CERTIFIED BY:

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# ACRS THERMAL HYDRAULIC PHENOMENA SUBCOMMITTEE MEETING MINUTES
## REVIEW OF THE NRC-RES ROSA-V TEST PROGRAM
OCTOBER 28, 1993
BETHESDA, MARYLAND

## PURPOSE

The purpose of the meeting was to review selected aspects of the NRC Office of Nuclear Regulatory Research's (RES's) ROSA-V confirmatory test program being developed in support of the Westinghouse (W) AP600 passive plant design certification effort. Specifically, the ACRS was asked by the Commission to review the following topics relative to the ROSA-V Program: the test matrix and facility design modifications and additions, including instrumentation and controls.

## ATTENDEES

Principal meeting attendees included the following:

| ACRS | NRC |
| --- | --- |
| I. Catton, Chairman | B. Sheron, RES |
| P, Davis, Member | L. Shotkin, RES |
| T. Kress, Member | R. Jones, NRR |
| R. Seale, Member | G. Rhee, RES |
| "V.J." Dhir, Consultant | D. Bessette, RES |
| V. Schrock, Consultant | J. Han, RES |
| W. Wulff, Consultant | G. D. McPherson, NRR |
| | R. Caruso, NRR |
| | A. Levin, NRR |

| INEL | Westinghouse |
| --- | --- |
| M. Ortiz | L. Hochreiter |

## MEETING HIGHLIGHTS, AGREEMENTS, AND REQUESTS

### INTRODUCTION

Dr. Catton noted that the Commission has requested that the ACRS provide formal comment on the RES ROSA test program in the areas of the test matrix, and, facility modifications - including instrumentation and controls. He also indicated that the Subcommittee should put aside its opposition to RES's use of ROSA and provide constructive comments on the above issues. Finally, he requested that the Consultants provide him with their written reports no later than C.O.B. November 1, 1993.

DESIGNATED ORIGINAL

Certified By EMB

RS01 /1

NRC-RES PRESENTATIONS

Overview of ROSA-V Test Program

Dr. L. Shotkin provided an overview of the RES ROSA-V integral system test facility program. Key points noted by Dr. Shotkin included:

- After evaluating the specific AP600 design features deemed in need of additional safety assessment, the NRC staff determined that full-height, full-pressure integral testing conducted under NRC auspices was desirable, given that the AP600 safety features must operate under three high-pressure accident scenarios: SBLOCA, SGTR, and, steam line break.

- Integral system testing by Westinghouse (W) and NRC at three facilities (SPES, APEX - Advanced Plant Experiment, and ROSA) will provide the most comprehensive T/H test data obtained to date for any reactor type.

- The ROSA facility has been modified to simulate the AP600 configuration. The new facility has been designated ROSA-V. Cost of the modifications is $6.73M. Shakedown tests will begin in January 1994. NRC has a full-time representative (from INEL) on site.

  In response to Professor Schrock's question relative to the details of the design of the diffuser to be incorporated into the CMT, Dr. Hochreiter (W) indicated that the diffuser being used in the CMT separate effects tests has greatly reduced the violence of the mixing phenomena. Dr. Shotkin said that RES intends to use a copy of the W diffuser design in ROSA.

- Details of the RES ROSA tests and accompanying analytical analyses schedule were shown (Figure 1). Concerning the test schedule, RES will be able to provide data in a timely manner to support NRR's regulatory review schedule. A Phase I test matrix, to be run during CY-94, has been approved by the Commission. A Phase II test matrix is under development and is pending Commission approval.

  Regarding the associated RES code development effort, it is planned to use TRAC-PWR for the modeling of large break- and, as necessary, intermediate break-LOCAs. RELAP5/MOD3.2 will be used for modeling the SB LOCA, and all remaining transients of concern. All model changes made for the MOD3.2 code version are based on engineering judgment; changes made to the final code version (MOD3.3), will be based on forthcoming test data. Dr. Shotkin also noted that RES may perform its own tests at the W OSU APEX facility beginning sometime in 1995.

• Figures 2-6 show photographs of some of the major ROSA-V facility components.

• Provisions taken to ensure adequate oversight/control of the ROSA Program include the establishment of a Steering Committee and Technical Group. NRC Committee and Group Members are Drs. E. Beckjord and L. Shotkin, respectively. Two NRR representatives are involved in both providing oversight of the test matrix development effort, and establishment of initial and boundary conditions for the tests.

ROSA-V Scaling Study

Dr. M. Ortiz (INEL) discussed the development of the LSTF design modifications for simulation of the AP600, with emphasis on the scaling rationale. He noted that given the judgment that there was an insufficient data base relative to the unique T/H phenomena expected to be seen in AP600, NRC elected to pursue the scaling approach associated with full-height, full-pressure testing. The DBAs selected for testing included: SBLOCA, SGTR, and, main steam line break.

Reviewing the specific scaling criteria chosen (i.e., full height, 1:30 power-to-volume scaling, preservation of relative component elevations and mass flow rates between same), there was extensive Subcommittee discussion. Points noted during this discussion included:

• Dr. Wulff indicated that, based on his reading of the INEL scaling report, no bases has been provided for the stated facility requirements. The scaling study appears to be intuitive in nature. Dr. Catton said that he did not find any scaling bases for the design of either the CMT or the IRWST, given his concern that these two components require evaluation of the phenomena of condensation and thermal stratification, respectively, two areas where the codes are strongly challenged. Dr. Shotkin indicated that RES had to "make do" here as the facility already exists - atypicalities included. He also said that RES has a model in mind for the CMT (i.e., condensation will not be important); for the IRWST, RES will await the W test data relative to the issue of thermal stratification.

• Dr. Shotkin noted that RES had performed a scaling analysis for ROSA using the RELAP5 code. Dr. Catton expressed strong concern with this approach, arguing that a detailed analysis is called for here, given the limitations (known and unknown) existing in this code.

• The new components added to ROSA and the alterations made to existing facility components were discussed. Associated instrumentation was also noted. Figure 7 lists these alterations. Figures 8-14 provide some details. During this discussion, the following concerns were noted by the Subcommittee:

- Dr. Catton observed that INEL will not be able to determine with much accuracy the relative volumes of condensate and fluid existing in the CMT during a transient test.

- In response to Dr. Wulff, Dr. Ortiz said that INEL had not documented the bases for preserving the scaling parameters deemed of importance. Mr. Schrock urged INEL to make use of standard notation relative to the scaling formulas used, in order to avoid confusion.

- INEL noted that they will use differential pressure (DP) instruments to activate the ADS, as is being done on the W AP600 integral test facilities (APEX, and SPES-II). The AP600 plant will, however, use heated junction thermocouples (HJTCs) for this task. Dr. Ortiz noted that JAERI has installed HJTCs on ROSA for their own use. The Subcommittee urged RES to make use of the HJTCs in order to ensure that the system effects resulting from use of DPs vs HJTCs is addressed. RES indicated that they will simulate these effects by manipulation of the facility controls, based on the result of the W CMT separate effects tests which will evaluate the impact resulting from the use of HJTCs. Dr. Catton observed that use of separate effects test results to address potential integral system effects may not resolve the concern here.

- Dr. Dhir noted that the instrumentation installed on the PRHR heat exchanger tubes is inadequate for determination of heat transfer to the IRWST pool, given two-phase flow conditions through these tubes. Dr. Shotkin noted, in response to Dr. Catton, that INEL has installed a new model in RELAP5 to address modeling of pool thermal stratification. This will be discussed with the Subcommittee during a January Subcommittee meeting.

• A listing of the LSTF's atypicalities with respect to simulation of the AP600 design was noted (Figure 15).

- There was a brief discussion of the listed sixty-one parameter radios represented as Pi-groups and used in association with the scaling study. Dr. Wulff stated that, with two exceptions, the list shown consists of ratios of dimensional parameters, not Pi-groups, and, as such, is not relevant to the scaling study.

  In response to Mr. Schrock, Dr. Ortiz committed to send some detailed information pertaining to the specifications of the gamma densitometers to be used in ROSA-V.

ROSA-V Instrumentation and Control Systems

Details of the instrumentation and control systems used at ROSA-V were discussed by Dr. G. Rhee. He noted the specifics of the systems that were added (Figure 16), and, those that were modified (Figure 17). This activity includes the recent addition of a diffuser to the top of the CMT (Figure 18).

The criteria for instrumentation selection is focused on assuring adequate data to support code assessment. In addition, RES took steps to ensure the reliability of the instruments used (e.g., proven measurement principles, commercially available, etc.). Dr. Rhee noted that ROSA is extensively instrumented, with over 2200 measurement parameters (Figure 19). In addition, the instrumentation that RES is installing for ROSA-V testing will add another 300 measurement parameters (Figure 20).

Control system logic for ROSA-V will follow that used for AP600. Figures 21-22 show details of the data collection and processing system to be used.

In response to Dr. Dhir, Dr. Rhee said that he would provide the Subcommittee with a copy of the calibration procedures to be used for the above instruments. In response to Dr. Wulff, Dr. Rhee said that a critical list of functioning instruments will be prepared for each test.

Comments by NRR on ROSA-V Test Matrix

Mr. A. Levin provided the following comments on the ROSA-V test matrix:

- NRR and RES had been collaborating on development of the test matrix for ROSA-V. In May 1993, NRR requested that the Phase-I matrix be modified to include beyond-DBA events.

- RES has accommodated the NRR request; two beyond-DBA tests have been added: (1) a one-inch cold-leg break LOCA combined with failure of ADS Stages 1-3, and, (2) a two-inch break in the pressure balance line combined with failure of RCPs to trip.

- All pre-operational tests will be completed prior to initiation of matrix testing (this was not to be the case initially). Matrix testing is scheduled to begin in February 1994.

