Westinghouse Electric Corporation
Energy Systems

Box 355
Pittsburgh Pennsylvania 15230-0355

AW-94-602

March 21, 1994

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

ATTENTION: MR. R. W. BORCHARDT

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

SUBJECT: PRESENTATION MATERIALS FROM THE MARCH 14, 1994 MEETING ON AP600 CORE MAKEUP TANK TESTS AND ANALYSIS

Dear Mr. Borchardt:

The application for withholding is submitted by Westinghouse Electric Corporation ("Westinghouse") pursuant to the provisions of paragraph (b)(1) of Section 2.790 of the Commission's regulations. It contains commercial strategic information proprietary to Westinghouse and customariiy held in confidence.

The proprietary material for which withholding is being requested is identified in the proprietary version of the subject report. In conformance with 10CFR Section 2.790, Affidavit AW-94-602 accompanies this application for withholding setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

Accordingly, it is respectfully requested that the subject information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10CFR Section 2.790 of the Commission's regulations.

Correspondence with respect to this application for withholding or the accompanying affidavit should reference AW-94-602 and should be addressed to the undersigned.

Very truly yours,

N. J. Liparulo, Manager
Nuclear Safety And Regulatory Activities

/nja

cc: Kevin Bohrer NRC 12H5

1578A

AW-94-602

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared Brian A. McIntyre, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Corporation ("Westinghouse") and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

Brian A. McIntyre, Manager
Advanced Plant Safety & Licensing

Sworn to and subscribed
before me this 23 day
of March, 1994

Rose Marie Payne
Notary Public

Notarial Seal
Rose Marie Payne, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Nov. 4, 1996
Member, Pennsylvania Association of Notaries

1590A

(1) I am Manager, Advanced Plant Safety and Licensing, in the Advanced Technology Business Area, of the Westinghouse Electric Corporation and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rulemaking proceedings, and am authorized to apply for its withholding on behalf of the Westinghouse Energy Systems Business Unit.

(2) I am making this Affidavit in conformance with the provisions of 10CFR Section 2.790 of the Commission's regulations and in conjunction with the Westinghouse application for withholding accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by the Westinghouse Energy Systems Business Unit in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.790 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information which is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10CFR Section 2.790, it is to be received in confidence by the Commission.

(iv) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(v) Enclosed is Letter NTD-NRC-94-4081, March 21, 1994, being transmitted by Westinghouse Electric Corporation (W) letter and Application for Withholding Proprietary Information from Public Disclosure, N. J. Liparulo (W), to Mr. R. W. Borchardt, Office of NRR. The proprietary information as submitted for use by Westinghouse Electric Corporation is in response to questions concerning the AP600 plant and the associated design certification application and is expected to be applicable in other licensee submittals in response to certain NRC requirements for justification of licensing advanced nuclear power plant designs.

This information is part of that which will enable Westinghouse to:

(a) Demonstrate the design and safety of the AP600 Passive Safety Systems.

(b) Establish applicable verification testing methods.

(c) Design Advanced Nuclear Power Plants that meet NRC requirements.

(d) Establish technical and licensing approaches for the AP600 that will ultimately result in a certified design.

(e) Assist customers in obtaining NRC approval for future plants.

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to sell the use of similar information to its customers for purposes of meeting NRC requirements for advanced plant licenses.

(b) Westinghouse can sell support and defense of the technology to its customers in the licensing process.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar advanced nuclear power designs and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended for developing analytical methods and receiving NRC approval for those methods.

Further the deponent sayeth not.

CORE MAKEUP TANK SCALING LOGIC

L. E. HOCHREITER

- CORE MAKE-UP TANK SCALING

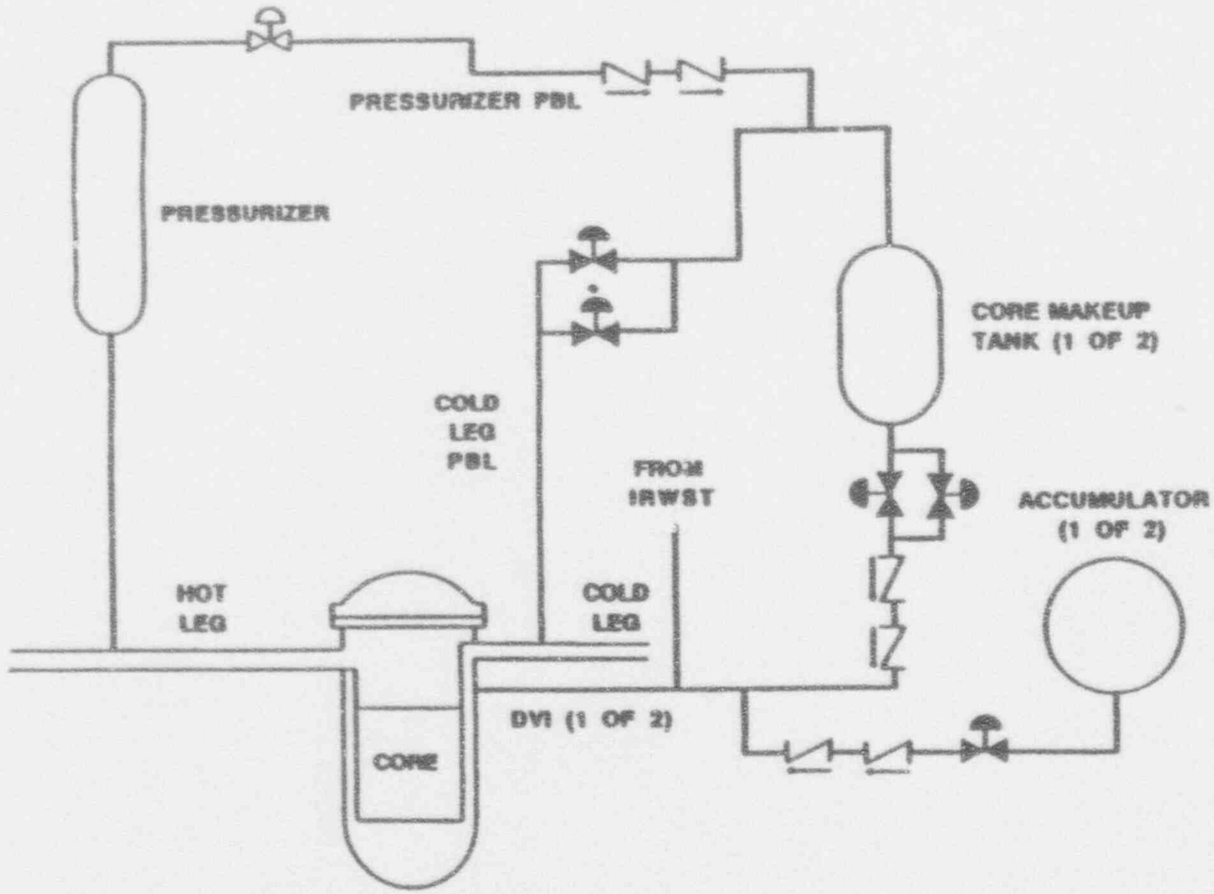
  - THE CMT HAS TWO MODES OF OPERATION

    - RECIRCULATION MODE IN WHICH COLD LEG WATER FLOWS INTO THE CMT, AS WATER DRAINS FROM THE CMT

    - DRAINING OF THE CMT WITH STEAM ENTERING THE TOP OF THE CMT AND MIXING WITH THE CMT WATER

AP600 PASSIVE CORE COOLING SYSTEM

AP600



- MODES OF CMT OPERATION DEPEND ON THE BREAK SIZE

  - FOR SBLOCA'S RECIRCULATION WILL OCCUR AND CREATE A HOT LIQUID LAYER AT THE TOP OF THE CMT

    - CALCULATED IN SSAR ANALYSIS
    - OBSERVED IN JAERI TEST
    - OBSERVED IN 1ST SPES TEST

  - FOR LARGER BREAKS DEG-DVI AND DEG-CLBL, AND LBLOCA RECIRCULATION IS MINIMIZED, AND STEAM INJECTION INTO CMT OCCURS AS IT DRAINS

    - CALCULATED IN SSAR ANALYSIS

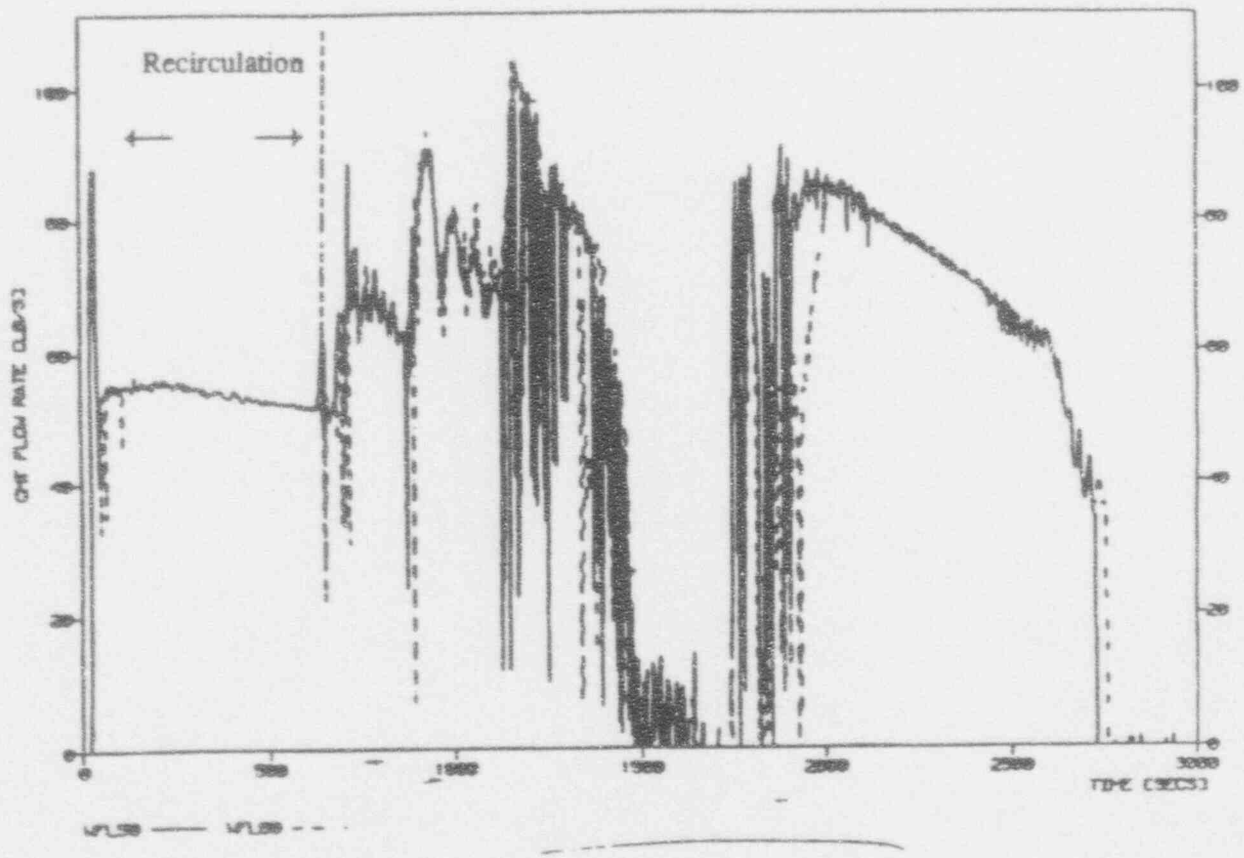


Figure 1-4 AP600 SSAR Calculation of CMT Draining Flow for 2-Inch Cold Leg Break

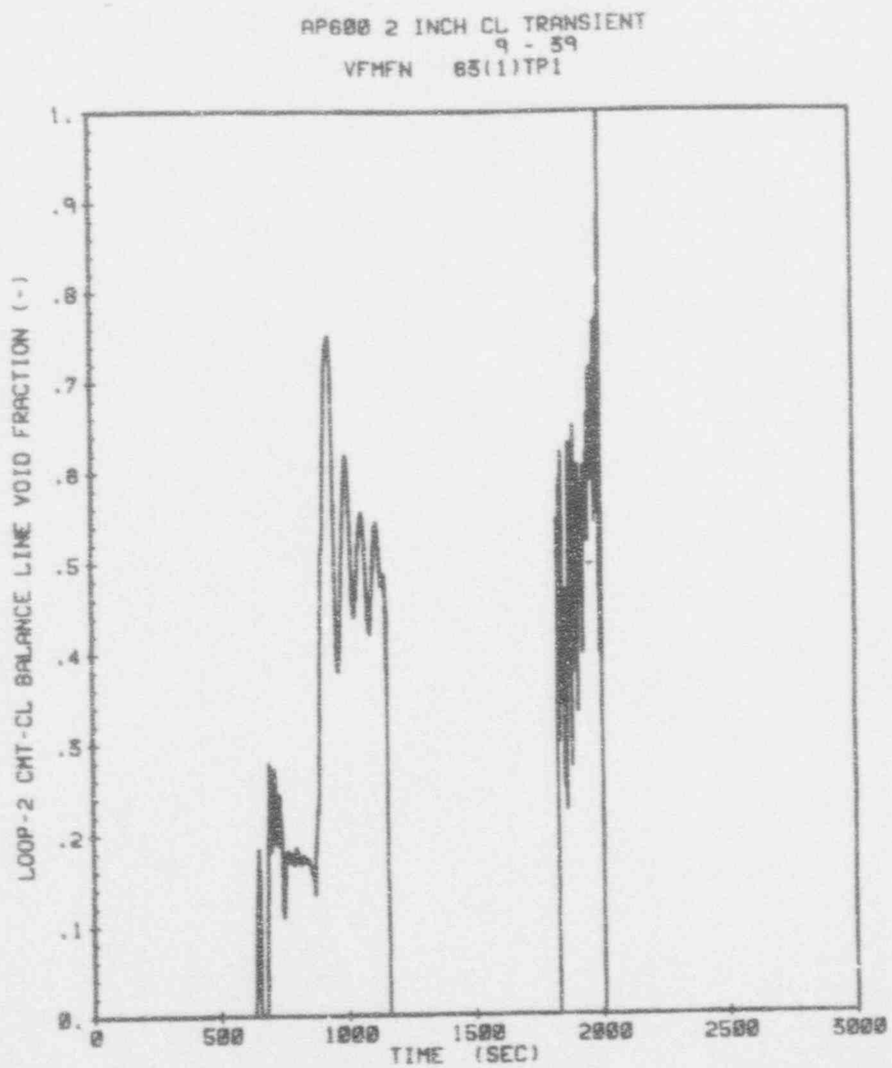
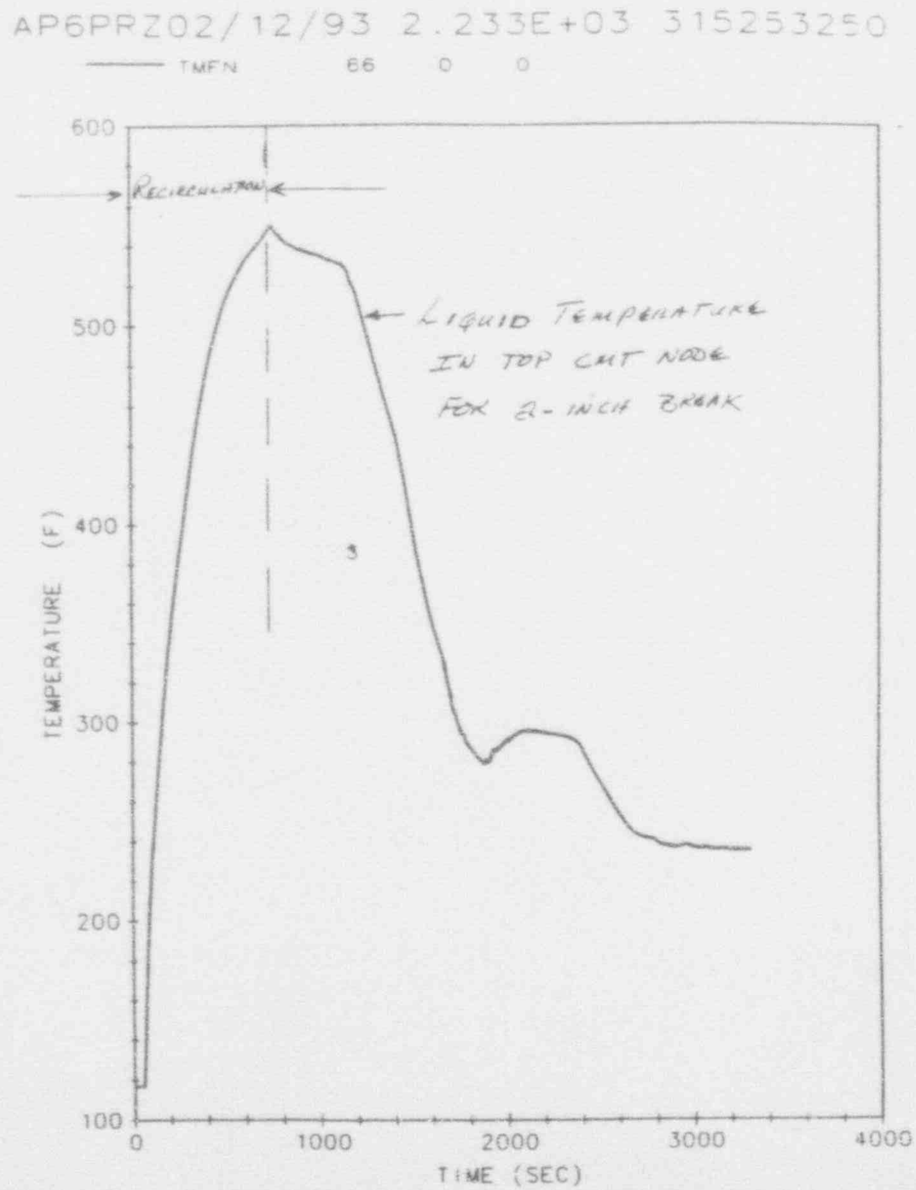
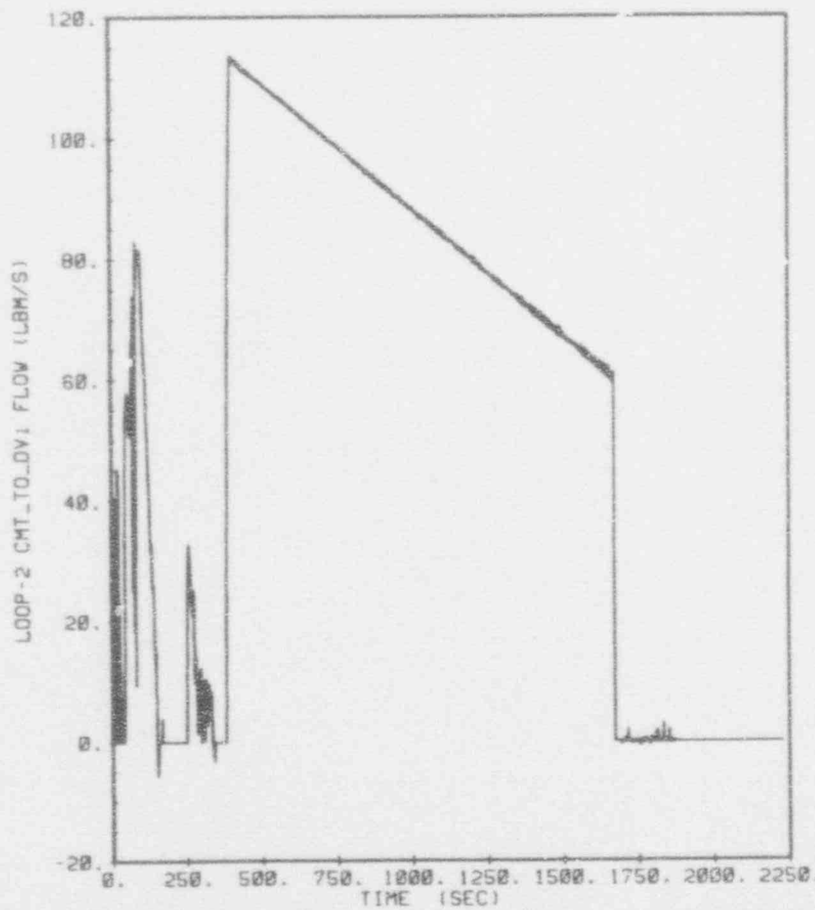
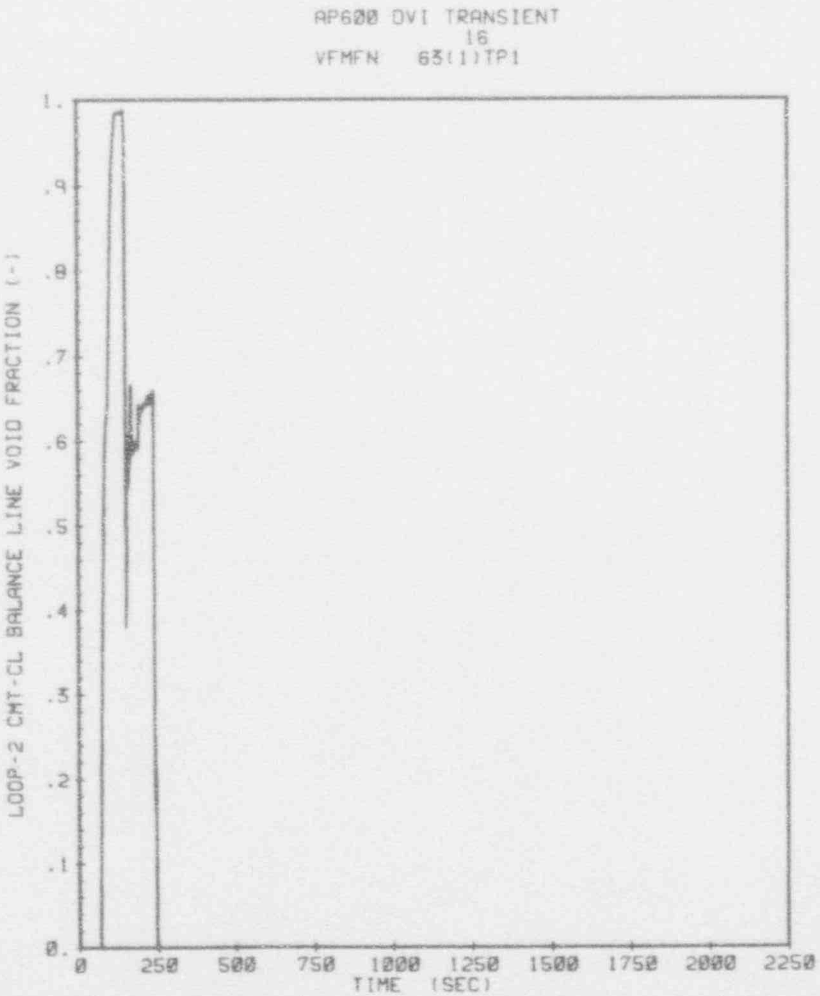


