{35} denotes the ΔP between the tie plate and the upper plenum.

50) Total of 3 new video optical probes for CCTF-II.

51) Deleted

52) Extend from lower plenum into core. On each LLD:19 axial probes.

53) 17 axial probes on each of 4 core LLDs in SCTF; 2 probes in LP, 15 probes in core.

54) Upper plenum/core interface instruments are being selected.

55) 2 T/C in each of 32 end boxes and remaining 36 T/C distributed.

56) Transducers and signal conditioners to be provided by USNRC, and tubes, plumbing, and purging control system to be provided by BMFT.

7) One T/C per hot leg in bottom of pipe.

1) One superheat probe per hot leg in upper half of pipe.

) 2 axial levels of 8 azimuthal taps; tie together vertically and azimuthally.

One instrument per zone; 17 zones.

DP transducers, signal conditioning electronics and purging control system to be supplied by the USNRC; tubes, plumbing and purging to be provided by the facility.

Changed in October 1981.

hanged in March 1982.