- NRR believes that ROSA data will be a valuable addition to the W integral test data set, and will aid in the exploration of the robustness of the passive safety systems.

Dr. Dhir inquired as to the ability of RELAP5 to model a crack-type break. Mr. Schrock, referring to earlier work he had conducted for NRC on this matter, indicated that RELAP cannot successfully model this type of break.

ROSA-V AP600 Test Matrix

Details of the ROSA-V test matrix were provided by Mr. D. Bessette. A Phase I test program has been approved; this Program's focus is, as noted above, on DBA-type scenarios with the two exceptions noted above. A Phase II Program is currently under development.

Starting in November, facility verification, check out and characterization of the new facility systems will take place. In response to Dr. Wulff, Mr. Bessette committed to providing the Subcommittee with the ranges for the parameters to be simulated in the Phase I tests.

Figure 23 shows the current schedule for the Phase I test matrix.

The schedule of counterpart tests and associated analyses were shown for ROSA/APEX/SPES-II (Figure 24). All analyses conducted by RES will be run using RELAP5. In response to Dr. Catton, RES indicated that it will run RELAP5 analyses for APEX/SPES-II counterpart tests.

Test plans for the Phase II matrix were discussed (Figure 25). Dr. Catton opined that RES should base its test selection on the needs for code "V&V", as that is the ultimate program objective. Dr. Levin indicated that the staff will evaluate this need; he also said that NRR may want to explore beyond-DBA scenarios that involve T/H phenomena associated with the passive systems. In any regard, the Phase II matrix is still under development. Dr. Catton indicated that given the status of the Phase II matrix, the Subcommittee would defer any comment on same at this time.

RES Comments on JAERI Tests to Simulate CMT Behavior

Mr. D. Bessette provided comment, based on his review of available Papers, on a test conducted by JAERI that was designed to simulate the behavior of the CMT, given passive safety injection. Figures 26-27 provide some details of the test conduct. In response to questions from Dr. Catton, Dr. Shotkin indicated that JAERI ran this test to confirm the results of RELAP5 calculations that showed extensive recirculation in the CMT and formation of a thick (~ nine foot) layer of hot water at the top of the fluid in the Tank. He said that they saw both phenomena in this test.

RES Concluding Remarks

Dr. Shotkin provided comments on future schedule milestones. He said that matrix testing on ROSA-V should commence in January 1994, and the Phase I tests should be concluded by the end of next year. Phase II testing (if approved by the Commission) would be scheduled to begin in January 1995.

Dr. Shotkin also committed to provide additional detail on the ROSA scaling analyses during the RES presentation scheduled for the full Committee during its November 1993 Meeting.

NRR PRESENTATIONS

Dr. A. Levin made some brief comments regarding NRR's support of the ROSA-V test program. In response to Mr. Kress, Dr. Levin opined that he is satisfied that the facility is sufficiently instrumented. In response to questions from Messrs. Davis, Schrock and Wulff, Dr. Levin said that the ROSA program in strictly confirmatory in nature and is not required to support AP600 design certification. He also said that NRR could successfully audit the W program without benefit of the ROSA tests, but to do so would complicate their task. Finally, Dr. Levin indicated that RELAP5 is a necessary tool for this audit task.

Mr. A. Caruso commented on the NRR analysis plans regarding use of the ROSA-V test data. He noted that NRR will coordinate its analysis effort with RES and INEL. Further, NRR will perform some blind calculations of selected ROSA tests and will run complementary analyses using the TRAC-P code.

RES Presentation - Confirmatory Test Program for SBWR Passive Design

[**Note**: Messrs. Schrock and Wulff declared themselves in conflict for this discussion.]

An overview of the RES confirmatory test program being conducted in support of the Simplified Boiling Water Reactor (SBWR) certification review for this passive plant design was given by Dr. J. Han. Key points noted by Dr. Han included the following:

- The GE SBWR design certification is scheduled for issuance in May 1996. GE has established three integral test programs to investigate the two unique SBWR safety systems: the GDCS and PCCS (Passive Core Cooling System). These integral facilities are known as GIST (gravity-driven cooling system integral system test), GIRAFFE and PANDA.

- RES has signed a three-year contract with Purdue University for the design, construction and operation of a low pressure (~150 psia) scaled (1/4-height, 1/400 volume) test facility to provide confirmatory integral test data to aid code assessment and investigate beyond-DBA type events. Brookhaven Laboratories will assess the test data using the coupled RELAP5/CONTAIN codes. Figures 28-29 show some details of the facility design parameters.

- A preliminary test matrix has been drawn up. Base case and counterpart test would be run under Phase 1; Beyond-DBA and sensitivity studies would be run in a Phase II matrix (Figures 30-31).

  Dr. Dhir asked if a facility scaling study has been conducted. Dr. Han said that a report on the preliminary scaling analysis should be available in December 1993. He said that he will provide the Subcommittee with a copy of this report.

- Construction of the Purdue facility should be complete in December of next year. Testing should commence in March 1995. The final Program report is scheduled to be issued in July 1996.

Dr. McPherson made some closing comments regarding the details of the coordination of NRR and RES activities relative to the review of the advanced plant test programs.

Subcommittee Discussion

The Subcommittee agreed that the full Committee should review the selected aspects of the ROSA test Program, pursuant to the Commission's SRM. Prior to adjournment, Dr. Catton provided direction to the prospective presenters relative to the ACRS discussion.

The meeting was adjourned at 4:15 pm.

FUTURE SUBCOMMITTEE ACTIONS ON THIS MATTER AND ITEMS FOR FOLLOW-UP

Future Subcommittee Actions

No specific additional Subcommittee action on this matter is planned at this time. The Subcommittee will monitor the progress of the RES and NRR actions relative to the ROSA Program and will hold meetings as Program results dictate.

The Subcommittee plans to meet in the near future (January/ February 1994) to continue its review of the GE SBWR test Programs.

Follow-Up Actions

Items identified during this meeting for follow-up are as follows:

1. In response to Mr. Schrock, Dr. Ortiz committed to send some detailed information pertaining to the specifications of the gamma densitometers to be used in ROSA-V.

2. Mr. Schrock urged INEL to make use of standard notation relative to the scaling formulas used in their ROSA-V scaling report in order to avoid confusion to the reader.

3. The Subcommittee urged RES to make use of the HJTCs installed by JAERI in ROSA-V in order to ensure that the impact on system effects resulting from use of DPs vs HJTCs is addressed.

4. In response to Dr. Dhir, Dr. Rhee said that he would provide the Subcommittee with a copy of the calibration procedures for the instruments used in ROSA-V.

5. In response to Dr. Wulff, Mr. Bessette committed to providing the Subcommittee with the ranges for the parameters simulated in the ROSA -V Phase I tests.

6. Dr. Shotkin also committed to provide numerical values of the Pi-groups used in the ROSA scaling analyses during the RES presentation scheduled for the full Committee during its November 1993 Meeting. [**Note**: RES provided this information to the ACRS during its discussion of this matter at its November 1993 Meeting.]

7. Dr. Han said he would provide the Subcommittee with a copy of the report on the preliminary scaling study conducted in support of the RES SBWR confirmatory test facility to be constructed at Purdue University.

BACKGROUND MATERIAL PROVIDED TO THE SUBCOMMITTEE FOR THIS MEETING

1. U.S. NRC Report, NUREG/CR-6066 (Draft), Analysis of LSTF Scaling for AP600 Testing, M. Ortiz, et. al., June 11, 1993

2. Memorandum, dated December 23, 1992, G. Rhee, RES to P. Boehnert, ACRS, transmitting INEL Report: "Description of Design Requirements for ROSA Modifications to Simulate AP600 Phenomena, (Revised September, 1992)"

3. Memorandum for I. Catton, et. al. from M. Stella, ACRS Fellow, dated July 19, 1993, "Review of ROSA-V Gravity Injection Test Results and Related Analyses"

4. U.S. NRC Report, NUREG/CR-5853, "Investigation of the Applicability and Limitations of the ROSA Large-Scale Test Facility of AP600 Safety Assessment", M.G. Ortiz, et.al., dated December, 1992

5. ACRS Report, dated July 17, 1993, "Integral System and Separate Effects Testing in Support of the Westinghouse AP600 Plant Design Certification"

6. Memorandum, dated September 16, 1992, S. Chilk, Secretary, to J. Taylor, EDO, "SECY-92-219 - NRC-Sponsored Confirmatory Testing of the Westinghouse AP600 Design"

7. SECY-92-219, "NRC Confirmatory Testing of the AP600 Design", dated June 16, 1992

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**Note:** Additional meeting details can be obtained from a transcript of this meeting available in the NRC Public Document Room, 2120 L St., NW, Washington DC 20006, (202) 634-3273, or can be purchased from Ann Riley and Associates, Ltd., 1612 K St., NW, Suite 300, Washington, DC, 20006, (202) 293-39501.