Figure 1-5 Cold Leg Balance Line Void Fraction for 2-Inch Cold Leg Break

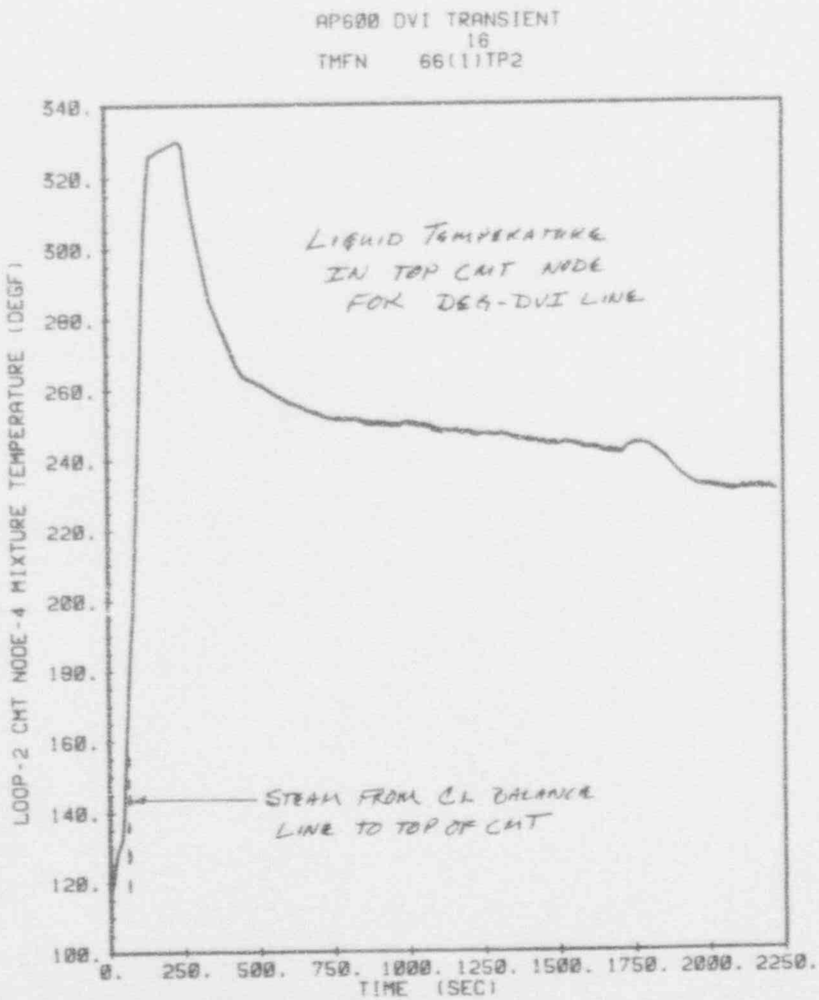

AP6PRZ02/12/93 2.233E+03 315253250
TMFN 66 0 0
RECIRCULATION
LIQUID TEMPERATURE
IN TOP CMT NODE
FOR 2-INCH BREAK
TEMPERATURE (F)
600
500
400
300
200
100
0
1000
2000
3000
4000
TIME (SEC)

AP600 DVI TRANSIENT
16
WFL 60(1)TP1





AP600 DVI TRANSIENT
16
VFMFN 63(1)TP1
LOOP-2 CMT-CL BALANCE LINE VOID FRACTION (-)
1.
.9
.8
.7
.6
.5
.4
.3
.2
.1
0.
0
250
500
750
1000
1250
1500
1750
2000
2250
TIME (SEC)


AP600 DVI TRANSIENT
16
TMFN 66(1)TP2
LOOP-2 CMT NODE-4 MIXTURE TEMPERATURE (DEGF)
TIME (SEC)
Liquid Temperature
In top CMT node
for DEG-DVI line
Steam from CL balance
line to top of CMT

- CMT CONDENSATION EFFECTS ARE MINIMAL WHEN CMT RECIRCULATION OCCURS, AND STABLE DRAINING WILL OCCUR.

- CMT CONDENSATION EFFECTS BECOME MORE IMPORTANT FOR THE VERY LARGE SBLOCA'S AND PERHAPS FOR LBLOCA, WHEN THE TOP OF CMT WATER REMAINS SUBCOOLED.

- CMT SCALING LOGIC --- APPROACH

  - KEY PHENOMENA WERE IDENTIFIED AND WERE COMPARED TO THE DIFFERENT MODES OF CMT OPERATION

  - A PHENOMENA IDENTIFICATION AND RANKING TABLE (PIRT) WAS DEVELOPED AND COMPARED FOR DIFFERENT TRANSIENTS

a,c

- CMT RECIRCULATION MODE

  - THE SCALING APPROACH WHICH WAS USED GAVE TWO DIMENSIONLESS GROUPS TO BE PRESERVED

$$\Pi_{R_i} = \frac{\beta_{T_s} g \Delta T_{sp}}{U_0^2} \quad \text{Richardson Number}$$

$$\Pi_F = \left[\frac{fL_f}{D_h} + K\right] \quad \text{Friction Number}$$

- CMT RECIRCULATION MODE (continued)

  - TO PRESERVE THE RECIRCULATION MODE OF THE CMT TEST TO THE AP600 CMT;

    THEN

$$\frac{\Pi_{R}\big)_{m}}{\Pi_{R}\big)_{p}} = 1 = \Pi_{R}\big)_{R}$$

$$\frac{\Pi_{F}\big)_{m}}{\Pi_{F}\big)_{p}} = 1 = \Pi_{F}\big)_{R}$$

- SINCE, FOR THE CMT TEST FACILITY
  - FLUID PROPERTIES ARE PRESERVED
  - HEIGHTS ARE RELATIVELY WELL PRESERVED
  - FRICTION AND FORM LOSSES ARE APPROXIMATELY PRESERVED
- RECIRCULATION BEHAVIOR OF CMT TEST SHOULD BE SIMILAR TO AP600

- A MORE DETAILED SCALING ANALYSIS WAS PERFORMED TO EXAMINE THE CMT TEST RECIRCULATION BEHAVIOR RELATIVE TO AP600

- ASSUMPTIONS

  - QUASI-STEADY
  - NO MOMENTUM EFFECTS
  - NO HEAT TRANSFER, VOLUME REPLACEMENT
  - NO FLUID MIXING WITHIN CMT, S/WR

- THE GOVERNING EQUATION FOR THE CMT PIPING SYSTEM IS:

$$\frac{\rho_2 U_{DVI}^2}{2g_c} - \frac{\rho_1 U_{CL}^2}{2g_c} + \left(K_{CL_{in}} + \frac{fL_t}{D_h}\right)_{CL} \rho_1 \frac{U_{CL}^2}{2g_c} + \left(K_T + K_{CMT_{in}} + \frac{fL_t}{D_h}\right)_{BL} \rho_1 \frac{U_{BL}^2}{2g_c} +$$

$$\left(K_{CMT_{ex}} + K_{CKV} + K_{DVI_{in}} + \frac{fL_t}{D_h}\right)_{DVI} \rho_2 \frac{U_{DVI}^2}{2g_c} + \frac{g}{g_c}\rho_1 L - \frac{g}{g_c}\rho_2 L = 0$$

- THE NETWORK SYSTEMS EQUATION WAS SOLVED FOR BOTH THE AP600 AND CMT TEST

- THE EFFECT OF THE S/W RESERVOIR WAS ACCOUNTED FOR IN THE ELEVATION HEADS IN THE CMT TEST SOLUTION

- COMPARISON OF THE RESULTS CONFIRM THAT THE CMT TEST CAN REPRESENT THE AP600 RECIRCULATION BEHAVIOR

- A GEOMETRIC SCALING ARGUMENT ALSO CONFIRMS THAT THE TEST AND PLANT SHOULD BEHAVE SIMILAR

a,c

[ ]

Figure 2-6 Recirculation Ratio of the CMT Test to the AP600 CMT at 1100 psia

a,c

Figure 2-7 Comparison of the Hot Layer Thickness of the CMT Test and the Plant CMT at 1100 psia

- WALL-TO-FLUID HEAT TRANSFER WAS EXAMINED DURING RECIRCULATION

- THE CONVECTION MODE WAS INVESTIGATED

$$\frac{Gr}{Re^2} >><< 1 \qquad\qquad Gr = \frac{\beta g \, (T_b - T_w) \, Z^3}{\nu^2}$$

  - THE π RATIO FOR NATURAL CONVECTION BECOMES:

$$\Pi_{HT} = \frac{Nu_m}{Nu_p} = \frac{[0.021 \ (Gr_L \cdot Pr)^{0.4}]_m}{[0.021 \ (Gr_L \cdot Pr)^{.4}]_p}$$

  - SINCE THE FLUID PROPERTIES ARE THE SAME

$$\frac{h_m}{h_p} = \left[\frac{(T_b - T_w)_m}{(T_b - T_w)_p}\right]^{.4} \left(\frac{Z_m}{Z_p}\right)^{.2}$$

  - SINCE THE DEVELOPMENT OF THE HOT THERMAL LAYER IS NEARLY THE SAME, THEN

$$\frac{h_p}{h_m} = 1.0$$

- CONCLUSION OF CMT TEST RECIRCULATION BEHAVIOR
  - KEY DIMENSIONLESS PARAMETERS WERE PRESERVED
  - MASS FLUXES FOR TEST AND PLANT ARE NEARLY EQUAL
  - DEVELOPMENT OF THERMAL LAYER IS NEARLY THE SAME
  - WALL HEAT TRANSFER BETWEEN HEATED LAYER AND CMT WALL IS PRESERVED

- CMT DRAIN DOWN BEHAVIOR --- SCALING ASSESSMENT

  - AN APPROACH SIMILAR TO THE OSU SCALING REPORT WAS USED

  - THE ONE-DIMENSIONAL GOVERNING EQUATIONS WERE NORMALIZED TO DEVELOP THE KEY DIMENSIONLESS PARAMETERS AND TIME CONSTANTS

- A DETAILED SCALING ANALYSIS WAS PERFORMED FOR THE CMT DRAINING PROCESS
  - SYSTEM OF EQUATIONS WAS SOLVED WITH THE FOLLOWING ASSUMPTIONS;
    - QUASI-STEADY STATE WITH FIXED WATER LEVEL WHICH WAS PARAMETRICALLY VARIED
    - MIXING DEPTH WAS PARAMETRICALLY VARIED TO ACCOUNT FOR DIFFERENT INTERFACIAL HEAT TRANSFER
    - 1-D TRANSIENT CONDUCTION CALCULATION WAS SEPARATELY USED FOR THE DOME AND SIDE WALLS
    - WALL CONDENSATION COEFFICIENTS WERE ASSUMED TO BE AVERAGE VALUES WHICH DEPENDED ON THE FILM REYNOLDS NUMBER

Table 3-4
Balance Equations for Top-Down Scaling Analysis of the CMTs

a,c

Solid Structure Energy:

$$\frac{\partial}{\partial t}(\rho_s V_s C_{vs} T_s) = \frac{1}{r}\frac{\partial}{\partial r}\left(r k_s \frac{\partial T_s}{\partial r}\right) \qquad (3\text{-}32)$$

Where the boundary conditions are:

$$k_s \frac{\partial T}{\partial r}\Big)_{r=R_i} = H_{Lr}\,(T_d - T_{ws}) \qquad (3\text{-}33)$$

and

$$k_s \frac{\partial T}{\partial r}\Big)_{r=R_o} = 0 \qquad (3\text{-}34)$$

a,c

- WALL CONDENSATION MODEL USED WAS THE COMBINATION OF THE NUSSELT LAMINAR FILM CONDENSATION AND MODIFIED COLBURN EQUATION

$$\bar{H}_{LP} = 0.94 \left[\frac{\rho_\ell g h_{fg} k_\ell^3}{\mu_\ell L \left(T_d - T_{ws} \right)} \right]^{1/4}$$

NUSSELT

AND

$$H_{LF} = 0.056 \left(\frac{4\Gamma_c}{\mu_\ell} \right)^2 \left(\frac{k_\ell^3 \rho_\ell^2 g}{\mu_\ell^2} \right)^{\frac{1}{3}} Pr_\ell^{\frac{1}{2}}$$

COLBURN

THE FILM REYNOLDS NUMBER GIVEN AS:

$$Re_f = \frac{4\Gamma}{\mu_f}$$

WAS USED TO DETERMINE WHICH CORRELATION WOULD BE USED

- INTERFACIAL CONDENSATION WAS CALCULATED USING GRIGULL CORRELATION FROM BIRD, STEWART, AND LIGHTFOOT

$$H_{i,s} = 0.003 \left[\frac{k_f^3 \; \rho_f^2 \; 8 \; (T_d - T_{ws})L}{\mu_f^3 \; h_{fg}} \right]^{1/2}$$

- THE KEY PARAMETER IN THE CALCULATION IS THE DEPTH OF THE MIXING LAYER IN THE CMT, SINCE THIS EFFECTS THE LIQUID TEMPERATURE AND THE RESULTING INTERFACIAL CONDENSATION

- THE WALL CONDUCTION EFFECTS WERE ALSO COMPARED BETWEEN THE AP600 AND THE CMT TEST
  - A CONDUCTION π RATIO CAN BE DEFINED AS: $\Pi_{cond} = \dfrac{B_i F_o)_m}{B_i F_o)_p}$

OR

$$\Pi_{cond} = \frac{\left.\frac{H_{HL}(R_o - R_i)}{k_s}\,\frac{\alpha t}{(R_o - R_i)^2}\right)_m}{\left.\frac{H_{HL}(R_o - R_i)}{k_s}\,\frac{\alpha t}{(R_o - R_i)^2}\right)_p}$$

- IF WE ASSUME THAT $\pi_{cond} = 1$, THEN

$$\frac{\left.\frac{t}{R_o - R_i}\right)_m}{\left.\frac{t}{R_o - R_i}\right)_p} = 1$$

- THIS INDICATED THAT THE TEST CMT TIME SCALE IS ~ 1/3 THAT OF THE PLANT

- COMPARISONS

  - WALL CONDUCTION CALCULATIONS INDICATE THAT THE TEST CMT WILL HEAT UP FASTER (~ 3 TIMES) AS THE PLANT

  - THE CONDENSATION CALCULATIONS WERE NORMALIZED ON THE RELATIVE WALL OR LIQUID SURFACE AREA (FLUXES) AND COMPARED FOR DIFFERENT LEVELS AT A FIXED MIXING DEPTH, AND DIFFERENT MIXING DEPTHS AT A GIVEN LEVEL

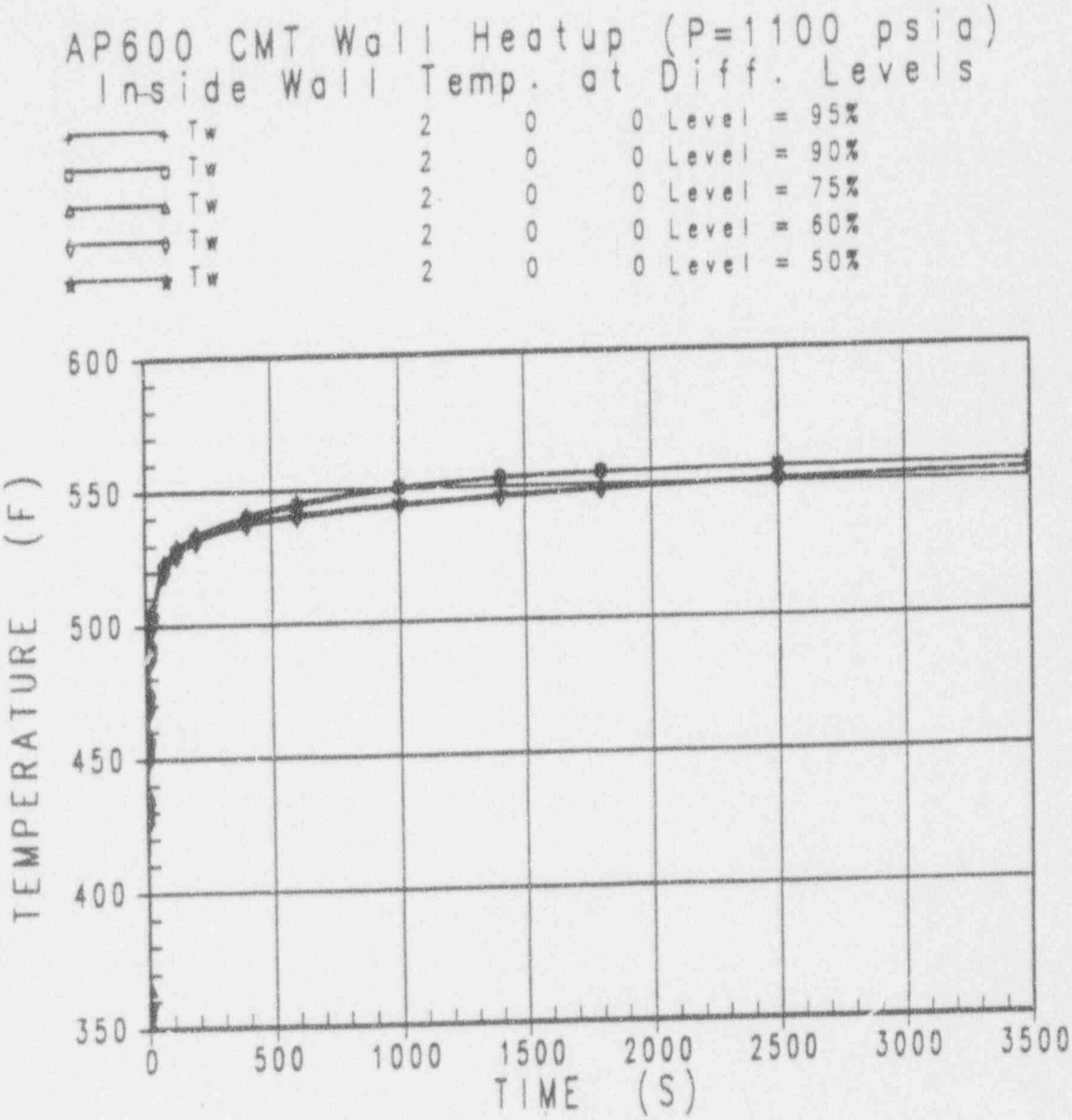


Figure 3-4 AP600 Plant CMT Inside Wall Temperatures for Different Levels

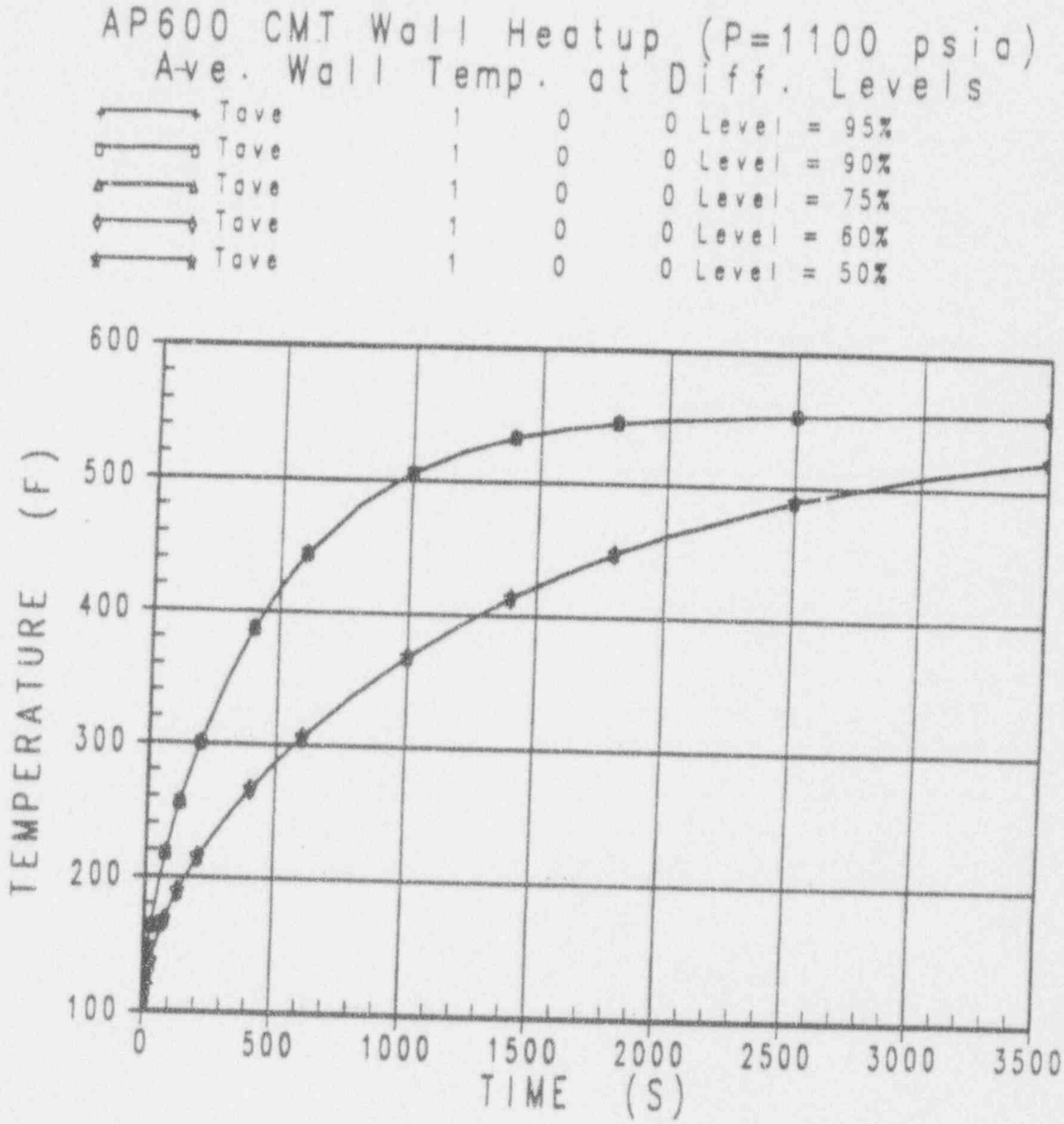


Figure 3-5 AP600 Plant CMT Average Wall Temperatures for Different Levels

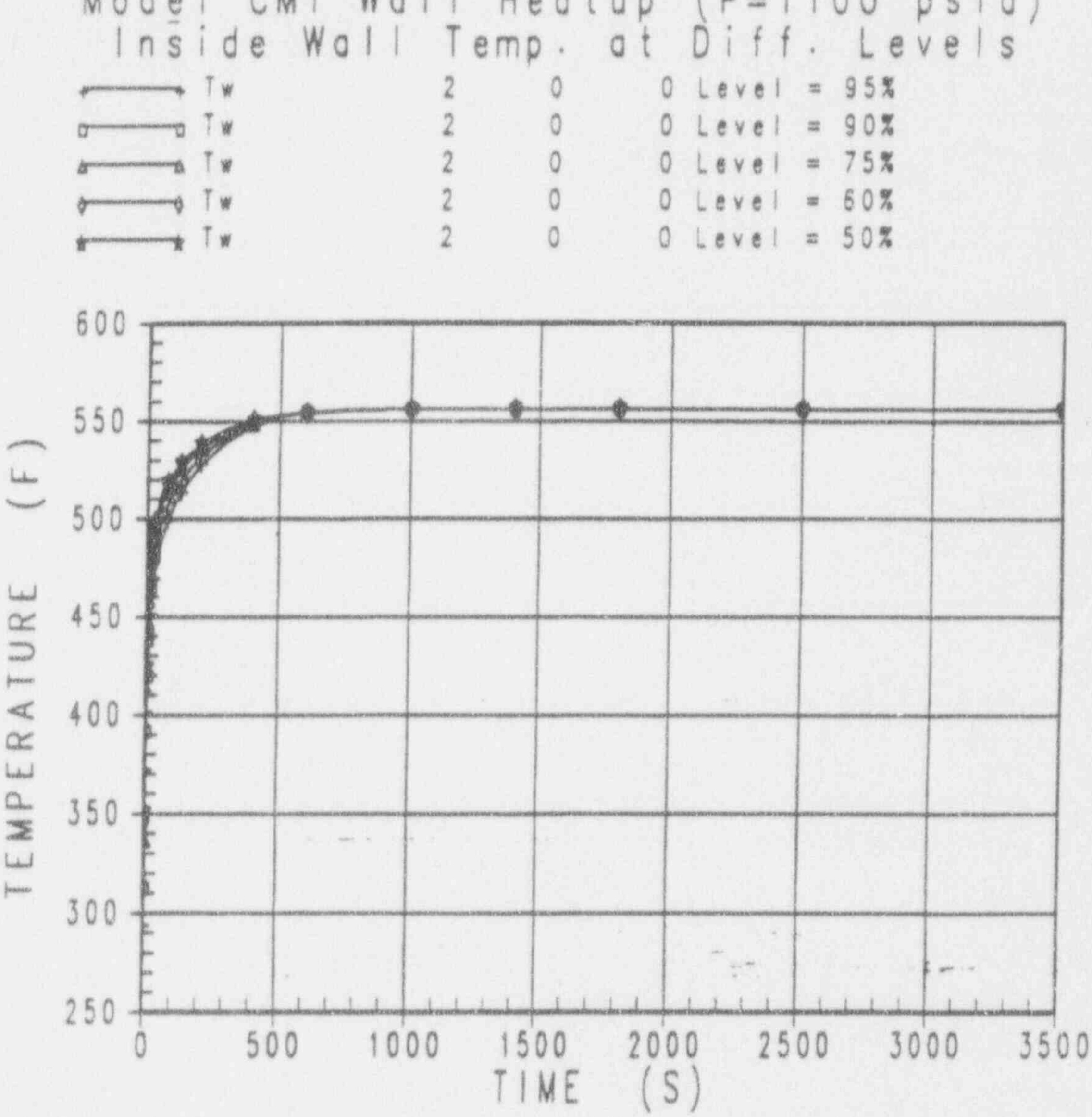


Figure 3-6 CMT Test Model Inside Wall Temperatures for Different Levels

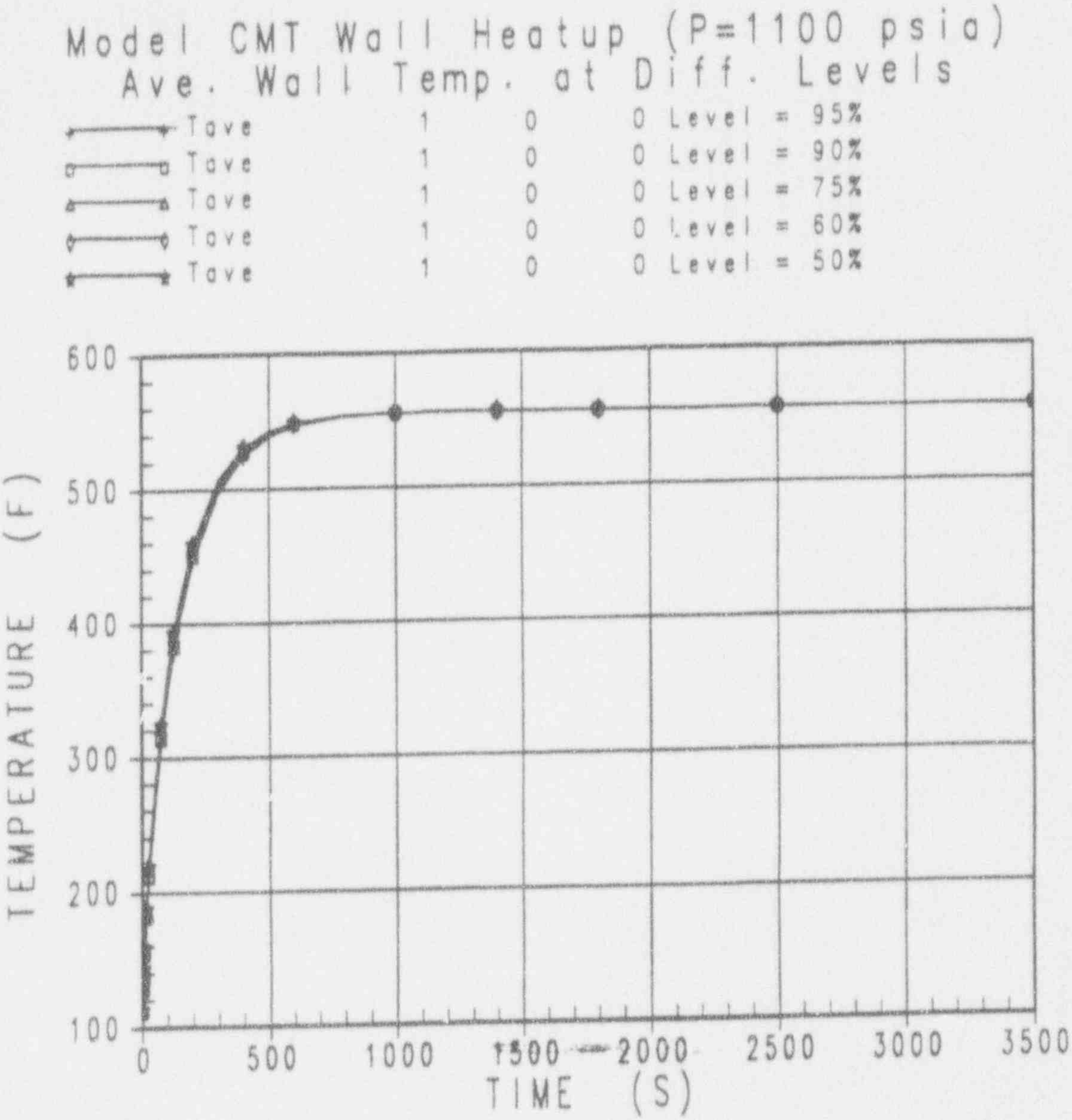


Figure 3-7 CMT Model Average Wall Temperatures for Different Levels

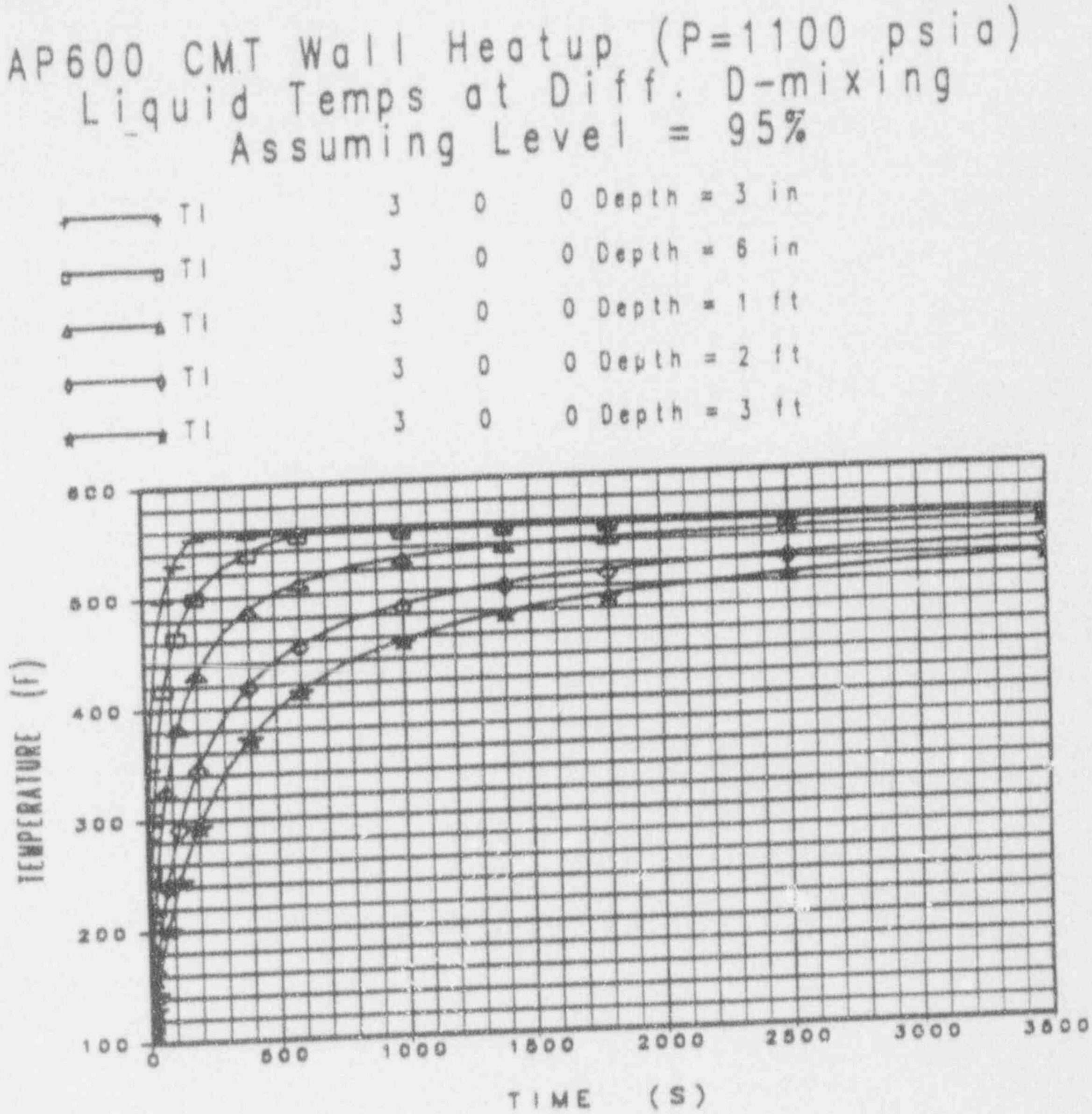


Figure 3-24 AP600 Plant CMT Liquid Temperatures for Different Mixing Depth at 95% Water Level

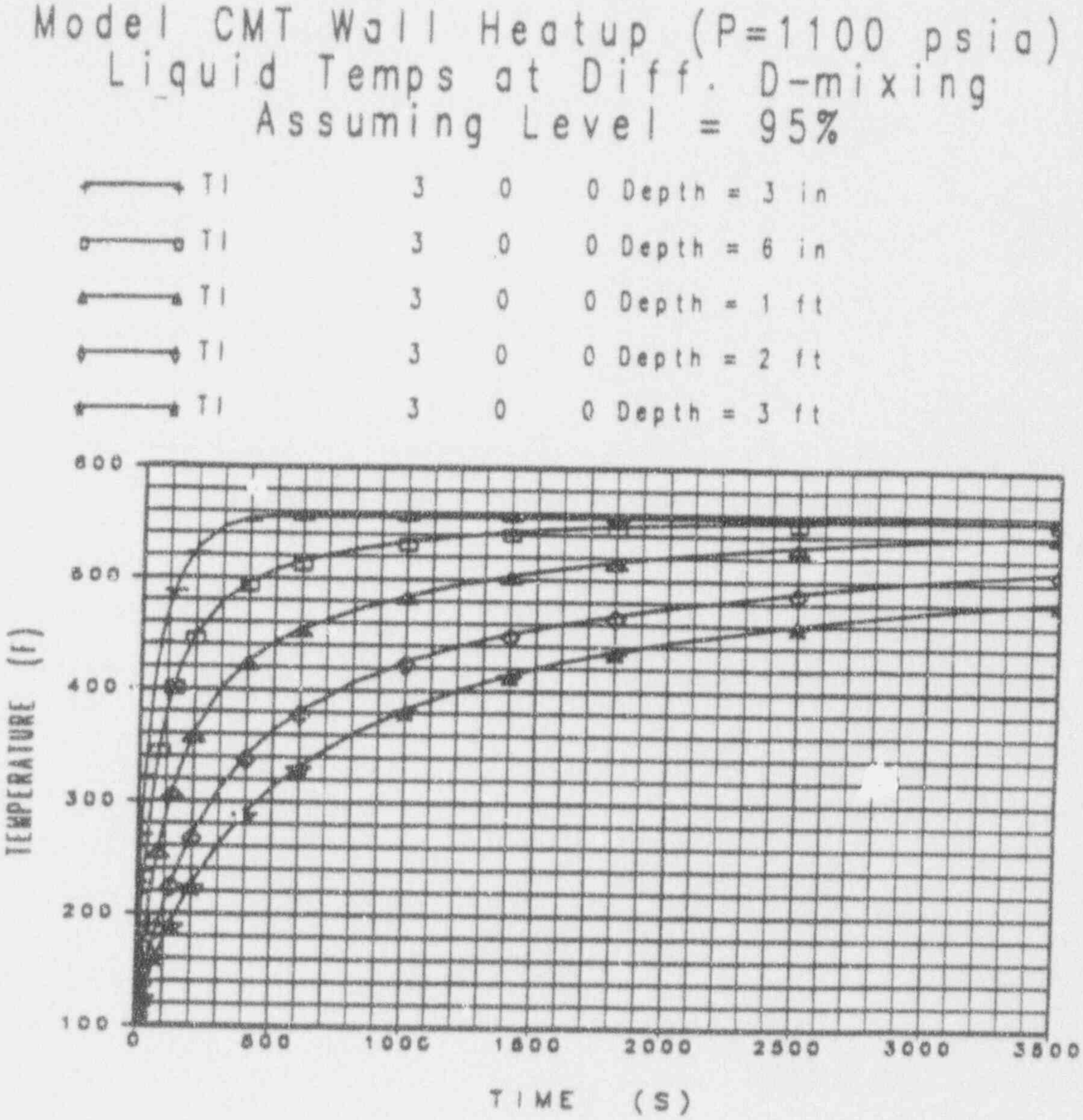


Figure 3-27 CMT Model Calculated Liquid Temperatures for Different Mixing Depths for 95% CMT Water Level

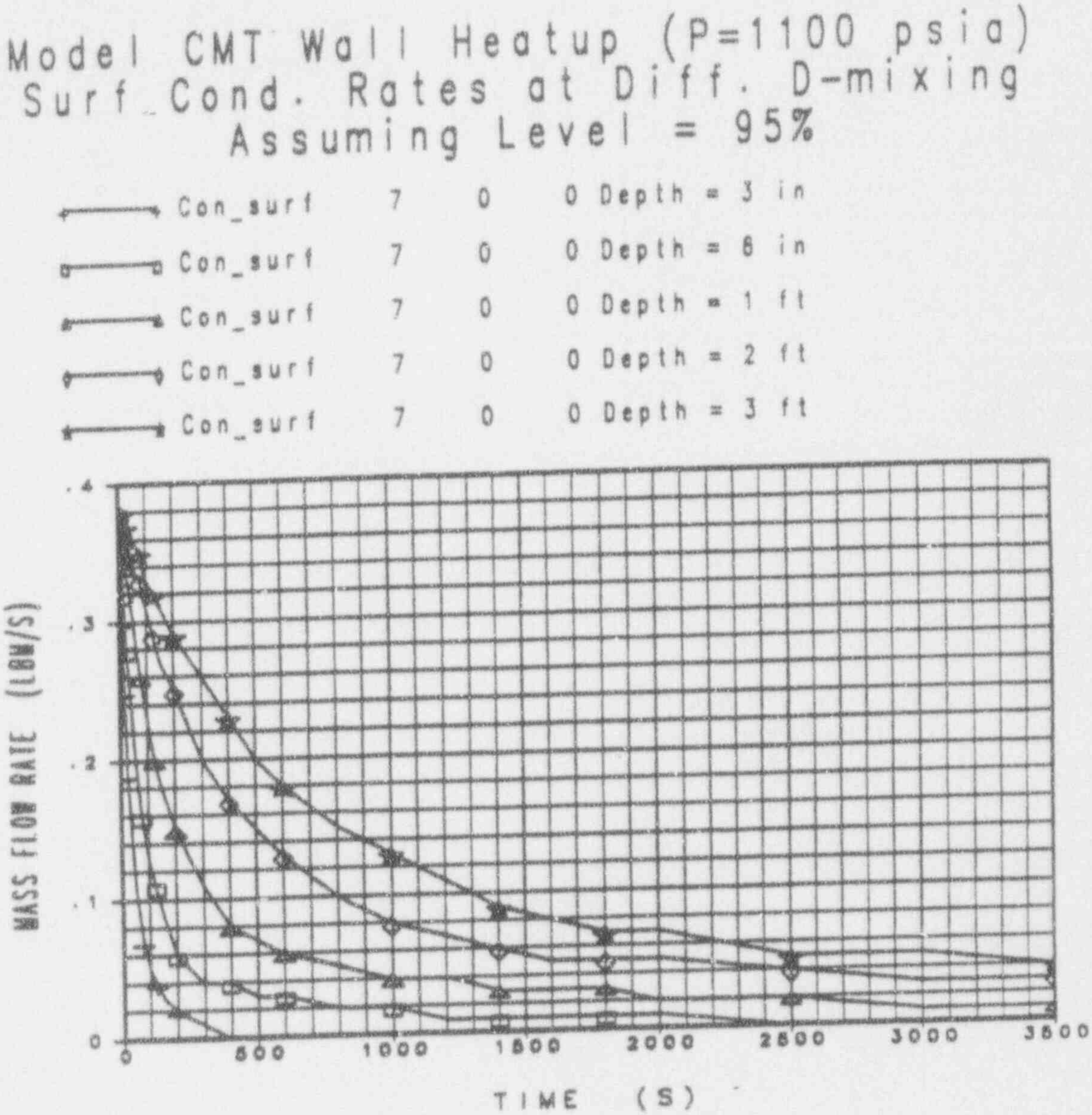


Figure 3-28 Calculated CMT Model Surface Condensation Rates for Different Mixing Depths with a CMT Level of 95%