AP600

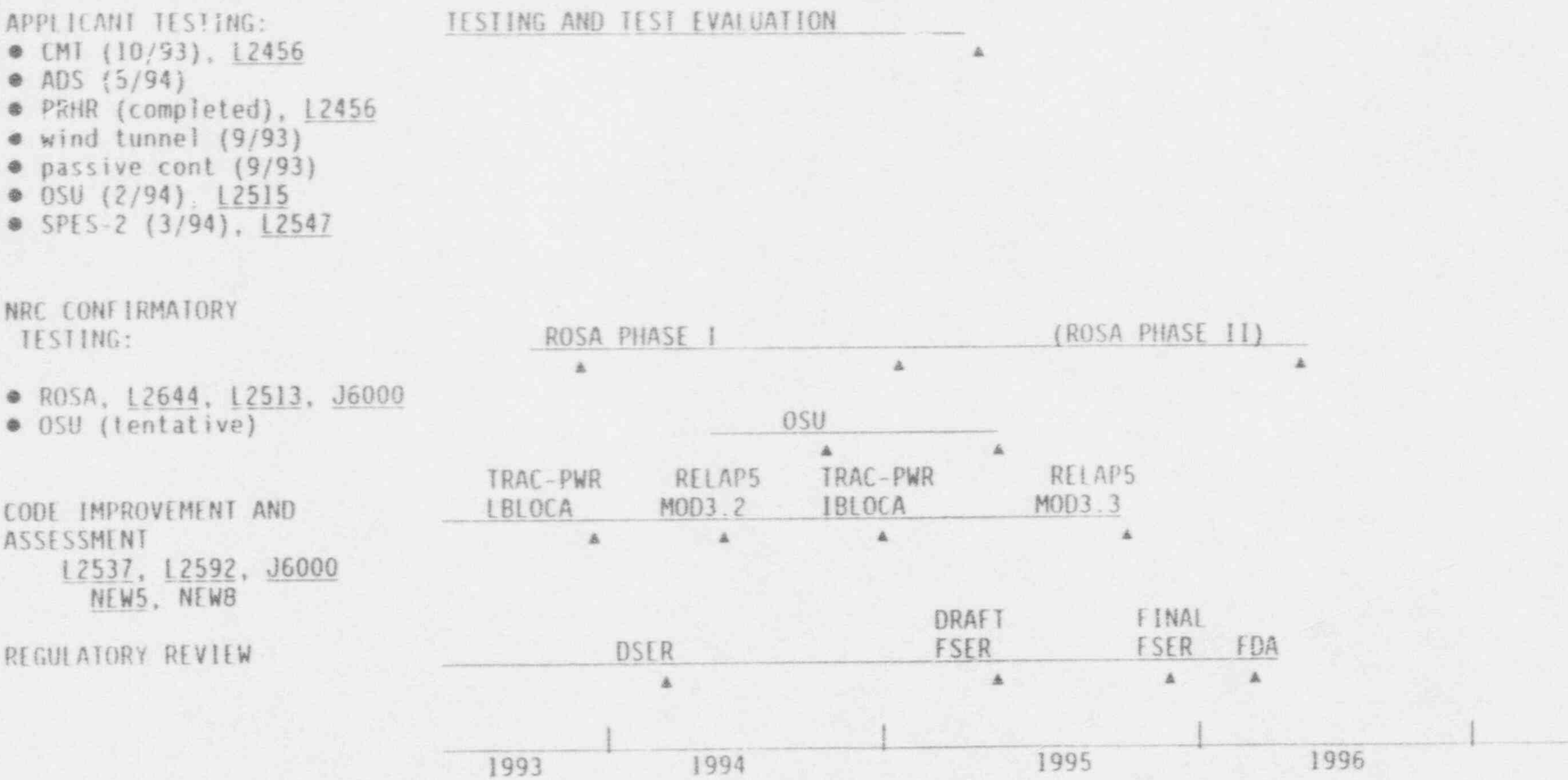
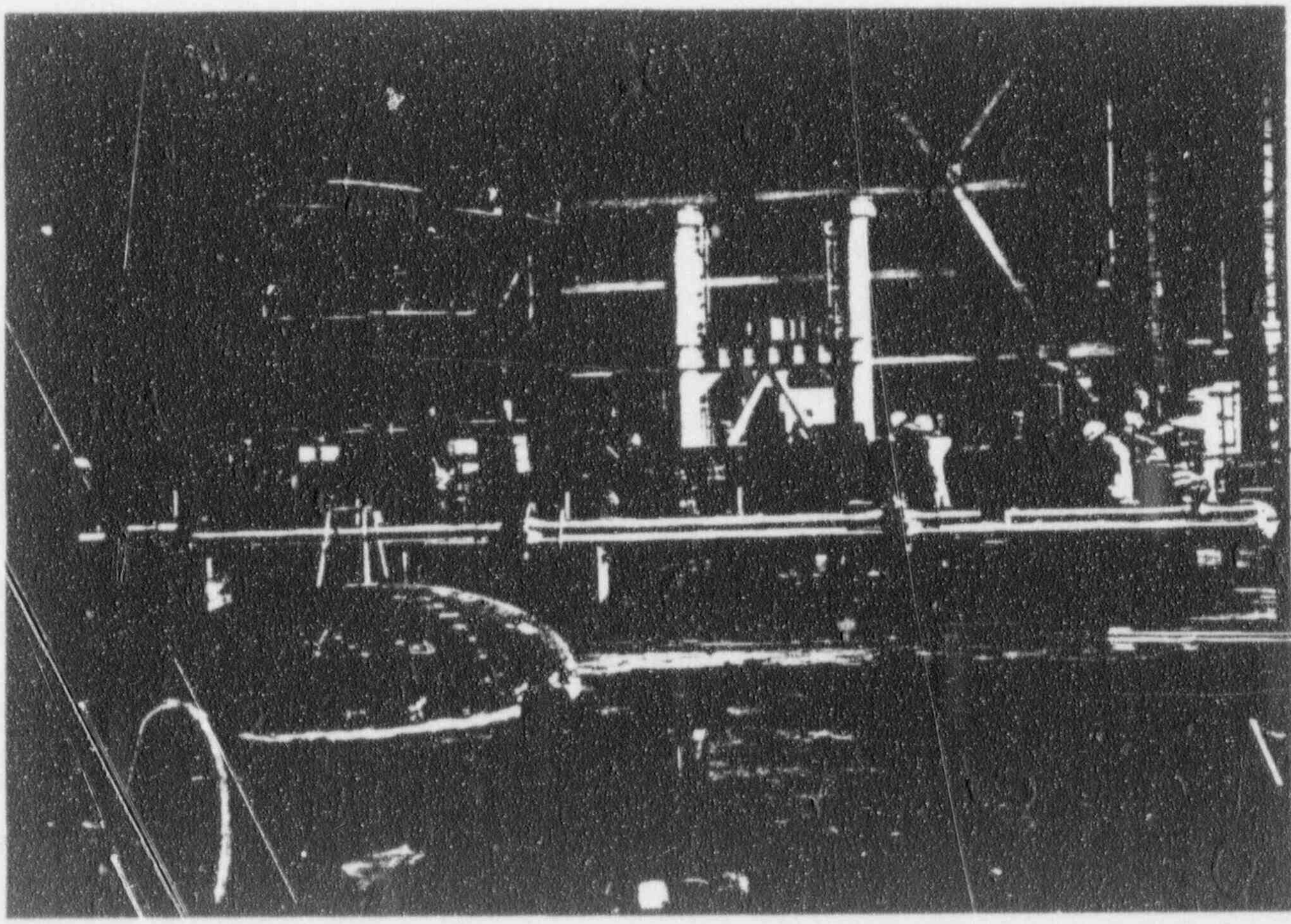


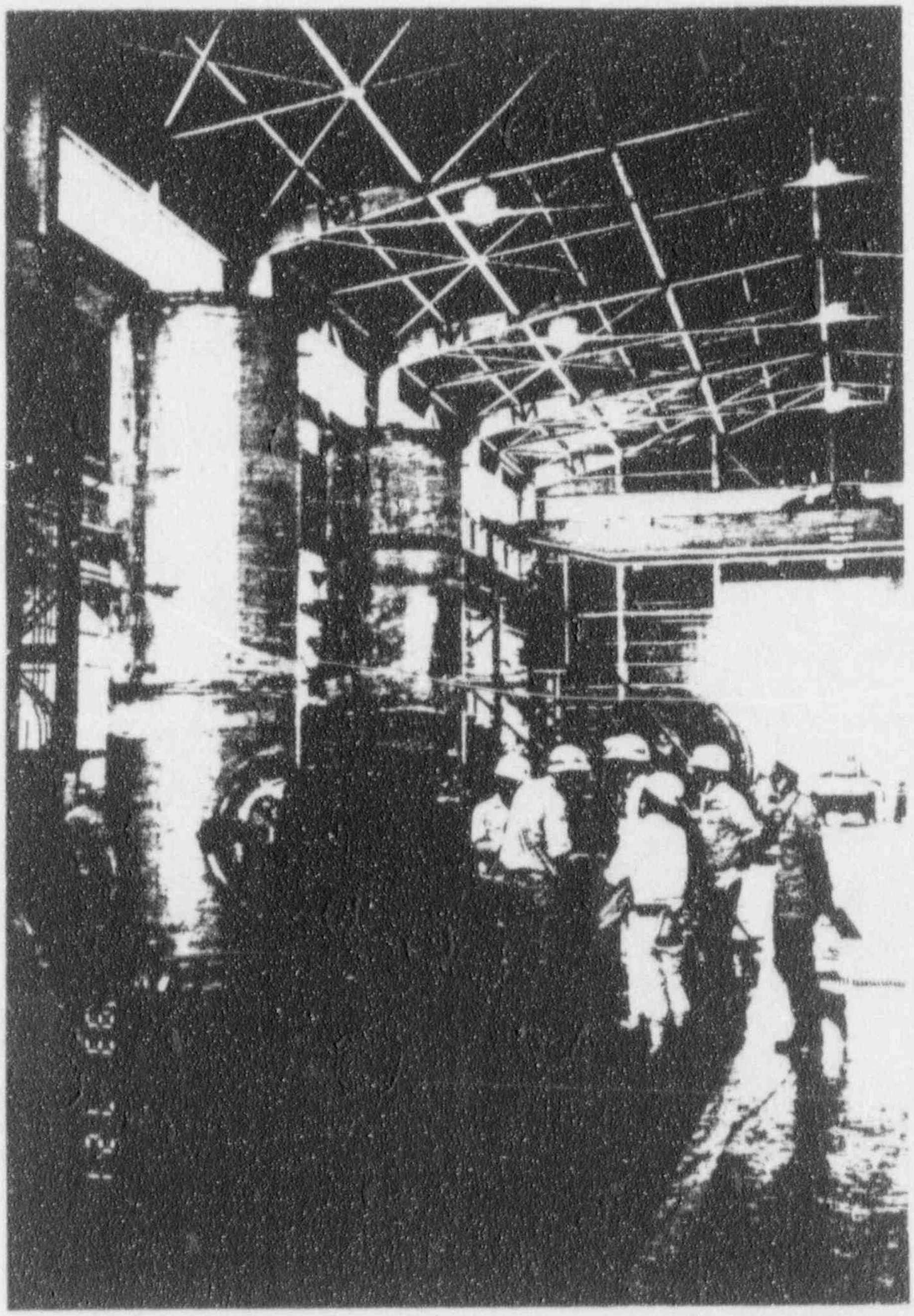

Figure 1




FOREGROUND: PRESSURIZER (PZR)