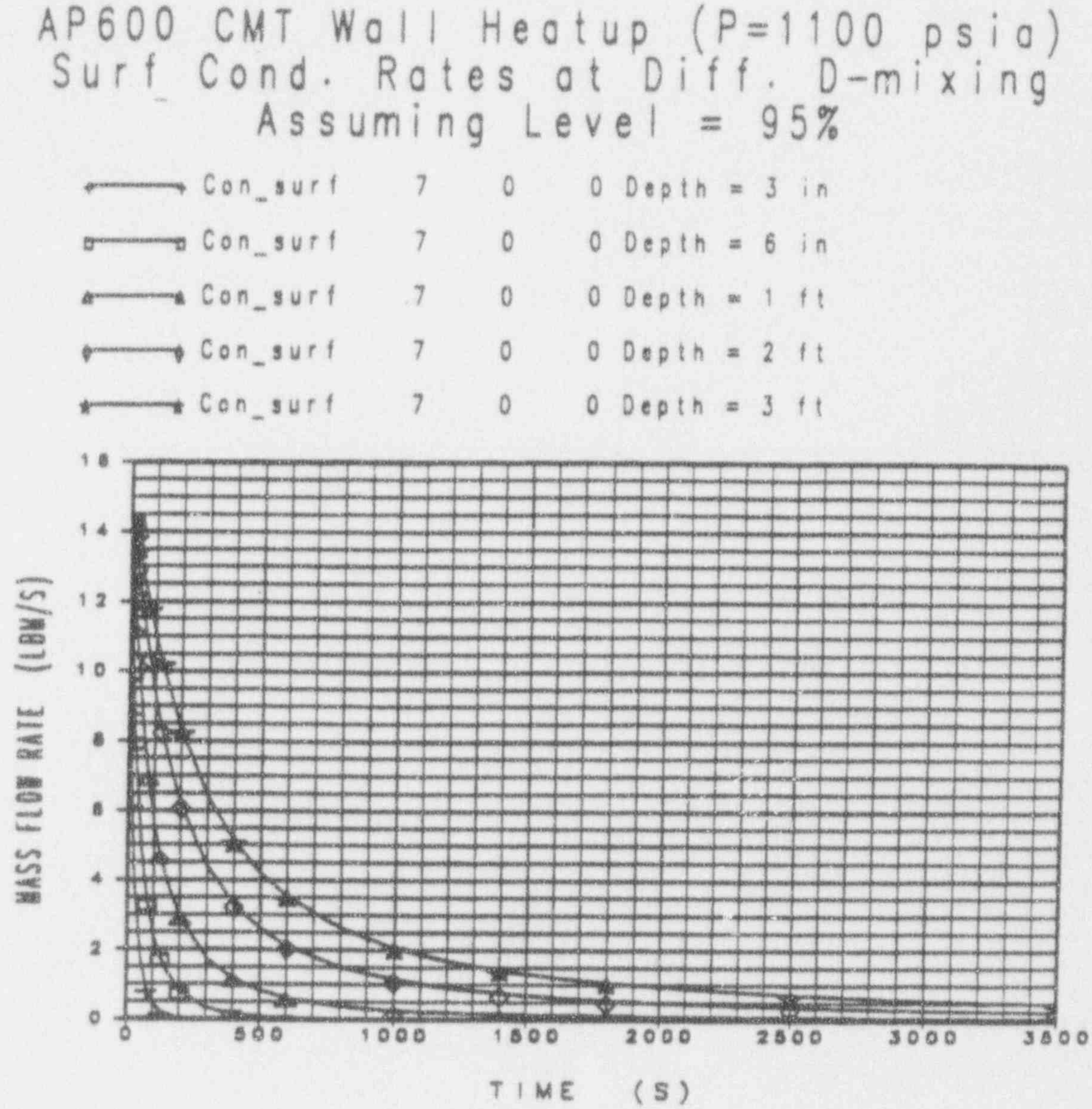


Figure 3-25 Calculated AP600 CMT Plant Water Surface Condensate Flow Rates for Different Mixing Depths at a Water Level of 95%

a,c

Figure 3-21 Ratio of the CMT Model to AP600 CMT Plant Wall Condensate Mass Flux for Different Water Levels and a Mixing Depth of 3 Feet a

Figure 3-22 Ratio of the CMT Model to AP600 CMT Plant Surface Condensate Mass Flux Rates for Different Water Levels and a Mixing Depth of 3 Feet

a,c

Figure 3-23 Ratio of the CMT Model to AP600 CMT Plant Total Condensate Mass Flux Rates for Different Water Levels and a Mixing Depth of 3 Feet

Figure 3-30 Ratio of the Calculated CMT Model to Plant Condensate Flow Rates for Different Assumed Mixing Depths at a CMT Water Level of 95%

Figure 3-31 Ratio of the Total Calculated CMT Model to Plant Condensate Flow Rates for Different Assumed Mixing Depths With a CMT Water Level of 95%

- THE π VALUES GIVEN IN TABLE 3-7 WERE ALSO CALCULATED FOR BOTH THE PLANT AND THE TEST CMT. THE RATIOS WERE COMPARED.

a.

Figure 3-34 Calculated Π Group Ratios for Wall Condensation for a 3-foot Mixing Depth and Different CMT Levels a

Figure 3-43 Calculated Surface Condensation Π Ratio for CMT Level of 95% and Different Mixing Depths

- CALCULATIONS INDICATE THAT THE CMT TEST WILL CAPTURE THE SAME EFFECTS AS THE PLANT CMT FOR SOME TIME PERIOD, AFTER WHICH, WALL CONDENSATION IS LESS DUE TO THE THINNER TEST WALLS.

- SURFACE CONDENSATION RATIO'S VARY BETWEEN 0.25 TO 1.25, INDICATING THAT THE TEST WILL CAPTURE THE EFFECTS, PARTICULARLY FOR THE MIXING DEPTHS OF INTEREST.

- COMPARISONS INDICATE THAT THE TEST WILL CAPTURE THE KEY PHENOMENA BUT NOT FOR ALL TIME PERIODS

PRESENTATION
TO
UNITED STATES
NUCLEAR REGULATORY COMMISSION

AP600 Core Makeup Tank Test

F. DELOSE

MARCH 14, 1994

TEST OVERVIEW

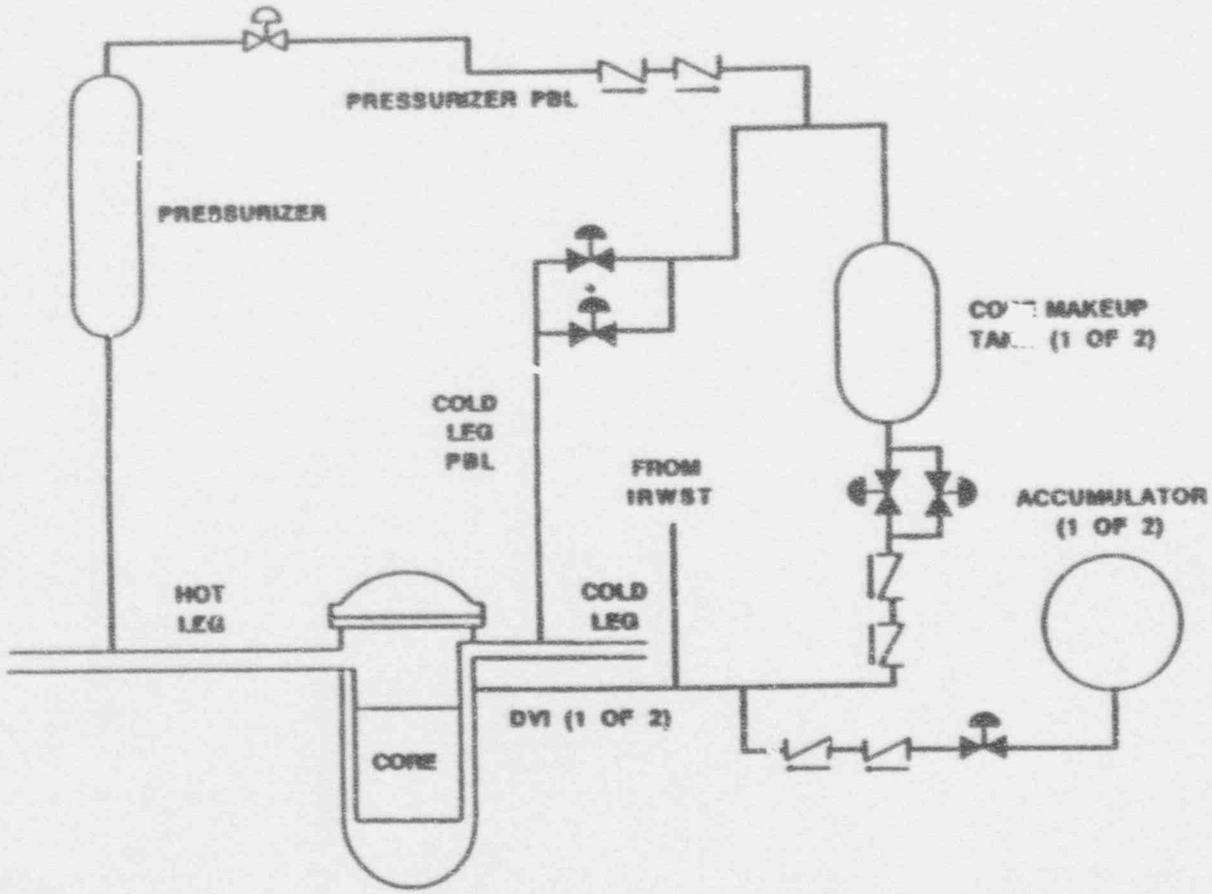
TEST DESIGN / INSTRUMENTATION

TEST MATRIX

TEST RESULTS TO DATE

CURRENT TESTING STATUS

AP600 PASSIVE CORE COOLING SYSTEM

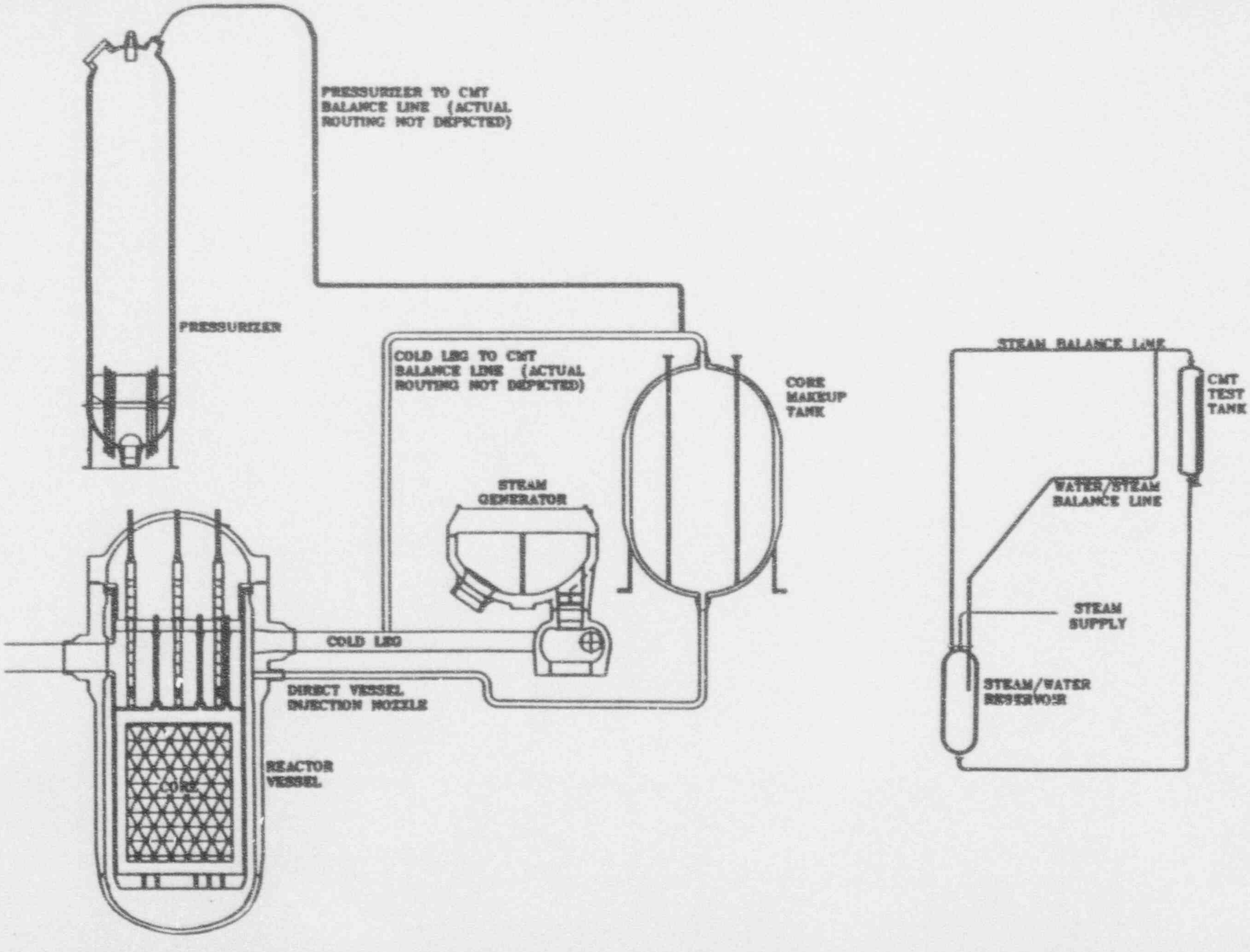


TEST PIPING LAYOUT

a,c

a,c

AP600 RCS AND CMT TEST LAYOUT COMPARISON



CMT TEST FACILITY MAJOR COMPONENTS

- CORE MAKEUP TANK (CMT)
- STEAM/WATER RESERVOIR (S/WR)
- STEAM ACCUMULATOR
- STEAM GENERATOR
- PIPING/VALVES
  - STEAM LINE #1
  - STEAM LINE #2
  - CMT DISCHARGE LINE

CMT TEST CORE MAKEUP TANK

AP600

2500 PSIG/700 °F DESIGN PRESSURE/TEMPERATURE

CARBON STEEL / UNINSULATED

2:1 SEMI-ELLIPTICAL HEADS (2.5 IN. MIN. WALL)

~20 $FT.^3$ INTERNAL VOLUME / 10 FT. OVERALL HEIGHT / 24 IN. O. D.

2.344 IN. THICK CYLINDRICAL SHELL (24 IN. SCH 160 PIPE)

INLET NOZZLE DIAMETER:
- 1.338 IN. I.D. (1 ½ IN. SCH 160 PIPE)
- 0.877 IN. I.D. WITH STEAM DISTRIBUTOR INSTALLED

DISCHARGE NOZZLE DIAMETER:
- 1.338 IN. I.D. (1 ½ IN. SCH 160 PIPE)

LOWER INSTRUMENT NOZZLE:
- 2.624 IN. I.D. (3 IN. SCH 160 PIPE)

INSTRUMENTATION:
- 21 WALL T/C'S (0.062 DIA. TYPE J GROUNDED JUNCTION)
- 41 FLUID T/C'S (0.125 DIA. TYPE J GROUNDED JUNCTION)
- 6 DIFFERENTIAL PRESSURE LEVEL TRANSMITTERS
- 1 PRESSURE TRANSMITTER
- 1 PROTOTYPE MULTI-POINT LEVEL INSTRUMENT (4 SENSORS)

CMT TEST STEAM/WATER RESERVOIR

2500 PSIG/700 °F DESIGN PRESSURE/TEMPERATURE

CARBON STEEL / INSULATED

2:1 SEMI-ELLIPTICAL HEADS (3.5 IN. MIN. WALL)

~70 FT.^{3} INTERNAL VOLUME / 10 FT. OVERALL HEIGHT / 36 IN. INSIDE DIAMETER

3.25 IN. THICK CYLINDRICAL SHELL

UPPER HEAD NOZZLES:

- 2 IN. SCH 160 (1.687 I.D.) STEAM SUPPLY
- 1 ½ IN. SCH 160 (1.338 IN. I.D.) STEAM LINE #1
- 1 ½ IN. SCH 160 (1.338 IN. I.D.) STEAM LINE #2

LOWER HEAD NOZZLES:

- 1 ½ IN. SCH 160 (1.338 IN. I.D.) RETURN FROM CMT
- 2 IN. SCH 160 (1.687 I.D.) FOR 1 IN. SPARGER

INSTRUMENTATION:

- 2 FLUID T/C'S (0.125 DIA. TYPE J GROUNDED JUNCTION)
- 6 DIFFERENTIAL PRESSURE LEVEL TRANSMITTERS
- 1 PRESSURE TRANSMITTER

CMT TEST STEAM ACCUMULATOR

3000 PSIG/700 °F DESIGN PRESSURE/TEMPERATURE

CARBON STEEL

INSULATED

TWELVE VESSELS (12 IN. SCH 160 PIPE)

25 FT. OVERALL LENGTH

~164 $FT.^3$ INTERNAL VOLUME

INLET NOZZLE:
- 2 IN. SCH 160 PIPE (1.687 I.D.)

OUTLET NOZZLE:
- 2 IN. SCH 160 PIPE (1.687 I.D.)

INSTRUMENTATION:
- 4 FLUID T/C'S (0.125 DIA. TYPE J GROUNDED JUNCTION)
- 1 PRESSURE TRANSMITTER

CMT TEST STEAM GENERATOR

NATURAL GAS FIRED

FORCED CIRCULATION COIL WATERTUBE TYPE

CAPACITY: 2000 LBM/HR. @ 2700 PSIG FROM 200 °F FEEDWATER

99.5 % QUALITY

SKID MOUNTED w/INTEGRAL FEEDWATER TREATMENT

CMT TEST PIPING/VALVES

AP600

STEAM LINE #1

- SIMULATES FEATURES OF PZR TO CMT BALANCE LINE
- TOP OF STEAM/WATER RESERVOIR TO CMT
- STEAM FLOW ONLY
- 1 ½ IN. SCH 160 (1.338 IN. I.D.) CARBON STEEL PIPE
- ~20 FT. HORIZONTAL 2.5° SLOPED PIPE
- INSULATED
- TWO 1 ½ IN. SWING CHECK VALVES IN SERIES
- 2 IN. ISOLATION VALVE w/VARIABLE OPENING TIME AND STROKE

CMT TEST PIPING/VALVES

AP600

STEAM LINE #2

- SIMULATES FEATURES OF COLD LEG TO CMT BALANCE LINE
- PROTRUDES 4 FT. INTO STEAM/WATER RESERVOIR
- ALLOWS STEAM AND/OR WATER FLOW TO CMT
- 1 ½ IN. SCH 160 (1.338 IN. I.D.) CARBON STEEL PIPE
- ISOLATION VALVE IN SECTION OF 2.5° SLOPED PIPE
- HEAT TRACED AND INSULATED
- 2 IN. ISOLATION VALVE w/VARIABLE OPENING TIME AND STROKE
- DRAIN DOWNSTREAM OF ISOLATION VALVE

CMT TEST PIPING/VALVES

CMT WATER DISCHARGE LINE

- 26.5 FT. ELEVATION BOTTOM OF CMT TO BOTTOM OF S/WR
- 1 ½ IN. SCH 160 (1.338 IN. I.D.) CARBON STEEL PIPE
- UNINSULATED
- 1 ½ IN. SWING CHECK VALVE
- 1 ½ IN. MANUAL GLOBE VALVE
- 1 IN. TURBINE FLOWMETER
- 2 IN. ISOLATION VALVE w/VARIABLE OPENING TIME AND STROKE

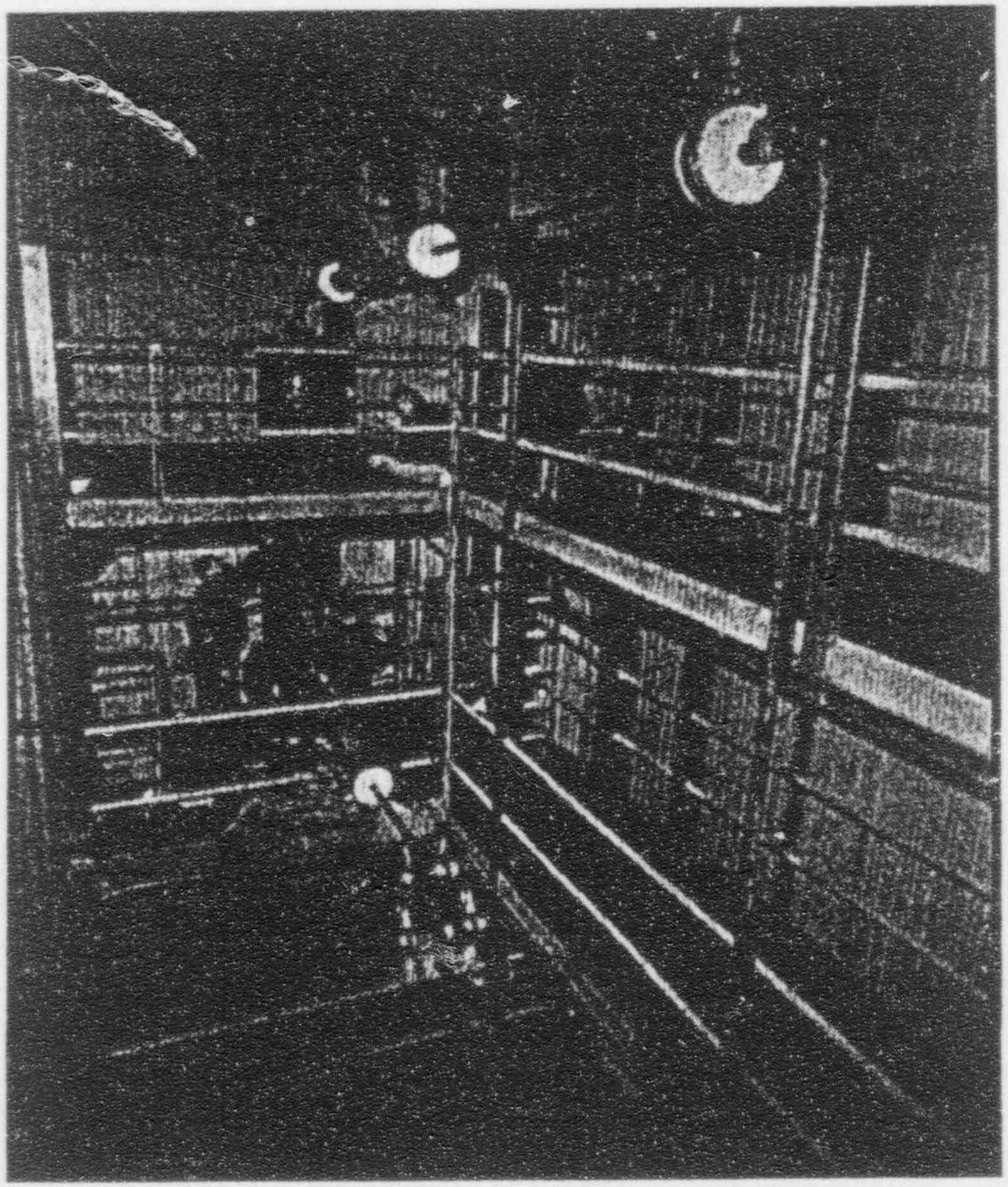
CMT TEST PIPING/VALVES

AP600

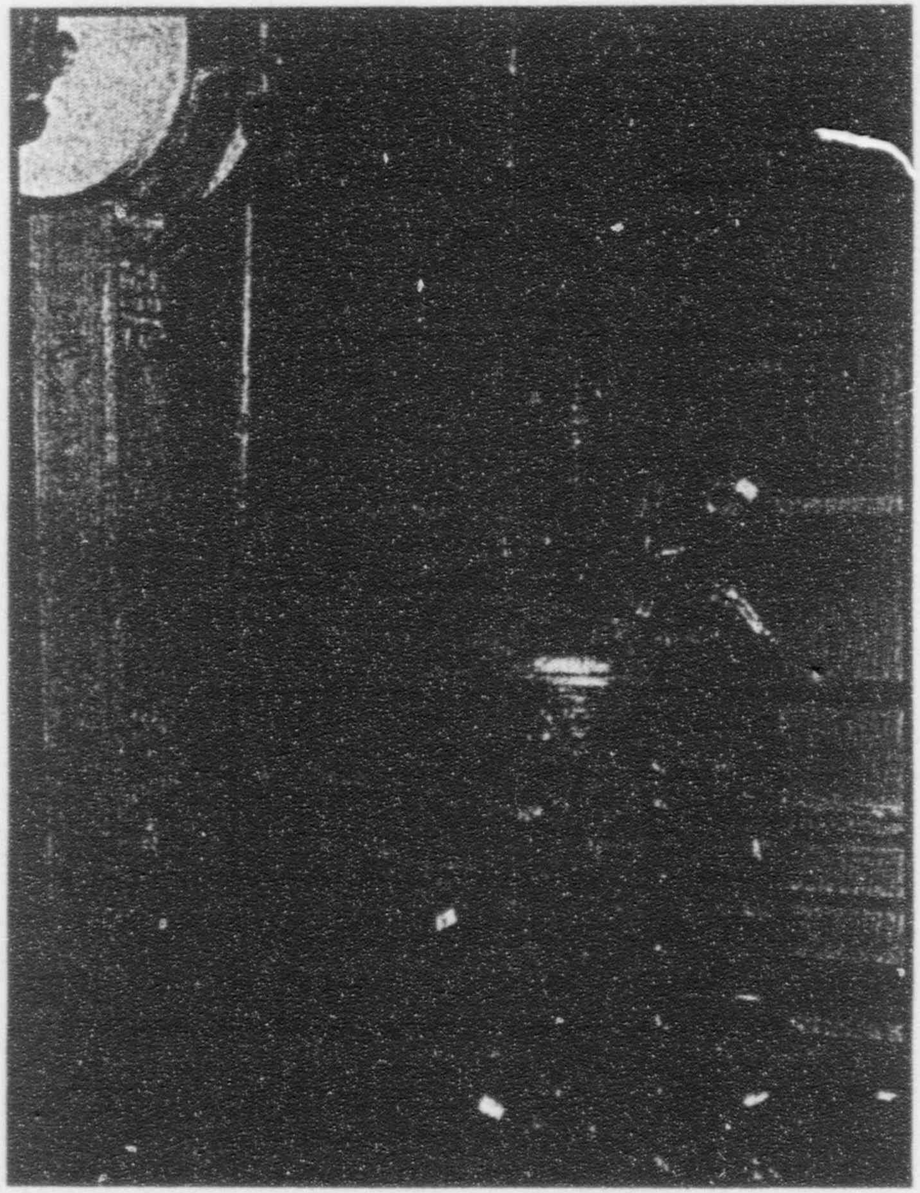
MISCELLANEOUS FEATURES

- CMT CONDENSATE DRAIN w/LEVEL CONTROL VALVE & FLOW MEASUREMENT - USED FOR CMT WALL/WATER CONDENSATION TESTS
- STEAM/WATER RESERVOIR DRAIN w/LEVEL CONTROL VALVE - USED FOR WATER TO STEAM TRANSITION TESTS
- STEAM ACCUMULATOR TO STEAM/WATER RESERVOIR PRESSURE CONTROL
- STEAM SPARGER PROVIDED TO HEAT RESERVOIR/WATER
- VENTS PROVIDED FOR SIMULATION OF ADS DEPRESSURIZATION
- VACUUM SYSTEM FOR REMOVAL OF NONCONDENSIBLES

AP600
CMT Test Facility
Core Makeup Tank Isolation Valve and Check Valves

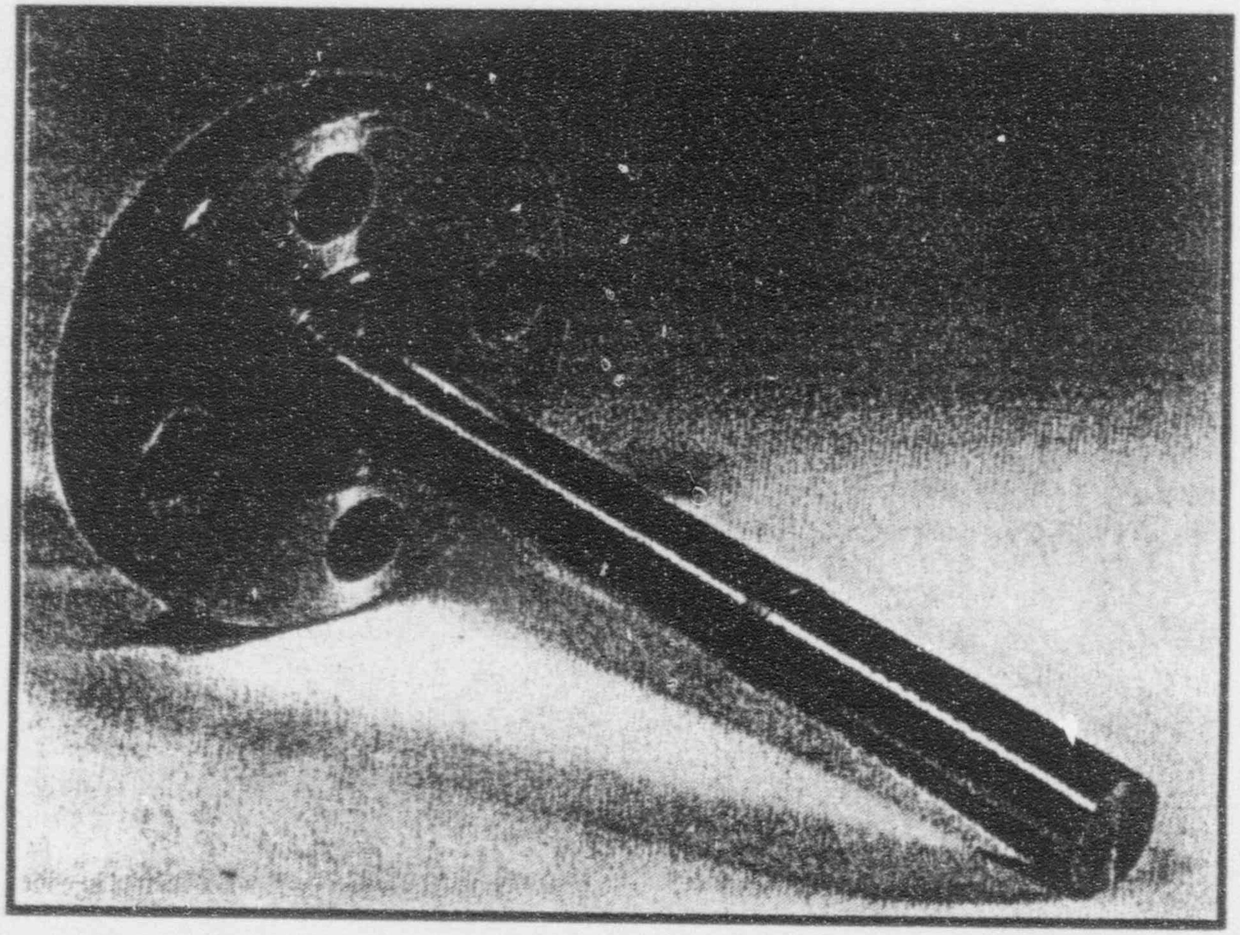


AP600
CMT Test Facility
Core Makeup Tank
Inlet Configuration

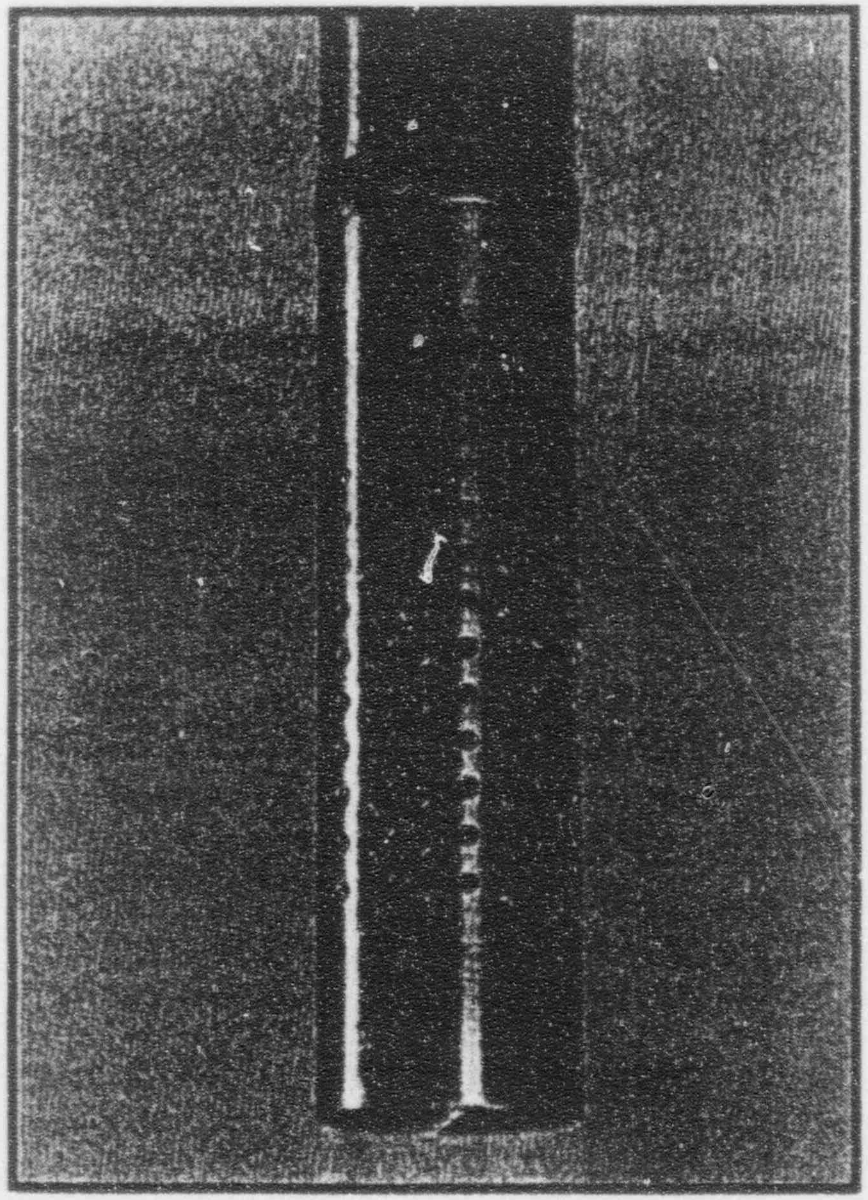


AP600-C-D.5

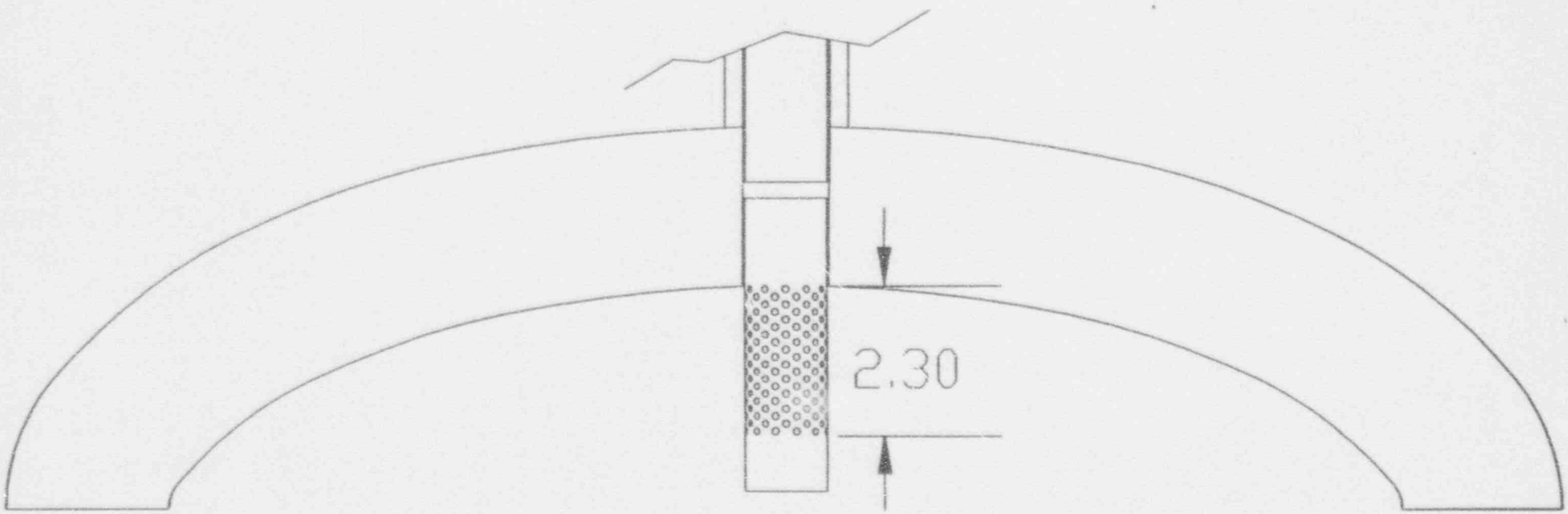
AP600 CMT Test
Steam Inlet Distributor Nozzle with Flange



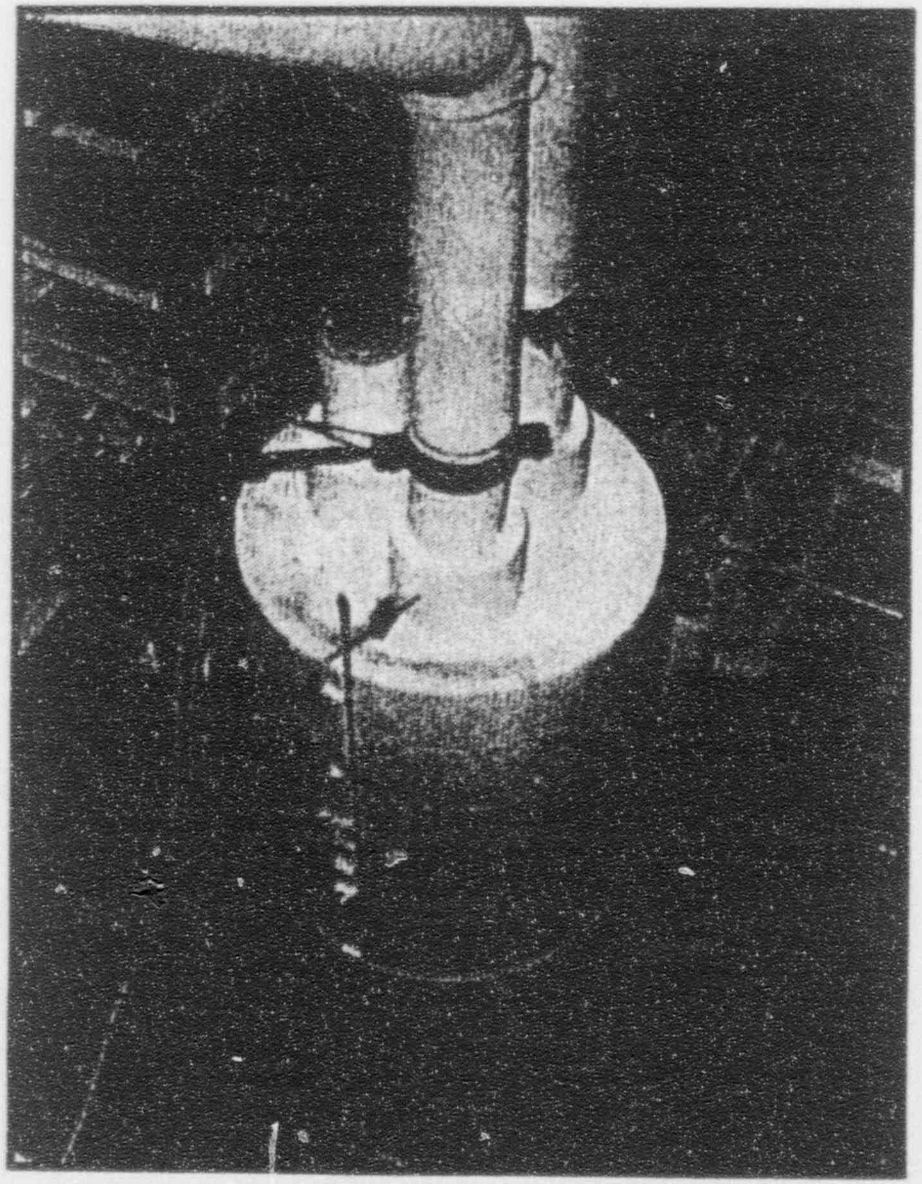
AP600
CMT Test Facility
Steam Inlet
Distributor Nozzle
CloseUp