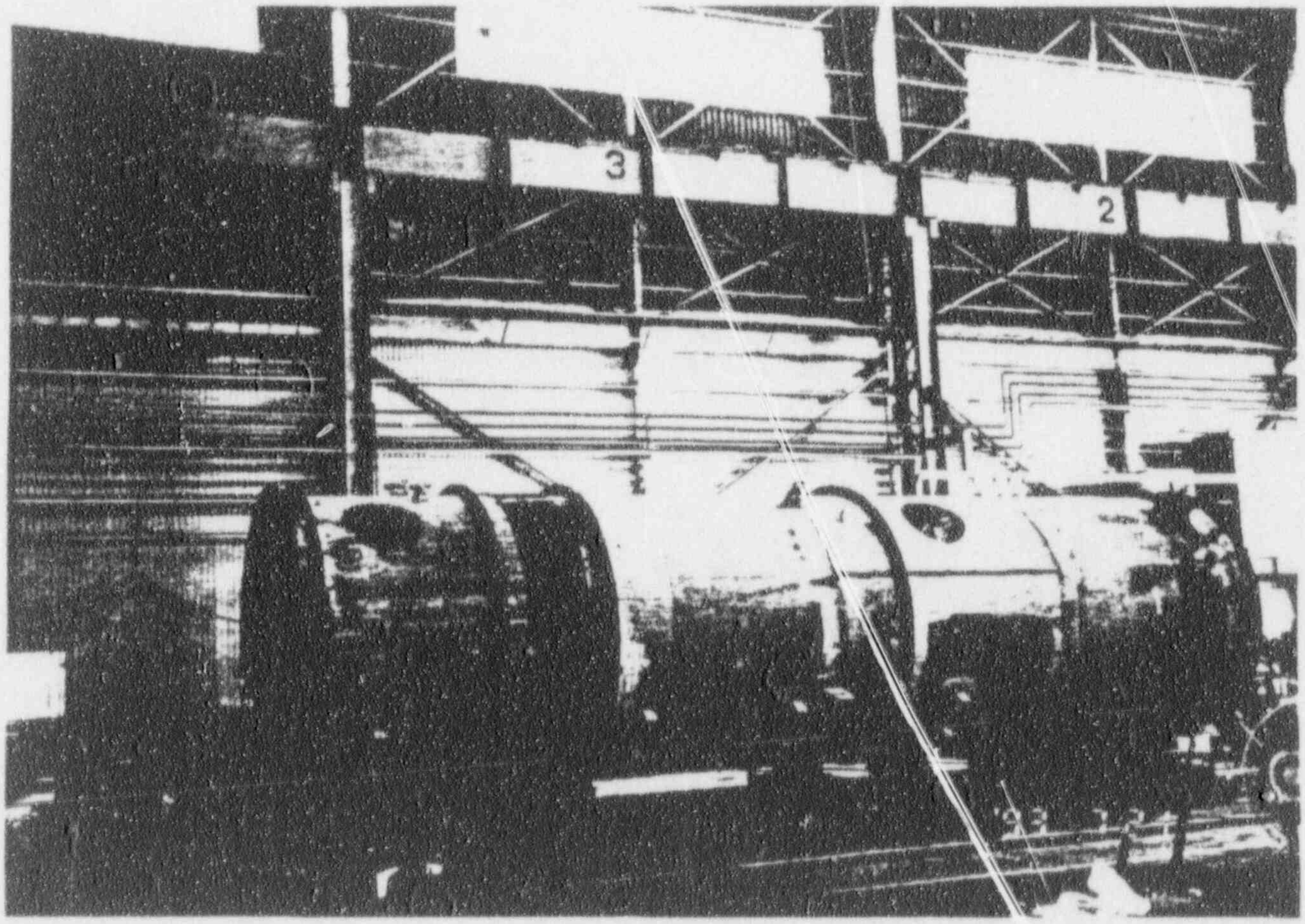
BACKGROUND: TWO CORE MAKE-UP TANKS (CMTs)

FIG-2



TWO CATCH TANKS FOR COLLECTING FLOWS FROM THE FOURTH STAGE OF THE AUTOMATIC DEPRESSURIZATION SYSTEM (ADS)

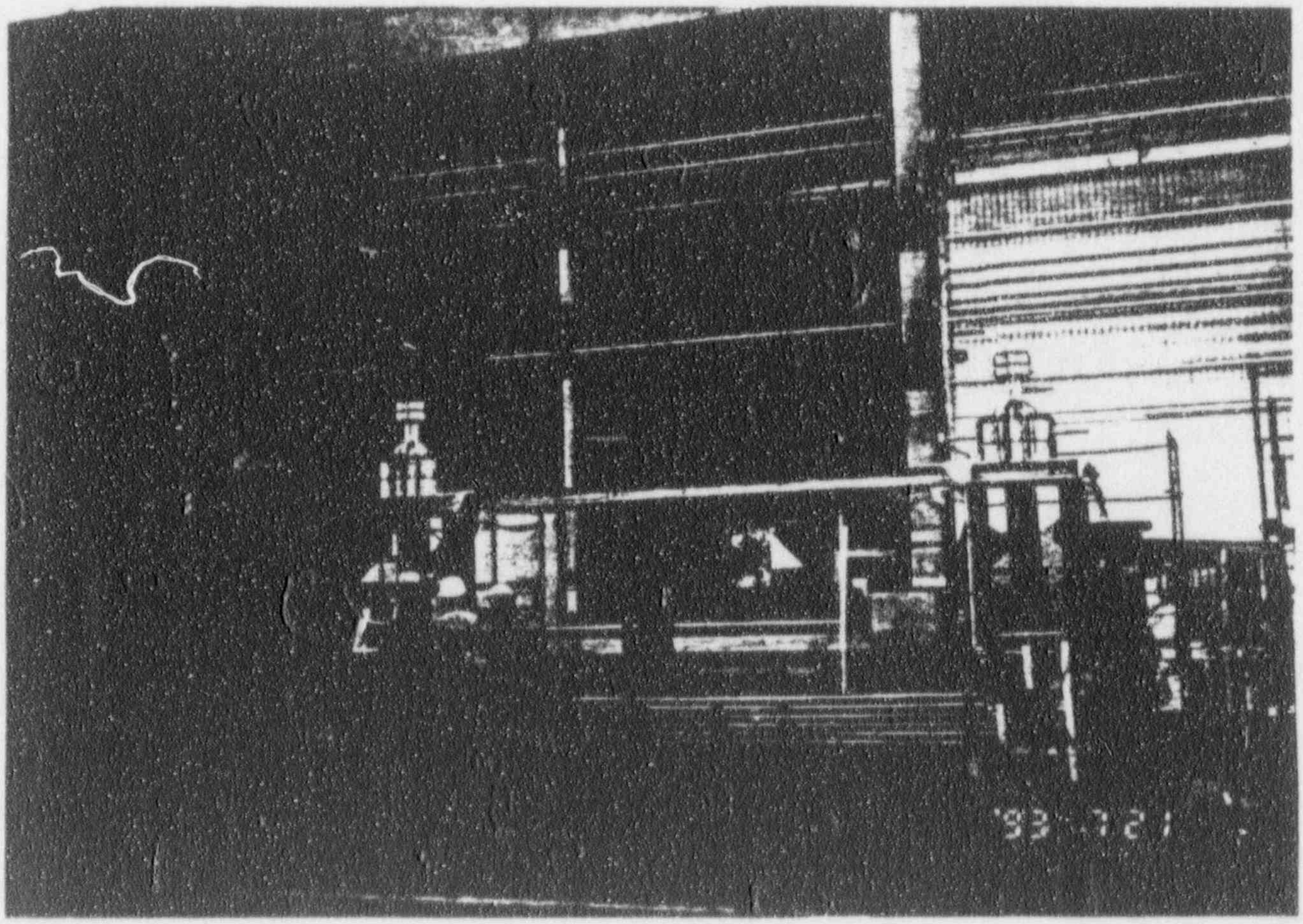
FIG-3




IN-CONTAINMENT REFUELING WATER STORAGE TANK (IRWST) WITH TWO PORTS SHOWN FOR INSERTION OF RESIDUAL HEAT REMOVAL (PRHR) SYSTEM TUBES

97

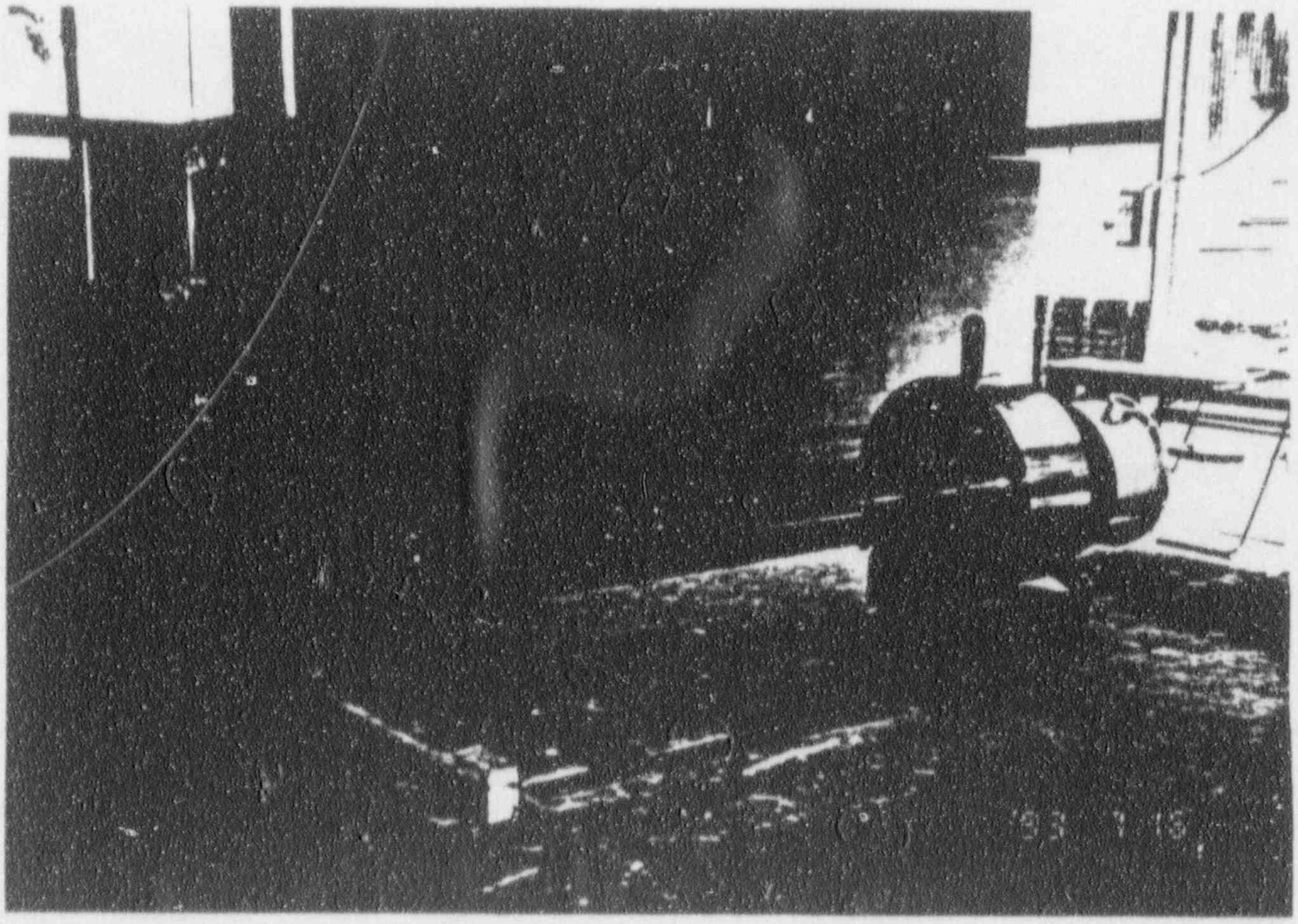
FIG-4



PASSIVE RESIDUAL HEAT REMOVAL (PRHR)

SYSTEM TUBES ( ⊔ SHAPE)

FIG-5



PRESSURIZER HEATER

FIG-6

## DESIGN REQUIREMENTS FOR LSTF MODIFICATIONS
(Continued)

* *New Components and Associated lines and Valves*

- CMTs (and discharge lines)
- PBLs and headers (CL and Pzr)
- IRWST (and discharge lines)
- ADS and Sparger (and catch tanks)
- PRHR
- DVI lines and Flow deflector

* → *Alterations to existing components*

- Pressurizer (new)
- Surge line (new)
- Upper head (Flow paths)
- Reduce Loop Seals to Minimum
- Accumulators (stand pipes)

FIG. 7

# DESIGN REQUIREMENTS FOR LSTF MODIFICATIONS
# NEW COMPONENTS

## <u>CMTs and Associated lines and Valves</u>

### <u>The Tank:</u>

- ❒ Cylindrical Tank (Preserve shape)
- ❒ ≈22 ft tall (AP600 elevations)
- ❒ ≈ 2 ft diameter (Scaled Volume)
- ❒ Insulated (25mm) to preserve heat losses and thermal response.
- ❒ Instrumented with TCs in different fluid locations and elevations, and Wall TCs at different elevations.
- ❒ Instrumented with consecutive and overall DPs to measure level.
- ❒ Level measurements produce ADS signals
- ❒ Instrumented to measure absolute Pressure.

FIG 8

# DESIGN REQUIREMENTS FOR LSTF MODIFICATIONS
## NEW COMPONENTS (Continued)

<u>The CMT Associated Lines and Valves:</u>

- ❐ CL-PBL scaled to preserve R';
  MOV at the proper elevation;
  Heat Traced.
  Instrumented with venturi, TCs, and γ-D

- ❐ Pzr-PBL scaled to preserve R'
  Check valve and heat traced
  Instrumented with FT, TCs, and DP.

- ❐ Discharge line scaled to preserve R'
  Check Valve, MOV, and Flow restriction Orifice.
  Instrumented with FT, TCs, and DP.

- ❐ Two configurations to include non-symmetric PBL break (Sketch attached).

FIG. 9

# DESIGN REQUIREMENTS FOR LSTF MODIFICATIONS
## NEW COMPONENTS (Continued)

<u>The IRWST and Discharge Lines:</u> scaled to wrong volume

- ❐ Scaled to simulate interactions with sparger and PRHR. is too small
- ❐ Full height to preserve driving head for injection (added head to compensate for backpressure). Elevations of sparger and PRHR connections are preserved.
- ❐ Separation plate to represent the two bays and their connecting path in the real IRWST.

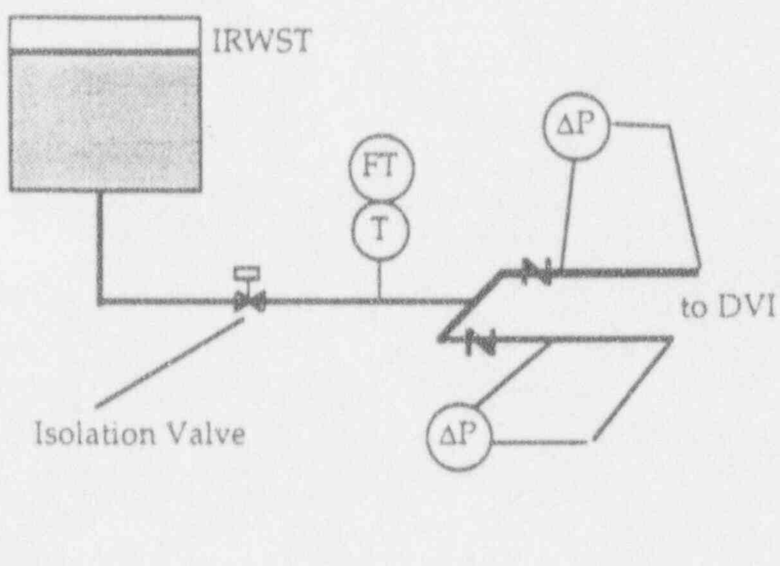



FIG 10

# DESIGN REQUIREMENTS FOR LSTF MODIFICATIONS
## NEW COMPONENTS (Continued)

<u>The ADS and SPARGER:</u>

- ❒ Scaled to simulate ADS mass flow out of the primary (R′ preserved). Two trains lumped into one set, with three parallel orifices that simulate AP600 valve openings.
- ❒ Operating logic similar to AP600.
- ❒ Instrumented with a γ-D, Pressure, and Temperature transducers.
- ❒ Sparger of similar configuration with a scaled number of holes to preserve mass flow and phenomena.
- ❒ ADS 1 , 2, and 3 discharge through the sparger in the IRWST. Two ADS 4 discharge separately in catch tanks.

FIG-11

# DESIGN REQUIREMENTS FOR LSTF MODIFICATIONS
# NEW COMPONENTS (Continued)

The PRHR:

- ❒ Prototypic size and shape of tubes. Scaled number of tubes.
- ❒ Inlet and outlet line scaled to preserve mass flow and instrumented to measure mass and energy flow.