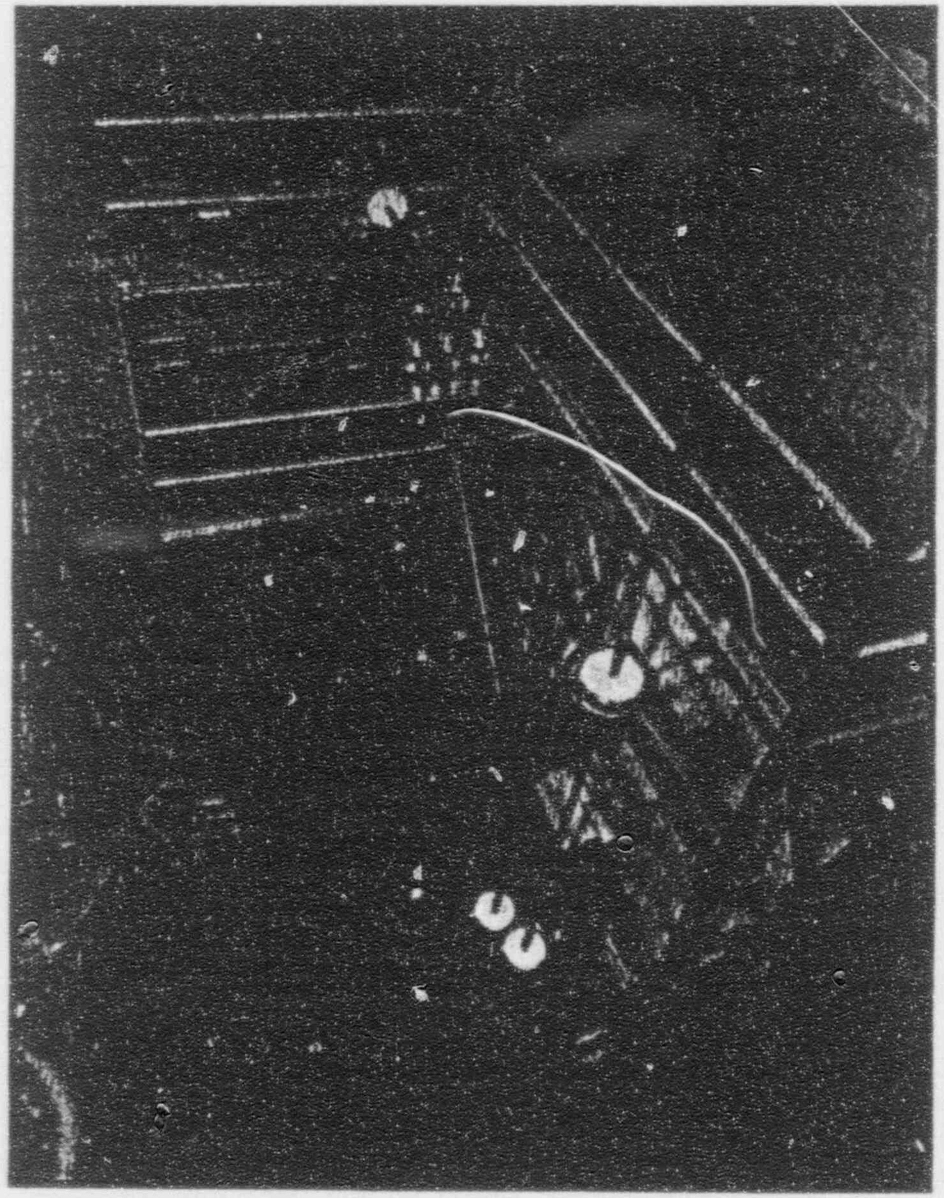
CMT TEST MODEL 2 STEAM DISTRIBUTOR



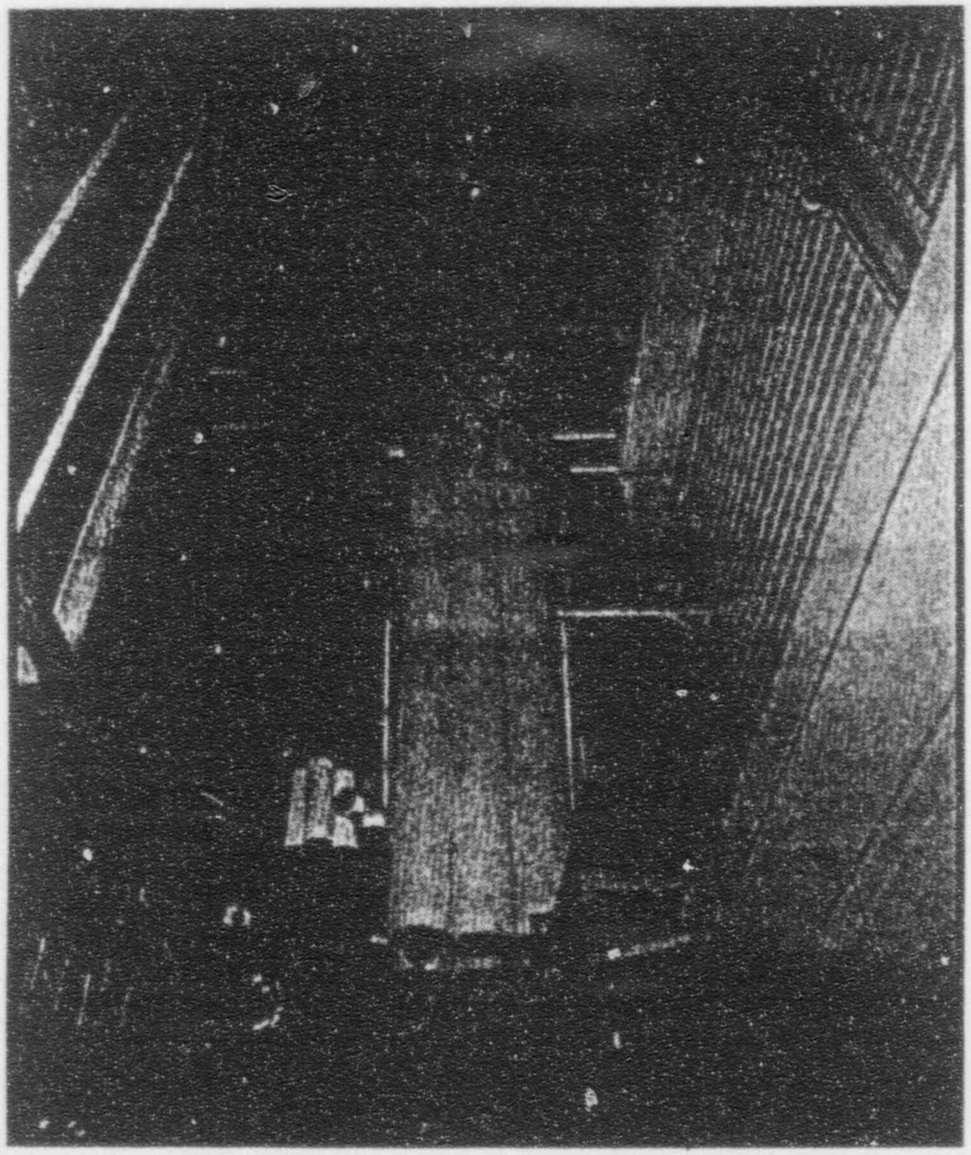
AP600
CMT Test Facility
Steam Water
Reservoir



AP600
CMT Test Facility
Simulated
Balance Lines



AP600
CMT Test Facility
Steam
Accumulators



CMT TEST INSTRUMENTATION

AP600

THE FOLLOWING PARAMETERS ARE MEASURED TO PERMIT CALCULATION OF TRANSIENT MASS ENERGY BALANCES:

TEMPERATURE:

- o 21 CMT WALL T/C'S
- o 41 CMT FLUID T/C'S
- o MISCELLANEOUS PROCESS T/C'S

PRESSURE:

- o CMT AND S/WR VESSEL PRESSURES
- o CMT INLET PRESSURE
- o STEAM LINE #1AND #2 INLET PRESSURES
- o STEAM SUPPLY PRESSURE

STEAM FLOW:

- o REDUNDANT STEAM LINE #1 PRESSURE DROP
- o REDUNDANT STEAM LINE #2 PRESSURE DROP
- o STEAM LINE #1 & #2 VORTEX FLOWMETERS (TEST PRESSURES ≤ 1500 PSIG)

LEVEL:

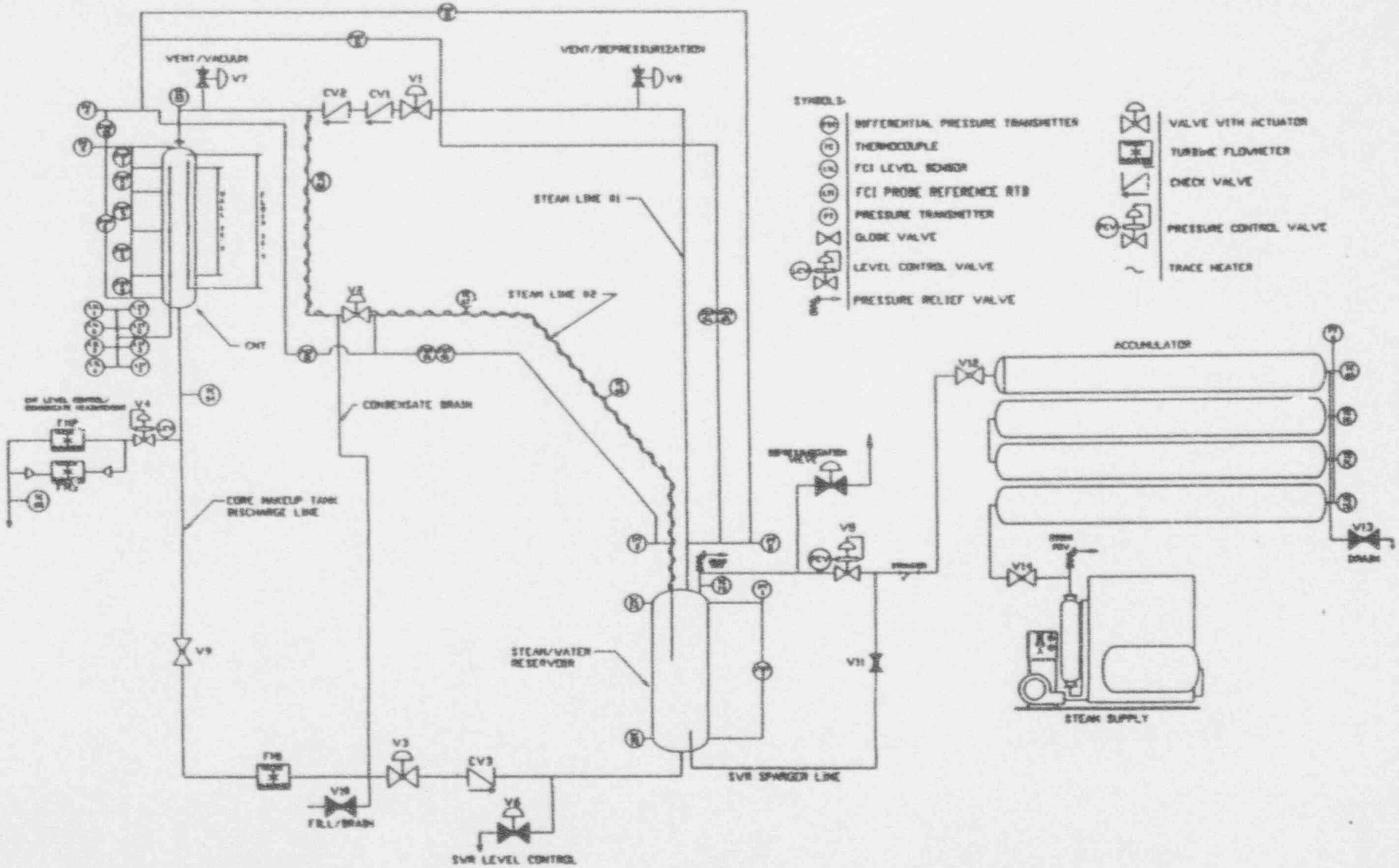
- o 6 CASCADED CMT DP TRANSMITTERS
- o PROTOTYPE CMT MULTI-POINT LEVEL INSTRUMENT
- o 1 S/WR DP TRANSMITTER

WATER FLOW:

- o CMT DISCHARGE TURBINE FLOWMETER
- o CMT CONDENSATE DRAIN TURBINE FLOWMETERS

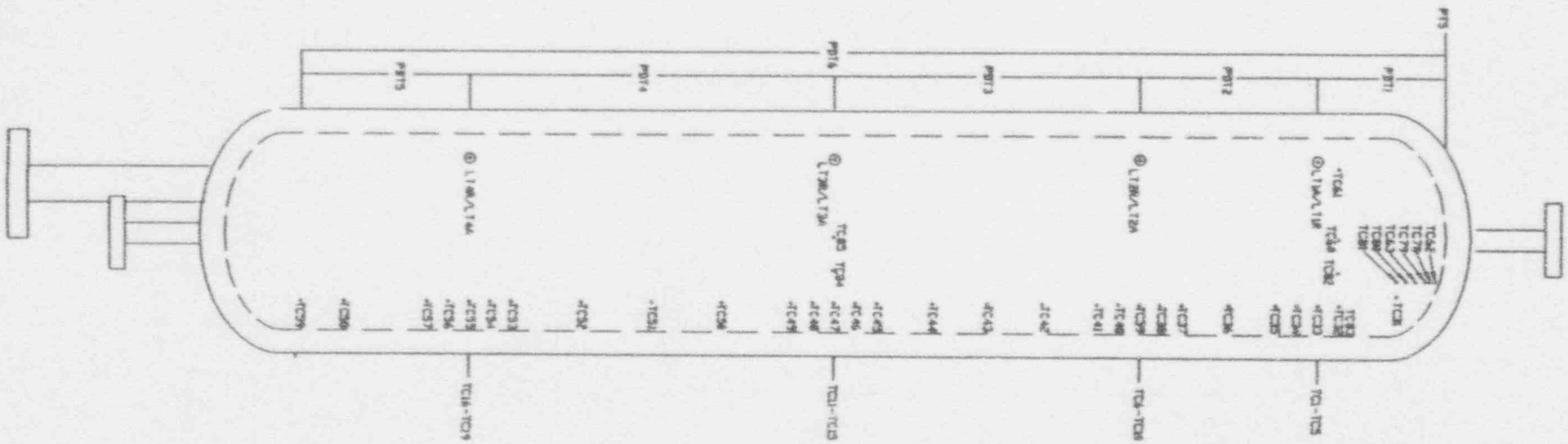
CMT TEST FACILITY P&ID

AP600



CMT INSTRUMENT LOCATIONS

AP600



CMT THERMOCOUPLE LOCATIONS

a,c

a,c

CMT WALL THERMOCOUPLES

AP600

INST I.D.	WIRE NO.	INSTRUMENT SERIAL NO.	INSTRUMENT LOCATION/DESCRIPTION		INST F.S. RANGE	ENG UNITS	BLK. NO.
TC1	1	49697	T1OW	LEVEL 1 WALL TC	700	F	1
TC2	2	49894	T1IW+1.5	LEVEL 1 WALL TC	700	F	2
TC3	3	49895	T1IW+0.5	LEVEL 1 WALL TC	700	F	3
TC4	4	49896	T1IW+0.125	LEVEL 1 WALL TC	700	F	4
TC5	5	49688	T1IW	LEVEL 1 WALL TC	700	F	5
TC6	6	49695	T2OW	LEVEL 2 WALL TC	700	F	6
TC7	7	49897	T2IW+1.5	LEVEL 2 WALL TC	700	F	7
TC8	8	49898	T2IW+0.5	LEVEL 2 WALL TC	700	F	8
TC9	9	49899	T2IW+0.125	LEVEL 2 WALL TC	700	F	9
TC10	10	49693	T2IW	LEVEL 2 WALL TC	700	F	10
TC11	11	49700	T3OW	LEVEL 3 WALL TC	700	F	11
TC12	12	49900	T3IW+1.5	LEVEL 3 WALL TC	700	F	12
TC13	13	49901	T3IW+0.5	LEVEL 3 WALL TC	700	F	13
TC14	14	49902	T3IW+0.125	LEVEL 3 WALL TC	700	F	14
TC15	15	49677	T3IW	LEVEL 3 WALL TC	700	F	15
TC16	16	49701	T4OW	LEVEL 4 WALL TC	700	F	16
TC17	17	49903	T4IW+1.5	LEVEL 4 WALL TC	700	F	17
TC18	18	49904	T4IW+0.5	LEVEL 4 WALL TC	700	F	18
TC19	19	49905	T4IW+0.125	LEVEL 4 WALL TC	700	F	19
TC29	29	49705	TDOW	DOME WALL TC	700	F	21
TC30	30	49704	TDIW	DOME WALL TC	700	F	22

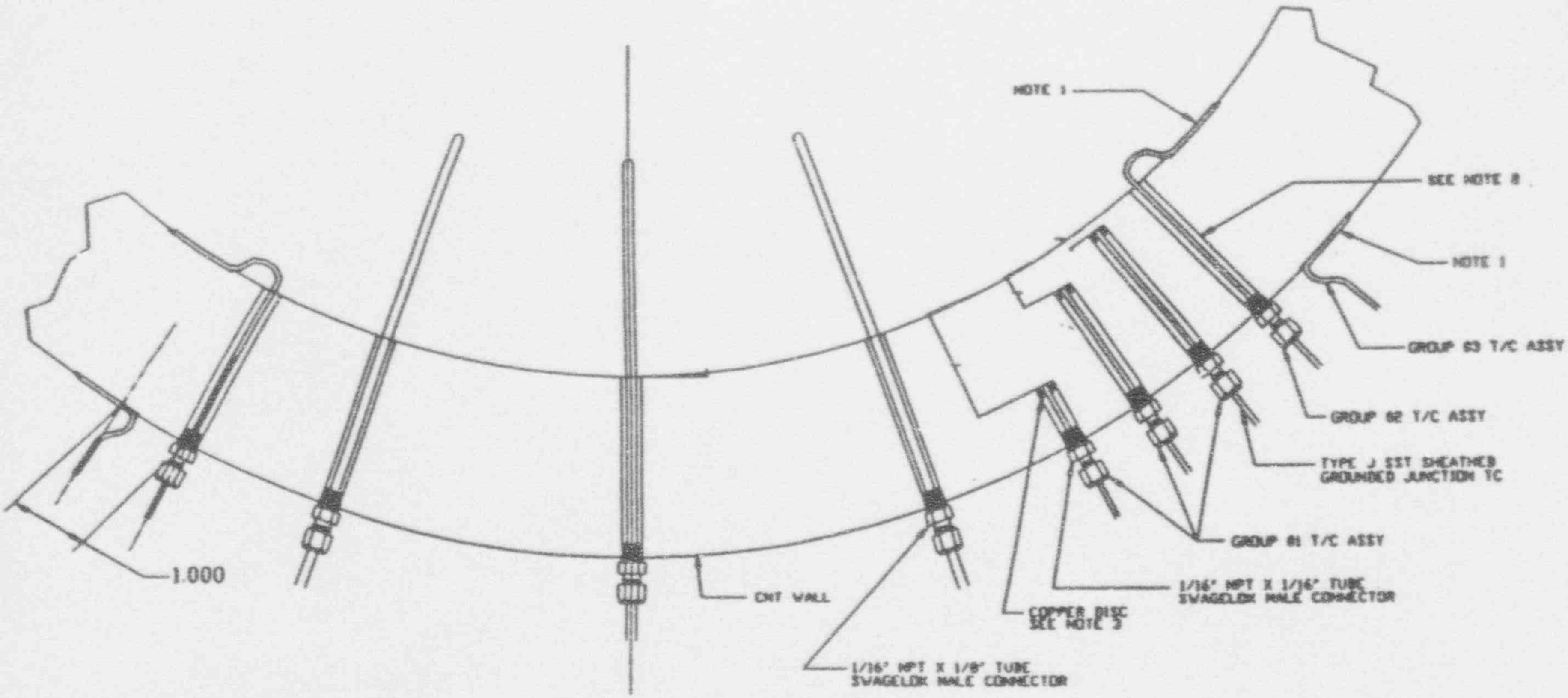
CMT WALL THERMOCOUPLES

AP600

INST I.D.	WIRE NO.	INSTRUMENT SERIAL NO.	INSTRUMENT LOCATION/DESCRIPTION		INST F.S. RANGE	ENG UNITS	BLK. NO.
TC1	1	49697	T1OW	LEVEL 1 WALL TC	700	F	1
TC2	2	49894	T1IW+1.5	LEVEL 1 WALL TC	700	F	2
TC3	3	49895	T1IW+0.5	LEVEL 1 WALL TC	700	F	3
TC4	4	49896	T1IW+0.125	LEVEL 1 WALL TC	700	F	4
TC5	5	49688	T1IW	LEVEL 1 WALL TC	700	F	5
TC6	6	49695	T2OW	LEVEL 2 WALL TC	700	F	6
TC7	7	49897	T2IW+1.5	LEVEL 2 WALL TC	700	F	7
TC8	8	49898	T2IW+0.5	LEVEL 2 WALL TC	700	F	8
TC9	9	49899	T2IW+0.125	LEVEL 2 WALL TC	700	F	9
TC10	10	49693	T2IW	LEVEL 2 WALL TC	700	F	10
TC11	11	49700	T3OW	LEVEL 3 WALL TC	700	F	11
TC12	12	49900	T3IW+1.5	LEVEL 3 WALL TC	700	F	12
TC13	13	49901	T3IW+0.5	LEVEL 3 WALL TC	700	F	13
TC14	14	49902	T3IW+0.125	LEVEL 3 WALL TC	700	F	14
TC15	15	49677	T3IW	LEVEL 3 WALL TC	700	F	15
TC16	16	49701	T4OW	LEVEL 4 WALL TC	700	F	16
TC17	17	49903	T4IW+1.5	LEVEL 4 WALL TC	700	F	17
TC18	18	49904	T4IW+0.5	LEVEL 4 WALL TC	700	F	18
TC19	19	49905	T4IW+0.125	LEVEL 4 WALL TC	700	F	19
TC29	29	49705	TDOW	DOME WALL TC	700	F	21
TC30	30	49704	TDIW	DOME WALL TC	700	F	22

CMT WALL THERMOCOUPLE LAYOUT

AP600



X–X

NOTES:

1) TC SOLDERED INTO 0.06 DP X 1.5 LG GROOVE CUT INTO CMT WALL
2) DRILL THRU AND TAP FOR 1/16" NPT
3) DRILL 1/4" DIA. FLAT BOTTOM HOLE TO DEPTH AS SHOWN. 'AP FOR 1/16" NPT. INSERT TC WITH COPPER DISC AND PEEN INTO BOTTOM OF HOLE.