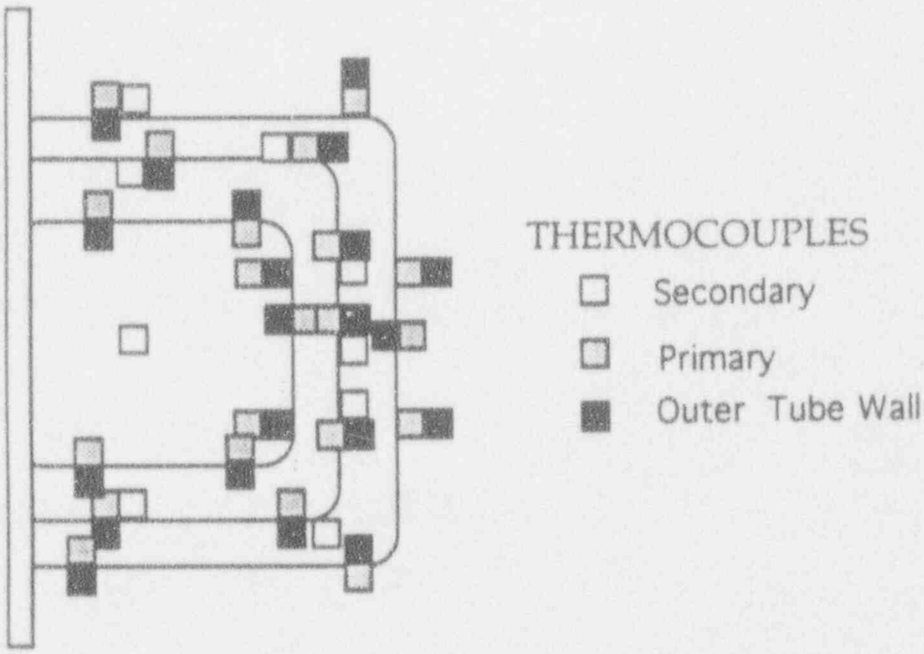



FIG. 12

# DESIGN REQUIREMENTS FOR LSTF MODIFICATIONS
## NEW COMPONENTS (Continued)

<u>The DVI line and Connection to the Vessel:</u>

- ❒ Line scaled and configured to preserve mass flow and sequence of safety systems.
- ❒ Instrumented to measure mass and energy flow.
- ❒ DVI connection at an available location, lower than prototype.
- ❒ DVI line deflector simulated in the downcomer.

FIG. 13

## DESIGN REQUIREMENTS FOR LSTF MODIFICATIONS
## ALTERED COMPONENTS

### PRESSURIZER

- New Pressurizer, Scaled to right volume, correct elevation and internals (including retainer basket).
- Instrumented with TCs, Wall TCs, and DPs.
- Heat Traced.
- Proper elevation and proper elevation of connections to PBL and ADS header.

### PRESSURIZER SURGE LINE

- New atypical surge line. A compromise to model proper inclination (2.5°), mass flow, and to connect to new pressurizer.
- Instrumented with TCs, DPs, and $\gamma$-D.

FIG. 14

# LIMITATIONS, COMPROMISES, AND SOURCES OF DISTORTION

⇒ <u>Atypicalities of LSTF with respect to AP600</u>

- Cold Legs (one per loop)
- Pumps and loop seal
- Steam Generators
- Surge Line
- Excess Metal Mass - not a major factor
- Excess Liquid volume (dead volumes)
- Cold Leg PBL Connection
- IRWST Volume (underscaled but adequate)
- Containment Backpressure

FIG. 15

## 3. FACILITY MODIFICATIONS AND ADDITIONS FOR AP600 TESTING

*A. ADDED SYSTEMS

- TWO CMTs (CORE MAKEUP TANKS)
- ADS (AUTOMATIC DEPRESSURIZATION SYSTEM) 1-4 STAGES
- IRWST (IN-CONTAINMENT REFUELING WATER STORAGE TANK)
- PRHR (PASSIVE RESIDUAL HEAT REMOVAL) SYSTEM
- CONNECTING LINES (PRESSURIZER SURGE LINE, CMT PRESSURE BALANCE LINES, CMT AND IRWST DISCHARGE LINES, DIRECT VESSEL INJECTION (DVI) LINES, ETC.)
- CMT STEAM DISTRIBUTORS (DIFFUSERS)
- TWO CATCH TANKS TO COLLECT FLUID FROM ADS STAGE 4

FIG.16

B. MODIFIED SYSTEMS

- LOOP SEALS DEPTH REDUCED FROM 3.7M TO 1.5M
- PROPERLY SCALED PRESSURIZFR (HEIGHT INCREASED AND INSIDE DIAMETER REDUCED)
- STAND PIPES (3.8M HIGH) IN ACCUMULATORS TO REDUCE CAPACITY TO SCALED VALUES
- GREATER FLOW PATHS BETWEEN UPPER PLENUM AND HEAD

FIG. 17

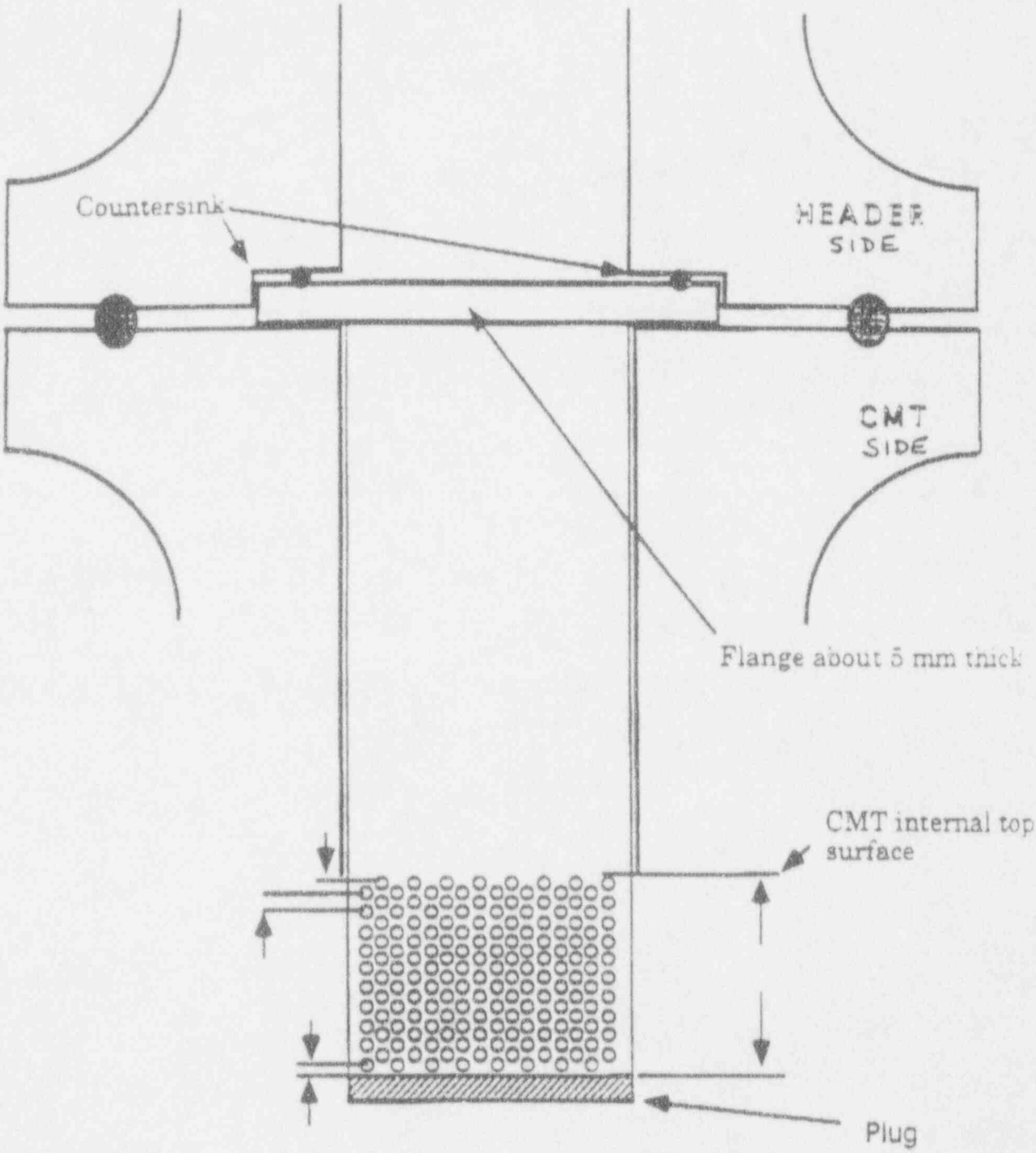

Countersink
HEADER SIDE
CMT SIDE
Flange about 5 mm thick
CMT internal top surface
Plug

FIG. 18

Table 6.1 Summary of measurement Types and Locations

| Instrument/Measurement | Symbol | Pressure Vessel | Primary System | Steam Generators | Pressurizer | Secondary System | Surpression Tank and Break Units | Other | Total |
|---|---|---|---|---|---|---|---|---|---|
| Fluid Temperature | TE | 191 | 60 | 246 | 17 | 15 | 17 | 97 | 643 |
| Wall Temperature | TW | 485 | 50 | 92 | 18 | | 4 | 9 | 656 |
| Differential Temperature | DT | 112 | 24 | 70 | 2 | | | | 208 |
| Conductance Probe | CP | 143 | 20 | 20 | 4 | | 1 | | 188 |
| Conductance Probe with TC | CPT | | 10 | 224 | | | | | 234 |
| Flow Rate | F | 2 | 4 | 12 | 3 | 8 | 4 | 25 | 58 |
| Pitot-tube Velocimeter | PIT | | 3 | | | | | | 3 |
| Liquid Level | L | 1 | | 8 | 1 | 1 | 4 | 4 | 19 |
| Pressure | P | 3 | 10 | 2 | 8 | 5 | 10 | 4 | 42 |
| Differential Pressure | DP | 24 | 62 | 22 | 9 | | 6 | 2 | 125 |
| Gamma Densitometer(1 Beam) | $GD_1$ | | 3 | 1 | 3 | | | | 7 |
| Gamma Densitometer(3 Beam) | $GD_3$ | | 6 | 1 | | | 3 | | 10 |
| Drag Disk Flow Meter | DD | | 26 | | 6 | | 4 | | 36 |
| Video Probe | VP | 2 | 6 | | | | | | 8 |
| Rotation Speed | RE | | 2 | | | | | | 2 |
| Pump oscillation | VE | | 2 | | | | | | 2 |
| Pump Torque | TQ | | 2 | | | | | | 2 |
| Power | WE | 11 | 8 | 16 | 4 | | | 4 | 43 |
| Total | | 974 | 298 | 714 | 73 | 29 | 53 | 145 | 2286 |

FIG. 19

| Summary of Instrumentation in New ROSA/AP600 Components | | | | | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|
| | Level | DPs | P | Fluid TCs | Metal TCs | DTs | Spool Pieces[1] | Flow | g-D | |
| CMTs | 8 | 2 | 2 | 48 | | 26 | | | | 86 |
| PZR PBLs | | 4 | | 6 | 2 | | | 2 | | 14 |
| CL PBLs | | 6 | 2 | 8 | 4 | | 2 | 2 | 2 | 26 |
| CMT Headers | | 2 | | 2 | | | | | | 4 |
| CMT Dschrgs | | 2 | | 4 | | | | 2 | | 8 |
| ACC Dschrgs | | 2 | 2 | 8 | 2 | | | 2 | | 16 |
| IRWST Dschrg | | 2 | | 2 | | | | 2 | | 6 |
| DVI Lines | | 2 | 4 | 2 | | | 2[2] | 2 | | 12 |
| PRHR | 1 | 3 | | 33 | 22 | | | 1 | | 60 |
| IRWST | | 2 | | 19 | | | | | | 21 |
| ADS-1,2,3 | | 3 | 2 | 2 | 1 | | 1 | | 1 | 10 |
| ADS-4 | | 4 | | 4 | | | | | 2 | 10 |
| Pressurizer | 1 | 8 | 2 | 6 | 6 | | | | | 23 |
| Surge Line | | 2 | | | | | | | 1 | 3 |
| Loop Seals | | 4 | | 2 | 2 | | | 2 | | 10 |
| TOTAL | 10 | 48 | 14 | 146 | 39 | 26 | 5 | 15 | 6 | 309 |

[1]The instruments included in the spool pieces have been included in the table.

[2] These spool pieces will be used only during a DVI break scenario.

6. DATA COLLECTION AND PROCESSING

A. DATA ARE COLLECTED AND RECORDED BY TWO COMPUTERS (YEWCOM 7000 AND FACOM S3300)

- T/C's BY YEWCOM AT 0.1-2 Hz SAMPLING RATE
- D/P's BY YEWCOM AT 0.25-5 Hz SAMPLING RATE
- CONDUCTIVITY PROBES FOR MEASURING FROTH LEVELS BY YEWCOM AT 0.5-10Hz SAMPLING RATE
- OTHER INSTRUMENTS (PUMP SPEED AND POWER METER, ETC.) BY YEWCOM AND FACOM AT 0.5-10Hz SAMPLING RATE
- SAMPLING RATE IS SET HIGH INITIALLY AND REDUCED AS SYSTEM IS SETTLED DOWN

B. DATA PROCESSING BY FACOM M780 MAIN COMPUTER

- DATA CONVERSION TO ENGINEERING UNITS.
- DATA SCANNING TO DETERMINE PEAK CLAD TEMPERATURES.
- CALCULATIONS OF BREAK FLOW RATES AND ACCUMULATOR INJECTION RATES.
- OTHER CALCULATIONS SUCH AS AVERAGE DENSITY AND MASS FLOW RATES.
- CREATION OF DATA TAPES.

C. DATA REVIEW TEAM WILL QUALIFY DATA WITHIN ONE MONTH FROM COMPLETION OF EACH TEST.

## CURRENT TESTING SCHEDULE

| | |
|---|---|
| FACILITY CHARACTERIZATION TESTING | NOV - JAN 1994 |
| 1" COLD LEG BREAK | FEB 1994 |
| 1/2" COLD LEG BREAK | MAR 1994 |
| DVI LINE BREAK | APR 1994 |
| INADVERTENT ADS1 OPENING | MAY 1994 |
| 2" COLD LEG BREAK W/NON SAFETY SYS | MAY 1994 |
| 1" COLD LEG BREAK W FAILURE ADS 1-3 | JUN 1994 |
| 2" COLD LEG PBL BREAK | SEP 1994 |
| 2" COLD LEG PBL BREAK W/O RCP TRIP | SEP 1994 |
| 200% COLD LEG PBL BREAK | OCT 1994 |
| SGTR | NOV 1994 |
| MULTIPLE SGTR WITH ADS ACTUATION | DEC 1994 |
| STEAM LINE BREAK | DEC 1994 |
| PHASE II | JAN - DEC 1995 |

FIG. 23

# COUNTERPART TESTING AND ANALYSIS

| | RELAP/ROSA-AP600 | RELAP/AP600 | OSU | SPES | W SER |
|---|---|---|---|---|---|
| INADVERTENT ADS-1 OPENING | X | X | X | X | X |
| 0.5" COLD LEG BREAK | X | X | | | |
| 1" COLD LEG BREAK | X | X | X | X | X |
| 2" COLD LEG BREAK ** | X | X | X | X | X |
| 2" CL BREAK W/NON-SAFETY SYS | X | | | X | |
| 4" COLD LEG BREAK ** | X | | X | | |
| 2" COLD LEG PBL BREAK | X | X | X | X | X |
| 200% COLD LEG PBL BREAK | X | X | X | X | X |
| 200% DIRECT VESSEL INJECTION BREAK | X | X | X | X | X |
| SINGLE SG TUBE RUPTURE | X | X | | X | X |
| MSGTR WITH ADS ACTUATION | X | X | | X(?) | |
| 100% MAIN STEAM LINE BREAK | X | X | | X | X |

** TO BE DEFERRED TO BE RUN DURING PHASE II TESTING

## PHASE II TEST PLANS

1. MAIN STEAM LINE BREAK WITH STEAM GENERATOR TUBE RUPTURE

2. 1" COLD LEG BREAK WITH FAILURE OF ADS STAGES 1, 2, 3 **

3. 2" COLD LEG BREAK WITH FAILURE OF 1/2 REACTOR COOLANT PUMPS TO TRIP (1/4 IN AP600) **

4. STATION BLACKOUT

5. LOSS OF FEEDWATER WITH FAILURE OF PRHR

6. 1" COLD LEG BREAK WITH FAILURE OF 2/2 FAILURE OF ADS STAGE 4

7. 2" COLD LEG BREAK WITH FAILURE OF 1/2 ADS TRAINS, 1/2 CMTs

8. 2" COLD LEG BREAK WITH FAILURE OF 2/2 CMTs, MANUAL ADS ACTUATION

9. 2" COLD LEG BREAK WITH SGTR WHEN PRIMARY PRESSURE IS LESS THAN SECONDARY PRESSURE

10. PRHR TUBE RUPTURE WITH FAILURE TO ISOLATE

11. PRHR RETURN LINE BREAK, 1/2 CMT INJECTION, 1/2 ACCUMULATOR INJECTION, 1/2 IRWST INJECTION

12. 2" ADS STAGE 1 LEAK WITH FAILURE OF 1/2 CMT, 1/2 IRWST, 1/2 ADS STAGE 4

** TO BE RUN DURING PHASE I TEST SERIES

(9)

F16-25

LSTF TEST TO SIMULATE CMT BEHAVIOR (SB-CL-27)

BASED ON REVIEW OF AVAILALBE PAPERS FROM JAERI

- 3 INCH COLD LEG TOP BREAK (16 MM)
- ONE OF THE TWO EXISTING LSTF ACCUMULATORS CONFIGURED TO SIMULATE A CMT
- CMT VALVES OPENED UPON BREAK INITIATION

| | ACC | SCALED CMT | |
|---|---|---|---|
| LENGTH | 22′ | 20.5′ | |
| DIAMETER | 3.1′ | 2′ | |
| ELEVATION | 28′ | 24′ | (FROM CORE BOTTOM) |
| WALL τ | 2.2" | 1.4" | |
| CL PBL DIAMETER | 2.4" | 1.7" | |
| PRZR PBL DIAMETER | 0.8" | 0.6" | |

TC'S LOCATED EVERY FOOT IN ACC, EVERY FOOT IN SCALED CMT

CALCULATED (RELAP) CMT DRAIN RATE ~1"/5 SEC (1 FT/MIN)

INITIAL P = 1650 PSI
SECONDARY P = 1000 PSI
INITIAL CMT T = 90 F
INITIAL CL T = 530 F

TWO ADS STAGES REPRESENTED
FIRST STAGE PROGRAMMED TO OPEN AT 865 PSI
SECOND STAGE PROGRAMMED TO OPEN AT 185 PSI

ACCUMULATER PRESSURIZER TO 650 PSI

# EVENT TIMINGS

| | |
|---|---|
| 0 | BREAK INITIATION AND CMT VALVES OPEN |
| 250 | PRIMARY P DECREASES BELOW SECONDARY P WHEN BREAK TRANSITIONS FROM LIQUID TO 2-PHASE |
| 350 | BEGIN TWO PHASE FLOW IN CL PBL |
| 417 | OPEN 1ST STAGE ADS |
| 474 | ACCUMULATOR INJECTION BEGINS |
| 475 | RECIRCULATION PERIOD ENDS |
| 1360 | ACCUMULATOR INJECTION ENDS |
| 1620 | OPEN SECOND STAGE ADS |
| 1900 | CMT INJECTION ENDS |

FIG. 27

PURDUE TEST FACILITY FOR SBWR

- 1/4 OF THE SBWR HEIGHT
  (FOR COMPARISON, GIST = 1,
  GIRAFFE = 1, PANDA = 1)

- 1/400 OF THE SBWR VOLUME
  (GIST = 1/508, GIRAFFE = 1/400,
  PANDA = 1/25)

- ASPECT RATIO (DIAMETER SCALE/HEIGHT SCALE)
  OF 1/2.5 (SBWR = 1, GIST = 1/22.5,
  GIRAFFE = 1/20, PANDA = 1/5)

- LOW-PRESSURE (APPROX. 150 PSIA)
  (SAME AS GIST, GIRAFFE, PANDA)

- WATER, STEAM, NON-CONDENSIBLE
  (SAME AS GIST, GIRAFFE, PANDA)

- ALL OF KEY COMPONENTS AND SYSTEMS:
  VESSEL, UPPER AND LOWER DRYWELLS, SUPPRESSION
  POOL, GDCS, PCCS, ICS, DRYWELL AND SUPPRESSION
  POOL SPRAYS, PIPING AND VALVES, AND
  INSTRUMENTATION.