AP600 CMT Test Core MakeupTank Thermocouple Installation

CMT FLUID THERMOCOUPLES

INST I.D.	WIRE NO.	INSTRUMENT SERIAL NO.	INSTRUMENT LOCATION/DESCRIPTION		INST F.S. RANGE	ENG UNITS	BLK. NO.
TC85	85	53636	TI3+OM9	WATER TC	700	F	20
TC31	31	49944	TID0	DOME WATER TC	700	F	23
TC32	32	49916	TI1+2R3	WATER TC	700	F	24
TC33	33	49917	TI1+OM3	WATER TC	700	F	25
TC34	34	49918	TI1-2L3	WATER TC	700	F	26
TC35	35	49919	TI1-4M3	WATER TC	700	F	27
TC36	36	49920	TI1/2+0M3	WATER TC	700	F	28
TC37	37	49921	TI2+4M3	WATER TC	700	F	29
TC38	38	49922	TI2+2R3	WATER TC	700	F	30
TC39	39	49923	TI2+OM3	WATER TC	700	F	31
TC40	40	49924	TI2-2L3	WATER TC	700	F	32
TC41	41	49925	TI2-4M3	WATER TC	700	F	33
TC42	42	49926	TI2/3+6R3	WATER TC	700	F	34
TC43	43	49927	TI2/3+0M3	WATER TC	700	F	35
TC44	44	49928	TI2/3-6L3	WATER TC	700	F	36
TC45	45	49929	TI3+4M3	WATER TC	700	F	37
TC46	46	49930	TI3+2R3	WATER TC	700	F	38
TC47	47	53634	TI3+OM3	WATER TC	700	F	39
TC48	48	49932	TI3-2L3	WATER TC	700	F	40
TC49	49	49933	TI3-4M3	WATER TC	700	F	41
TC50	50	49934	TI3/4+6R3	WATER TC	700	F	42
TC51	51	49935	TI3/4+0M3	WATER TC	700	F	43
TC52	52	49936	TI3/4-6L3	WATER TC	700	F	44
TC53	53	49937	TI4+4M3	WATER TC	700	F	45
TC54	54	49938	TI4+2R3	WATER TC	700	F	46
TC55	55	49939	TI4+OM3	WATER TC	700	F	47
TC56	56	49940	TI4-2L3	WATER TC	700	F	48
TC57	57	49941	TI4-4M3	WATER TC	700	F	49
TC58	58	49942	TI4-8M3	WATER TC	700	F	50
TC59	59	49943	TI4-12M3	WATER TC	700	F	51
TC69	69	49963	TCACC	ACCUMULATOR TOP	700	F	52
TC70	70	49962	TCACC	ACCUMULATOR	700	F	53
TC71	71	49961	TCACC	ACCUMULATOR	700	F	54
TC72	72	49960	TCACC	ACCUMULATOR BOT	700	F	55
TC73	73	49952	TCSTIN	STEAM IN	700	F	56
TC74	74	49954	TCSWRT	S/W RES TOP	700	F	57
TC75	75	49953	TCSWRB	S/W RES BOT	700	F	58
TC63	63	53667	TIDSW2	WATER TC	700	F	59
TC84	84	53635	TI3+OM6	WATER TC	700	F	60
TC65	65	49909	AMBIENT	AMBIENT TEMP	700	F	61
TC60	60	53645	TI1+2M9	WATER TC	700	F	62
TC61	61	49956	TI180+2M3	WATER TC	700	F	63
TC62	62	53655	TIDNE0.5	WATER TC	700	F	64
TC76	76	49949	TCCMTI	CMT STEAM IN	700	F	65
TC77	77	49945	TCCMTO	CMT STEAM OUT	700	F	66
TC78	78	53656	TIDNE1.0	WATER TC	700	F	67
TC79	79	53657	TI[illegible]E1.5	WATER TC	700	F	68
TC80	80	53668	TIDSW3	WATER TC	700	F	69
TC81	81	53669	TIDSW4	WATER TC	700	F	70
TC82	82	53644	TI1+2M6	WATER TC	700	F	71
TC83	83	53643	TI1+2M3	WATER TC	700	F	72

AP600 CMT TEST

AP600

CMT PRESSURE, LEVEL & FLOW INSTRUMENTATION

INST I.D.	WIRE NO.	INSTRUMENT SERIAL NO.	INSTRUMENT LOCATION/DESCRIPTION	INST F.S. RANGE	ENG UNITS	BLK. NO.
PDT1	1	9240-00880126005	CMT LEVEL 1-2	36 (1)	in.H20	73
PDT2	2	9240-00880126009	CMT LEVEL 2-3	36 (1)	in.H20	74
PDT3	3	9240-00880126010	CMT LEVEL 3-4	36 (1)	in.H20	75
PDT4	4	9240-00880126008	CMT LEVEL 4-5	36 (1)	in.H20	76
PDT5	5	9240-00880126011	CMT LEVEL 5-6	36 (1)	in.H20	77
PDT6	6	9240-00880126006	OVERALL CMT LEVEL 1-6	124 (1)	in.H20	78
PDT13	7	8950-00762880019	PT4 - PT5	400 (1)	in.H20	79
PT4	9	9244-00880126013	CMT INLET PRESSURE	3000 (2)	PSIG	80
PT5	10	9244-00880126015	CMT VESSEL PRESSURE	3000 (2)	PSIG	81
PT6	11	9321-00907269005	ACCUMULATOR PRESSURE	3000 (2)	PSIG	82
PT7	12	NA	NOT USED			83
PDT11	13	9325-00910428003	SL #1 DOWNSTREAM DP	400 (1)	in.H20	84
PDT12	14	9325-00910428001	SL #2 DOWNSTREAM DP	400 (1)	in.H20	85
PDT10	23	9006-00773891001	PT1 - PT4	3000 (2)	PSIG	86
PT1	15	9321-00907269006	S/W RES PRESS TO PCV	3000 (2)	PSIG	87
PT2	16	9244-00880126016	STEAM LINE #1 INLET	3000 (2)	PSIG	88
PT3	17	9244-00880126014	STEAM LINE #2 INLET	3000 (2)	PSIG	89
PDT7	18	9005-00772871013	S/W RES. LEVEL	124 (1)	in.H20	90
PDT8A	19	9240-00880126012	SL #1 UPSTREAM DP	400 (1)	in.H20	91
PDT8B	20	9325-00910428002	SL #1 UPSTREAM DP - REVERSED	400 (1)	in.H20	92
PDT9A	21	9240-00880126007	SL #2 UPSTREAM DP	400 (1)	in.H20	93
PDT9B	24	9408-00936005033	SL #2 UPSTREAM DP-REVERSED	400 (1)	in.H20	94
PAT1	22	2500790/3170177 (4)	BAROMETRIC PRESSURE	15	PSIA	95
LT1R	40	3509-N	FCI PROBE ACTIVE SENSOR	800	F	96
LT1A	41	3509-N	FCI PROBE ACTIVE SENSOR	800	F	97
LT2R	42	3509-N	FCI PROBE ACTIVE SENSOR	800	F	98
LT2A	43	3509-N	FCI PROBE ACTIVE SENSOR	800	F	99
LT3R	44	3509-N	FCI PROBE REFERENCE SENSOR	800	F	100
LT3A	45	3509-N	FCI PROBE REFERENCE SENSOR	800	F	101
LT4R	46	3509-N	FCI PROBE REFERENCE SENSOR	800	F	102
LT4A	47	3509-N	FCI PROBE REFERENCE SENSOR	800	F	103
TACC	NA	NA	AVG ACC TEMP	NA	F	104
FM1	85	45585/45017 (4)	CMT DRAINLINE 1"TFM	75	GPM	105
FM2	84	45584/45016 (4)	LCV DRAIN 3/4"TFM	35	GPM	106
FM3	83	45583/45018 (4)	LCV DRAIN 1/2"TFM	3	GPM	107
FM4	TBD	TBD	SL #1 VORTEX FLOWMETER	TBD	FT/SEC	TBD
FM5	TBD	TBD	SL #2 VORTEX FLOWMETER	TBD	FT/SEC	TBD
TIME	NA	NA	ELAPSED TIME FROM DAS SYSTEM CLOCK	NA	SEC	108

CMT TEST MATRIX

AP600

SERIES 100 TESTS

CMT WALL CONDENSATION WITH AND WITHOUT NONCONDENSIBLES

SERIES 200 TESTS

CMT WALL AND WATER SURFACE CONDENSATION

SERIES 300 TESTS

CMT DRAINDOWN AT CONSTANT PRESSURE

SERIES 400 TESTS

CMT DRAINDOWN DURING DEPRESSURIZATION

SERIES 500 TESTS

NATURAL CIRCULATION FOLLOWED BY DRAINDOWN AND DEPRESSURIZATION

SERIES 600 TESTS

CMT ACTUATION WITH BOTH STEAM LINES WITH AND WITHOUT NONCONDENSIBLES

TABLE 8-1
AP600 CMT TEST MATRIX (Sheet 1 of 2)

Test No.	Test Type	CMT Drain Rate	Steam Supply Pressure(s) psig	Comments
101-105	CMT wall condensation with and without noncondensible gases	N/A CMT drain rate based on steam condensation rate and drain capability.	10/135/685/1085/2235, with subsequent depressurization	CMT initially contains no water, and is evacuated (no air).
106-108			10	CMT initially evacuated and then pressurized with air (or N_2) to .236, 1.13 and 2.13 psia, respectively.
109-111			1085	CMT initially evacuated and then pressurized with helium to 42, 146, and 296 psia, respectively.
201-208	CMT Wall and Water Surface Condensation	N/A - CMT level fixed. Water drained from CMT via external path to match steam condensation	10/135/1085/2235, with subsequent depressurization	CMT initially 90% and 75% full, CMT level control used to maintain fixed CMT level.
209-214			10/135/1085, with subsequent depressurization	CMT initially 50% and 25% full, CMT level control used to maintain fixed CMT level.
301-312	CMT draindown at constant pressure	6/11/16/MAX	10/135/1085	Low resistance steam supply line no. 2 utilized; drain rate controlled by discharge line resistance.
313-316		Flow rate controlled by steam supply line no. 1 resistance, (3 ft/gpm²).	1085/2235	Discharge line resistance set to provide 6/16 gpm.
401-402	CMT draindown during depressurization	Discharge line resistance for 6/16 gpm	1085 followed by depressurization to 20	Low resistance steam supply line no. 2 utilized; drain rate controlled by discharge line resistance.
403-404		Drain rate controlled by steam supply line no. 1 resistance	2235 followed by depressurization to 20	Discharge line resistance set to provide 6/16 gpm gravity drain rate at atmospheric pressure.

CMT TEST MATRIX

AP600

TABLE 6-1
AP600 CMT TEST MATRIX (Sheet 2 of 2)

Test No.	Test Type	CMT Drain Rate	Steam Supply Pressure(s) psig	Comments
501-502	Natural circulation followed by draindown and depressurization	Discharge line resistance set for 6/16 gpm drain rate	1085 followed by depressurization to 20	Steam supply line no. 1 is closed. Reservoir water level at "HI" level. reservoir water temperature initially 545°F. Steam supply line no. 2 is opened to initiate natural circulation until one-fifth of CMT heated. Reservoir water level is reduced to initiate draindown. The steam supply is isolated and the water/steam reservoir is vented when the CMT is drained to 97 inches.
503-504				Repeat with natural circulation until one-half of CMT heated.
505-506				Repeat with natural circulation until CMT is completely heated.
601-606	CMT actuation with both steam lines, with and without noncondensible gas.	Discharge line resistance set for 6/16 gpm. Steam supply line no. 1 resistance set to be 3 ft/gpm².	1835 - constant	Reservoir water level "HI". Reservoir water temperature initially 545°F. Steam supply line no. 1 is open. Both steam supply line no. 2 and CMT discharge lines opened simultaneously. Performed with steam, and with 146 and 296 psig of He initially in CMT side of steam supply line no. 2.
607-612			1085 - constant	

a,c

a,c

AP600

a,c

a,c

CMT TEST RESULTS

AP600

a,c

a,c

a,c

a,c

CMT TEST RESULTS

AP600

a,c

a,c

CMT TEST RESULTS

AP600

a,c

a,c

CMT TEST RESULTS

AP600

a,c

a,c

CMT TEST STATUS

AP600

- o COMPLETED COLD PRE-OPERATIONAL TESTING
  - CHARACTERIZED COMPONENT VOLUMES
  - CHARACTERIZED LEVEL INSTRUMENTATION
  - MEASURED DRAIN RATES
  - MEASURED STEAM LINE RESISTANCES
- o COMPLETED HOT PRE-OPERATIONAL TESTING
  - MEASURED SINGLE PHASE LINE RESISTANCES AT ELEVATED TEMPERATURE
  - CHARACTERIZED CMT THERMOCOUPLES
  - CHARACTERIZED CMT PRESSURIZATION / HEATUP RATES
  - CHARACTERIZED STEAM JET / WATER INTERACTION
    - INVESTIGATED "LOW" AND "HIGH" DRAIN RATES
    - EVALUATED ALTERNATE CMT INLET NOZZLE CONFIGURATIONS
  - TRAINED FACILITY OPERATORS
- o MATRIX TESTING
  - COMPLETED SERIES 100, 200 AND 300 MATRIX TEST PROCEDURES
  - MATRIX TESTING BEGAN ON 2/15/94
    - COMPLETED MATRIX TESTS C001105 AND C002105
      - TEST ACCEPTANCE COMPLETED
  - STEAM LINE #1 ISOLATION VALVE REPAIR IN PROGRESS
    - REPAIR TO BE COMPLETED BY 3/14/94

CMT TEST SCHEDULED ACTIVITY

COMPLETE "HIGH" PRESSURE SERIES 200 / 300 MATRIX TESTS

COMPLETE STEAM FLOWMETER INSTALLATION

COMPLETE "LOW" PRESSURE SERIES 100 / 200 / 300 TESTS

CMT TEST DATA ANALYSIS

ROBERT C. HABERSTROH
WESTINGHOUSE

MARCH 14–15, 1994

Introduction

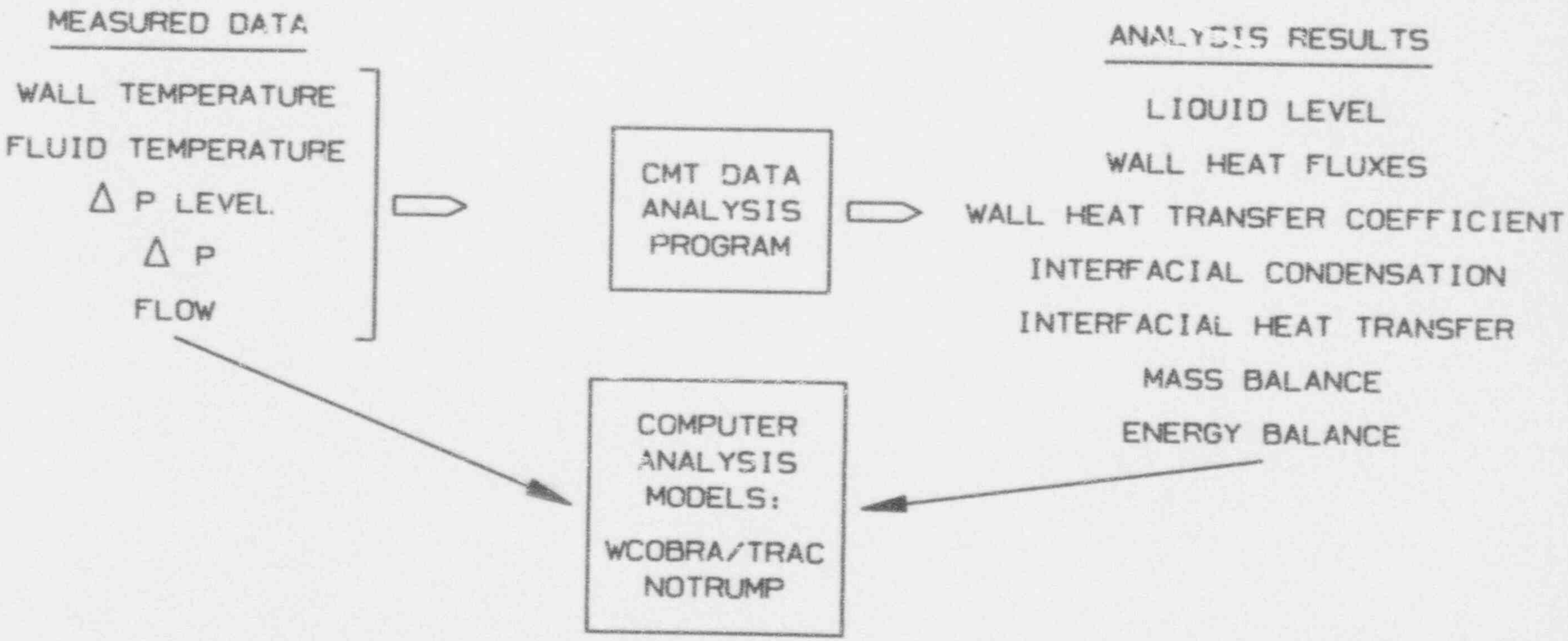
AP600

- Objectives
- CMT Data Analysis Program
- CMT Flow, Liquid Level, and Volume Calculations
- Mass Balance
- CMT Wall Heat Transfer
- Interfacial Condensation
- Preliminary Results for Pre-operational Test B0377
- Conclusions

Objectives

- Develop a detailed understanding of the thermal-hydraulic behavoir of the CMT tests
- Analysis Conditions: CMT in Draining Mode
- Provide Parameters for comparison to LOCA analysis codes
- Calculated Values
  CMT inlet flow and outlet flows
  CMT Values
    - liquid level
    - vapor and liquid mass
    - local wall heat flux
    - wall heat transfer
    - interfacial, wall, and total condensation
    - wall heat transfer coefficient
    - interfacial heat transfer coefficient
    - mass and energy balances