- BOTH SHORT-TERM AND LONG-TERM CORE AND
  CONTAINMENT COOLING WILL BE COVERED
  TO OVERLAP GIST/GIRAFFE/PANDA DATA
  (GIST COVERED SHORT-TERM COOLING ONLY,
  GIRAFFE AND PANDA COVER LONG-TERM COOLING ONLY)

FIG. 28

(4)

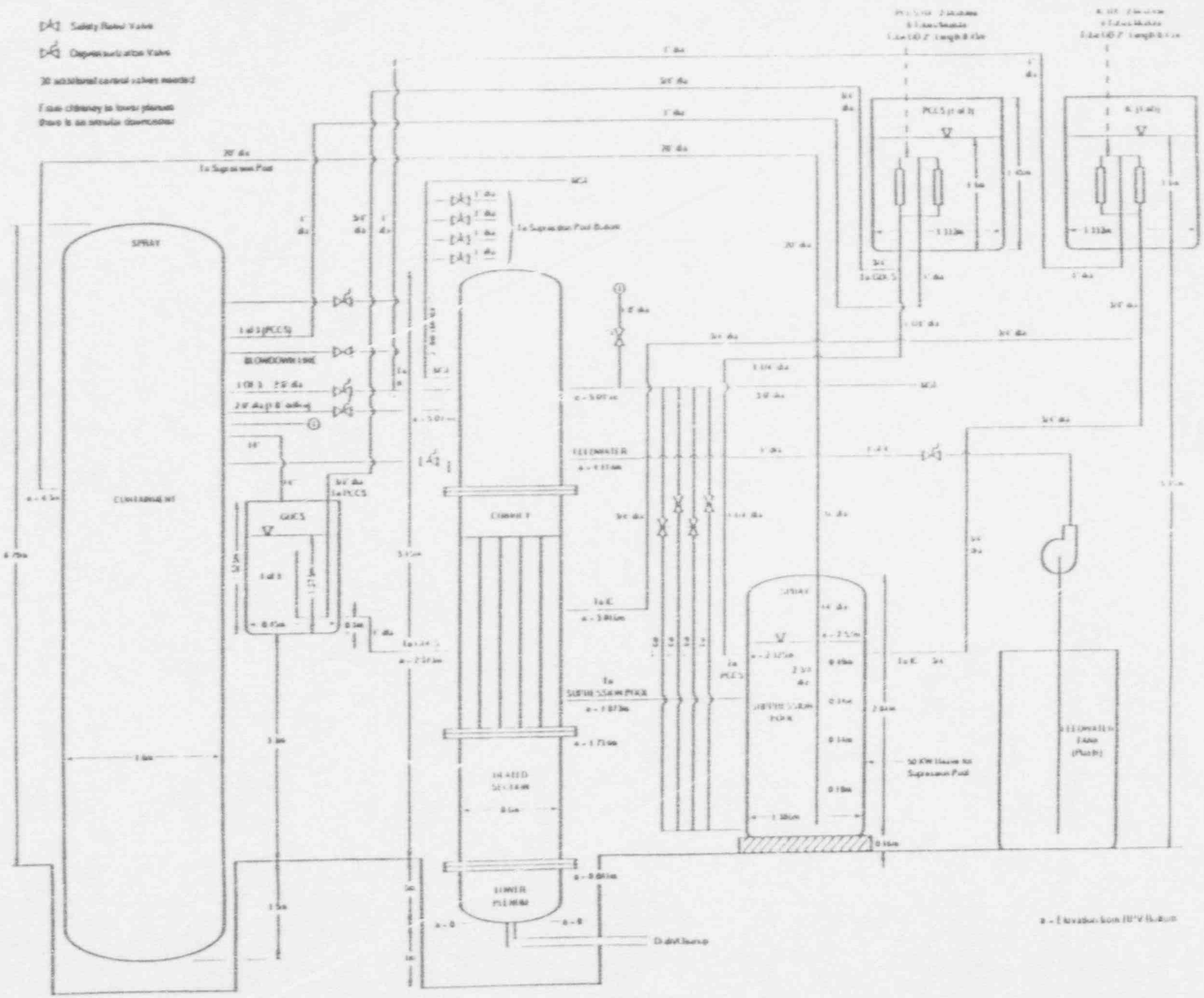



Figure 1. Elevation Drawing of Proposed Integral Facility for SBWR

(5)

F16-29

PRELIMINARY TEST MATRIX: PHASE 1 - BASE CASE AND COUNTERPART TESTS

| | | OPERATIONAL COMPONENTS | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Test | Event | PCCS | ICS | GDCS Lines | DPV | VB | EQUAL | DWS | WWS |
| 1 (BASE) | MSLB | 3 | 3 | 6 | 6 | 3 | 3 | 0 | 0 |
| 2* | MSLB (GIST B01) | 0 | 0 | 4 | 6 | 3 | 3 | 0 | 0 |
| 3 | MSLB | 3 | 3 | 4 | 6 | 3 | 3 | 0 | 0 |
| 4 (BASE) | BDLB | 3 | 3 | 6 | 6 | 3 | 3 | 0 | 0 |
| 5* | BDLB (GIST A07) | 0 | 0 | 4 | 6 | 3 | 3 | 0 | 0 |
| 6 | BDLB | 3 | 3 | 4 | 6 | 3 | 3 | 0 | 0 |
| 7 (BASE) | GDLB | 3 | 3 | 6 | 6 | 3 | 3 | 0 | 0 |
| 8* | GDLB (GIST C01A) | 0 | 0 | 4 | 6 | 3 | 3 | 0 | 0 |
| 9 | GDLB | 3 | 3 | 4 | 6 | 3 | 3 | 0 | 0 |
| 10 (Base) | LOFW | 3 | 3 | 6 | 6 | 3 | 3 | 0 | 0 |
| 11* | LOFW (GIST D03A) | 0 | 0 | 4 | 6 | 3 | 3 | 0 | 0 |
| 12 (BASE) | FWLB | 3 | 3 | 6 | 6 | 3 | 3 | 0 | 0 |
| 13* | FWLB | 0 | 0 | 4 | 6 | 3 | 3 | 0 | 0 |
| 14 | MSLB(GIRAFFE/PANDA) | | | | | | | | |
| 15 | BDLB(GIRAFFE) | | | | | | | | |
| 16 | GDLB(GIRAFFE/PANDA) | | | | | | | | |
| 17 | ICRLB(PANDA) | | | | | | | | |

*Test will be terminated when a temperature or pressure setpoint is reached to prevent damage.

VB = vacuum breaker between drywell and wetwell, EQUAL = equalization line connecting suppression pool to the vessel (e.g., 3 means all three equalization lines will open if actuated automatically or manually), DWS = drywell spray, WWS = wetwell spray, MSLB = main steam line break, BDLB = bottom drain line break, GDLB = GDCS line break, LOFW = loss of feedwater, FWLB = feedwater line break, ICRLB = isolation condenser condensate return line break. No information is currently available regarding the number of operational components in the GIRAFFE and PANDA tests.

(3) (FIG 30)

PRELIMINARY TEST MATRIX: PHASE 2 - SENSITIVITY STUDY AND BEYOND DBA TESTS

| Test | Event | OPERATIONAL COMPONENT PCCS | ICS | GDCS Lines | DPV | VB | EQUAL | DWS | WWS |
|---|---|---|---|---|---|---|---|---|---|
| 18 | BDLB | 3 | 3 | 6 | 5 | 3 | 3 | 0 | 0 |
| 19 | BDLB | 3 | 3 | 5 | 6 | 3 | 3 | 0 | 0 |
| 20 | BDLB | 3 | 3 | 6 | 6 | 3 | 2 | 0 | 0 |
| 21 | BDLB (1 VB failed in open position) | 3 | 3 | 6 | 6 | 2 | 3 | 0 | 0 |
| 22 | BDLB (1 VB failed in closed position) | 3 | 3 | 6 | 6 | 2 | 3 | 0 | 0 |
| 23 | BDLB (all 3 VBs failed in open position) | 3 | 3 | 6 | 6 | 0 | 3 | 0 | 0 |
| 24 | Blackout | 2 | 3 | 4 | 6 | 3 | 3 | 0 | 0 |

In addition to the above tests, the following tests will be selected:

1. Several additional tests with multiple component failure.

2. A few tests to assess the impact of non-safety systems upon GDCS and PCCS (e.g., control rod drive flow or RWCU/SDCS flow on GDCS performance, drywell spray on PCCS and GDCS performance, wetwell spray on suppression pool flow to the vessel via equalization line).

3. A few tests at different break sizes (e.g., 50% of BDLB).

4. A few tests to assess natural circulation flow characterization by measuring core flow as a function of power, downcomer water level, and vessel pressure (including the determination of any flow oscillation or instability).

5. Several sensitivity tests by varying core power or other PIRT-identified important parameters.

6. A few helium tests to investigate the presence of hydrogen on PCCS performance.

7. A few repeatability tests.

FIG-31