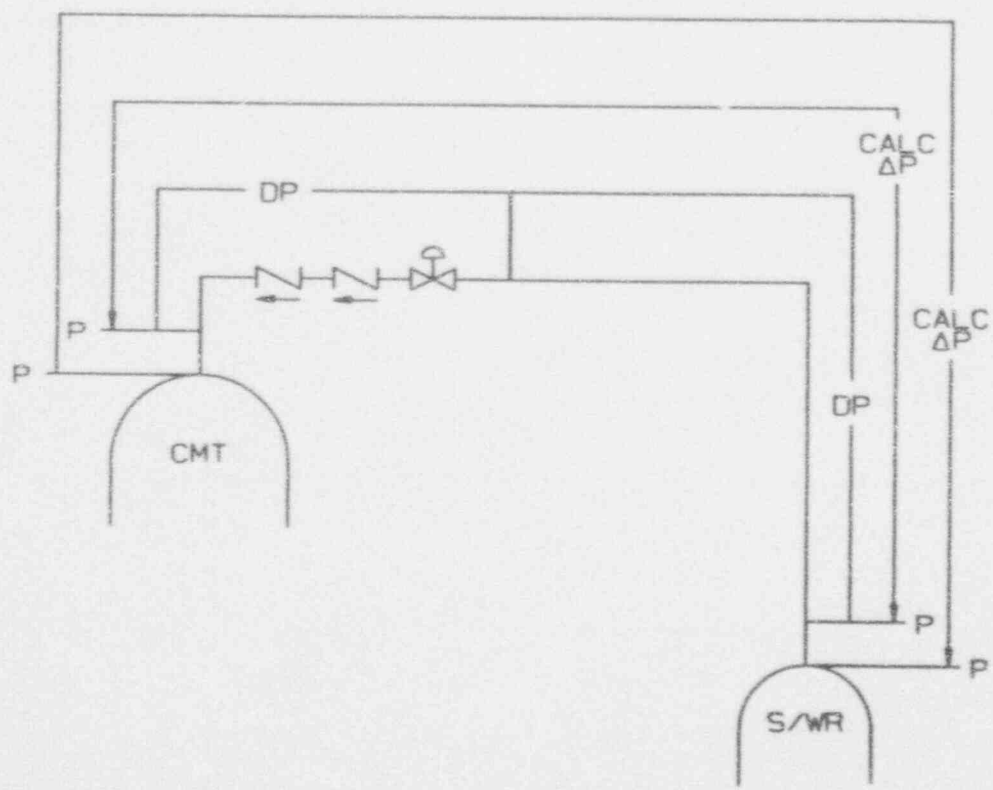
CMT Data Analysis Program



CMT Flow Calculations

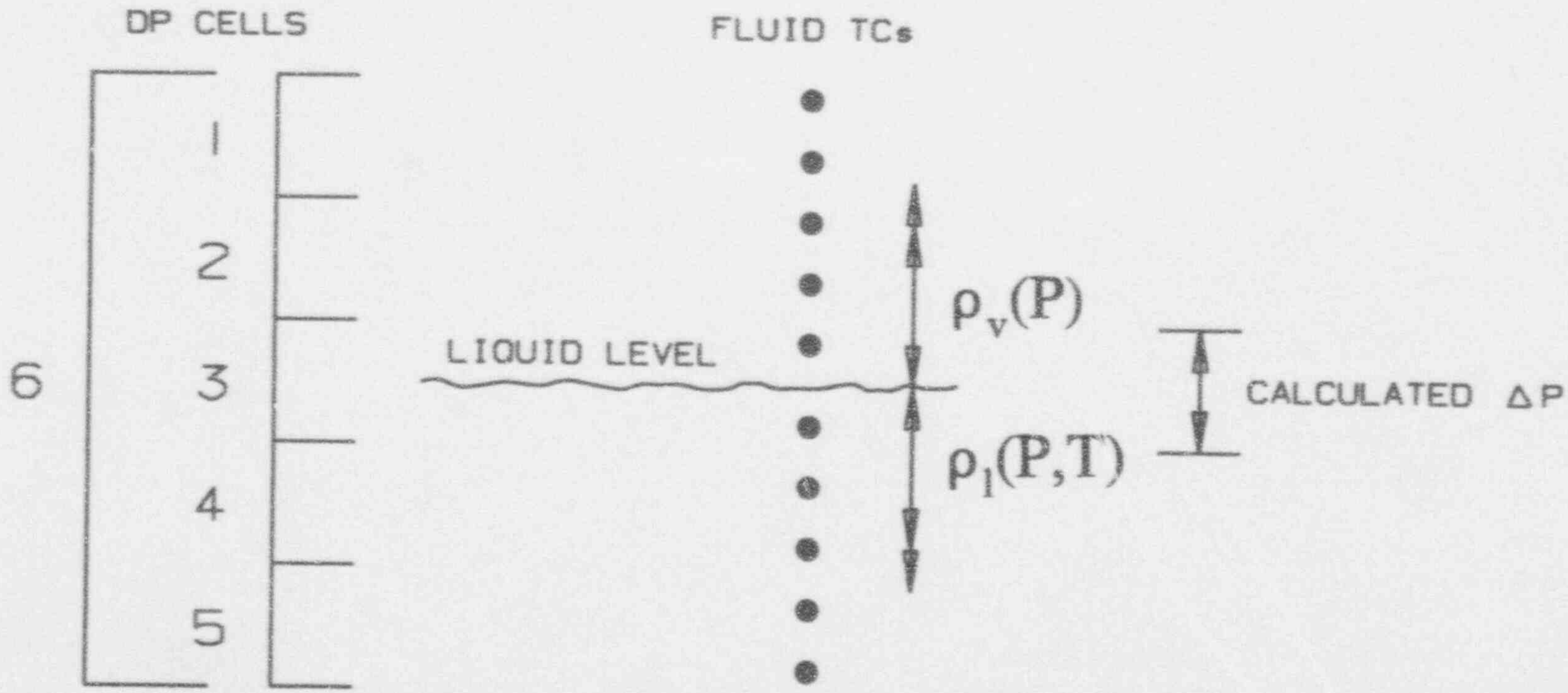
- flow meter for outlet line

- inlet flow calculated from line ΔP
  - 4 methods: 2 DP cells and 2 pairs of pressure taps
  - calculation normalized for zero flow during pretest period with closed valves



CMT Liquid Level Calculations

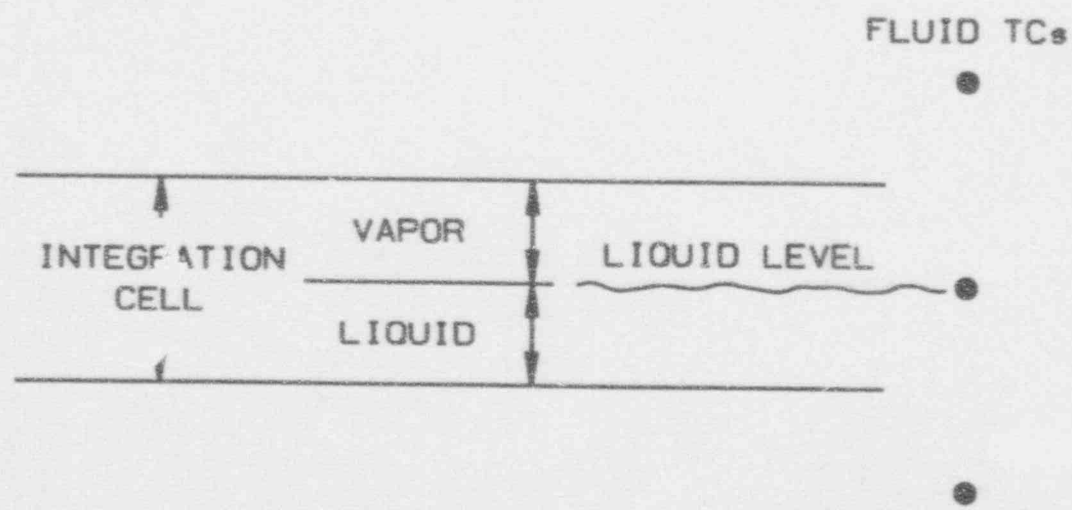
- 2 methods: 5 narrow-range DP cells, or wide-range DP cell
- use 32 cells corresponding to the fluid TCs
- compare measured ΔP and calculated ΔP to determine level
  calculated ΔP = f(Pressure, Temperature, liquid level)



CMT Volume Calculations

- integrate using 32 cells corresponding to the fluid TCs
- vapor and liquid volume calculated for each cell: ΔV_{vap} and ΔV_{liq}
- total vapor and liquid volumes:

$$V_{vap} = \sum_{\text{fluid TCs}} \Delta V_{vap} \qquad V_{liq} = \sum_{\text{fluid TCs}} \Delta V_{liq}$$



CMT Mass Balance

$$M_{v-in_t} = \int_{t_o}^{t} w_{in} \, dt$$ mass in: steam

$$M_{l-out_t} = \int_{t_o}^{t} w_{out} \, dt$$ mass out: liquid

$$M_v = \sum_{\text{fluid TCs}} \rho_v(P) \, \Delta V_{vap}$$ vapor mass in CMT

$$M_l = \sum_{\text{fluid TCs}} \rho(P,T) \, \Delta V_{liq}$$ liquid mass in CMT

mass balance error = excess mass in CMT

$$\text{mass balance error}_t = \left[M_v + M_l\right]_t - \left[M_v + M_l\right]_{t_o} - \left[M_{v-in} - M_{l-out}\right]_t$$

Mass Balance Plot

Flows and Mass Balance Error
for Pre-operational Test B0377

—— Integrated Outlet Flow
— — Integrated Inlet Flow
— — Mass Balance Error

Corresponding Level Change
for Pre-operational Test B0377

—— Delta-Elev = Mass Balance Error / CMT Liquid Mass
* Level

a,b

Plot of Measured Fluid and Wall Temperatures

——— TC33 Fluid Temperature
o——o TC5 Metal Temperature at 0.031 inches from ID
▲——▲ Delta-T = TC33 - TC5

a,b

Local CMT Wall Heat Transfer

a,c

- evaluated with CONTRA
  - inverse heat transfer calculation based on metal TCs
  - method per "Inverse Heat Conduction -- Ill-posed Problems" by J.V. Beck, B. Blackwell and C. R. St.Clair, Jr.
  - calculates local heat flux and local wall ID temperature

- calculate local heat transfer coefficient

Local Heat Transfer Plot

AP600

a,b

[ ]

CMT Wall Heat Transfer

- interpolate and extrapolate CONTRA results
  - time shift local heat flux based on time water level reaches an elevation
  - elevation-weighted average adjacent CONTRA results for intermediate elevations

- integrate using 20 cells in 6 regions (above, below and between CONTRA analysis elevations)

- calculations for code comparision for CMT subregions corresponding to code nodalization
  - mass and enthalpy for liquid and vapor
  - liquid temperature calculated from total subregion enthalpy and pressure

Mapping of Heat Flux vs. Time into Heat Flux vs. Elevation

[ ] a,c

Integration Model for Wall Heat Transfer

a,c

Interpolation of CONTRA Results to an Intermediate Cell

[ ]a,b

Heat Transfer in an Intermediate Cell

AP600

[ ]a,b

Methods for Estimating the Interfacial Condensation

- Steam Mass Balance
- Liquid Mass Balance
- Liquid Energy Balance

Condensation Based on Steam Mass Balance

total condensation = steam flow into CMT - change of steam mass

$$M_{cond_t} = M_{v-in_t} - \left[M_{v_t} - M_{v_{t_o}} \right]$$

wall condensation = wall heat transfer / h_{fg}

$$M_{wall\ cond_t} = \int_{t_o}^{t} \frac{q_v}{h_{fg}}\, dt$$

interface condensation = total condensation - wall condensation

$$M_{int\ cond_t} = M_{cond_t} - M_{wall\ cond_t}$$

Condensation Based on Liquid Mass Balance

total condensation = drain flow from CMT + change in liquid mass

$$M_{cond_t} = M_{l-out_t} + \left[M_{l_t} - M_{l_{t_o}} \right]$$

wall condensation = wall heat transfer / h_{fg}

$$M_{wall\ cond_t} = \int_{t_o}^{t} \frac{q_v}{h_{fg}}\, dt$$

interface condensation = total condensation - wall condensation

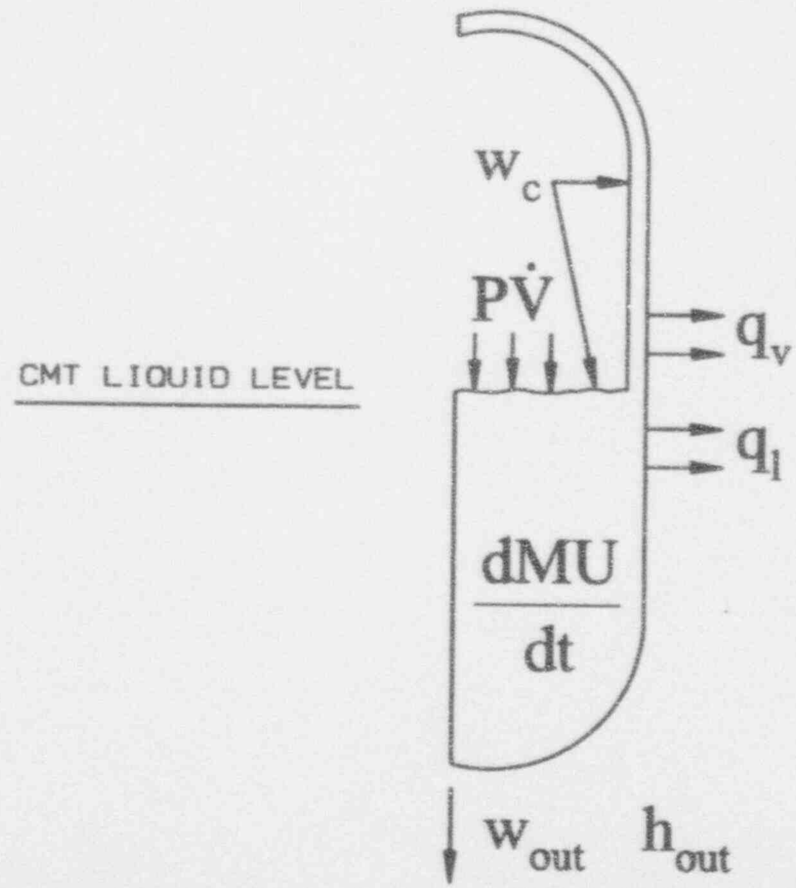
$$M_{int\ cond_t} = M_{cond_t} - M_{wall\ cond_t}$$

Condensation Based on Liquid Energy Balance

total condensation rate = w_{cond} =
- rate of change of liquid internal energy
- + rate of drain flow * enthalpy
- + total wall heat transfer above and below water level
- - pressure * rate of change of liquid volume / J) h_g

total condensation

$$M_{cond_t} = \int_{t_o}^{t} w_{cond}\, dt$$



Condensation Based on Liquid Energy Balance

wall condensation = wall heat transfer / h_{fg}

$$M_{wall\ cond_t} = \int_{t_o}^{t} \frac{q_v}{h_{fg}}\, dt$$

interface condensation = total condensation - wall condensation

$$M_{int\ cond_t} = M_{cond_t} - M_{wall\ cond_t}$$

Preliminary Results for Pre-operational Test B0377

AP600

a,b

[ ]

Preliminary Results for Pre-operational Test B0377

CMT Level: Comparison of Two Methods

- 2 methods: 5 narrow-range DP cells, or wide-range DP cell
- When filling DP cells are consistent until liquid level reaches top tap for DP1 and DP6
- DP cells DP2 thru DP5 generally consistent
- level curves for DP6 & combination of DP2 thru DP5 are parallel

Preliminary Results for Pre-operational Test B0377

Comparison of Calculated Levels

Level per DP6

Level per DP1 thru DP5

a,b

CMT Level: Comparison of Two Methods

- all DP taps are horizontal except for top tap for DP1 & DP6
- configuration of top tap results in inconsistencies in calculated level
- Design Fix:
  horizontal top tap for DP1 and DP6

All test results shown on following slides use wide-range DP cell, DP6

Preliminary Results for Pre-operational Test B0377

Calculated CMT Inlet Steam Flows

Flow per PT1-PT5
Flow per PT2-PT4
Flow per DPT8: Upstream DP Cell
Flow per DPT11: Downstream DP Cell

a,b

Preliminary Results for Pre-operational Test B0377

Calculated CMT Fluid Level

a,b

AP600

CMT Fluid Temperature Profiles for 0 to 240 Seconds with 20 Second Spacing

a,b

CMT Mass Balance

Mass Balance Error
for Pre-operational Test B0377

Corresponding Level Change
for Pre-operational Test B0377
—— Delta-Elev = Mass Balance Error / CMT Liquid Mass
+ Level

a,b

Preliminary Results for Pre-operational Test B0377

Measured Temperatures at Top CONTRA Analysis Elevation

TC5	1	2	377 T CMT 103.00 W+ .000
TC4	1	2	377 T CMT 103.00 W+ .125
TC3	1	2	377 T CMT 103.00 W+ .500
TC2	1	2	377 T CMT 103.00 W+1.500
TC1	1	2	377 T CMT 103.00 W+2.343
TC33	1	2	377 T CMT-FLUID @ 103.00

a,b

Measured Temperatures at Second CONTRA Analysis Elevation

TC10	1	2	377 T CMT 86.25 W+ .000
TC9	1	2	377 T CMT 86.25 W+ .125
TC8	1	2	377 T CMT 86.25 W+ .500
TC7	1	2	377 T CMT 86.25 W+1.500
TC6	1	2	377 T CMT 86.25 W+2.343
TC39	1	2	377 T CMT-FLUID @ 86.25

a,b

Preliminary Results for Pre-operational Test B0377

Local Heat Flux at Each Analysis Elevation

Heat Flux at Elevation 103 inches
Heat Flux at Elevation 86.25 inches
Heat Flux at Elevation 57.5 inches
Heat Flux at Elevation 23 inches

a,b

CMT Wall Heat Transfer

—— Vapor Region Heat Transfer Rate

o——o Liquid Region Heat Transfer Rate

a,b

CMT Wall Condensation

a,b

Preliminary Results for Pre-operational Test B0377

CMT Total Condensation

——— Condensation Based on Steam Mass Balance
□——□ Condensation Based on Liquid Mass Balance
△——△ Condensation Based on Liquid Energy Balance

a,b

Preliminary Results for Pre-operational Test B0377

CMT Interface Condensation

——— Interface Cond. Based on Steam Mass Balance
□——□ Interface Cond. Based on Liquid Mass Balance

a,b

Condensation Ratios Based on Steam Mass Balance

—— Interface Condensation / Total Condensation

a,b

Conclusions

- Instrumentation sufficient to provide for analysis of key thermal-hydraulic phenomena in CMT
- Can calulate parameters for development of understanding of tests, and for comparison to LOCA analysis codes
- Preliminary evaluation of Pre-operational test B0337 demonstrates consistency between alternate methods for calculating flows and condensation

CMT ANALYSIS PLAN

L. E. HOCHREITER
NUCLEAR SAFETY ANALYSIS AND STRATEGIC DEVELOPMENT

- CMT ANALYSIS PLAN --- STATUS
  - OVERALL APPROACH
    - DEVELOP A DETAILED UNDERSTANDING OF THE THERMAL-HYDRAULIC BEHAVIOR OF THE CMT THROUGH TEST/ANALYSIS
    - CHARACTERIZE CMT BEHAVIOR IN MORE DETAILED CALCULATIONS
    - IF NEEDED, USED MORE DETAILED ANALYSIS TO ADDRESS SCALING ISSUES
    - BASED ON THE RESULTS, SIMPLIFYING THE MODELS/MODELING FOR THE PLANT CALCULATIONS WITH TWO MAIN OBJECTIVES:
      - TO CAPTURE THE KEY OR PRINCIPLE EFFECTS THAT SIGNIFICANTLY INFLUENCE THE PLANT TRANSIENT
      - IF NECESSARY, TO INSURE THE MODEL IS APPLIED IN A CONSERVATIVE FASHION

- THREE ANALYSIS APPROACHES WILL BE GIVEN, EACH WITH DIFFERENT LEVELS OF COMPLEXITY
  - AXI-SYMMETRIC THREE-DIMENSIONAL WCOBRA/TRAC MODEL OF THE CMT USING THE VESSEL (COBRA) COMPONENT
  - 1-D TRAC COMPONENT MODEL OF THE CMT
  - THE NOTRUMP CMT MODEL

- THE PURPOSE IS TO SHOW THAT DETAILED MODELING IS NEEDED TO IMPROVE OUR UNDERSTANDING OF THE CMT PHENOMENA BUT COARSE MODELING WILL CAPTURE THE KEY CMT EFFECTS

CMT DRAINDOWN TEST AND ANALYSIS

(WITH WCOBRA/TRAC, 3D VESSEL COMPONENT)

K. TAKEUCHI
NUCLEAR SAFETY ANALYSIS AND STRATEGIC DEVELOPMENT

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CMT Draindown Test and Analysis with WCOBRA/TRAC, 3D Vessel Component.

Kenji Takeuchi

March 14 - 15, 1994

1. Introduction
2. Test Facility
3. Selected Test B0377
4. WCOBRA/TRAC Model
5. Analysis Results
6. Conclusion

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OBJECTIVE:

for modeling the CMT Test <u>in Detail</u> with the COBRA (3D) Vessel Component of WCOBRA/TRAC :

- o Gain insight into thermal/hydraulic phenomena occurring within the CMT.
- o Assess the degree of complexity needed to sufficiently model CMT.
- o Develop an approach to use simpler models (TRAC component and NOTRUMP) for plant analyses.
- o Help develop scaling rational for CMT.

Test Facility

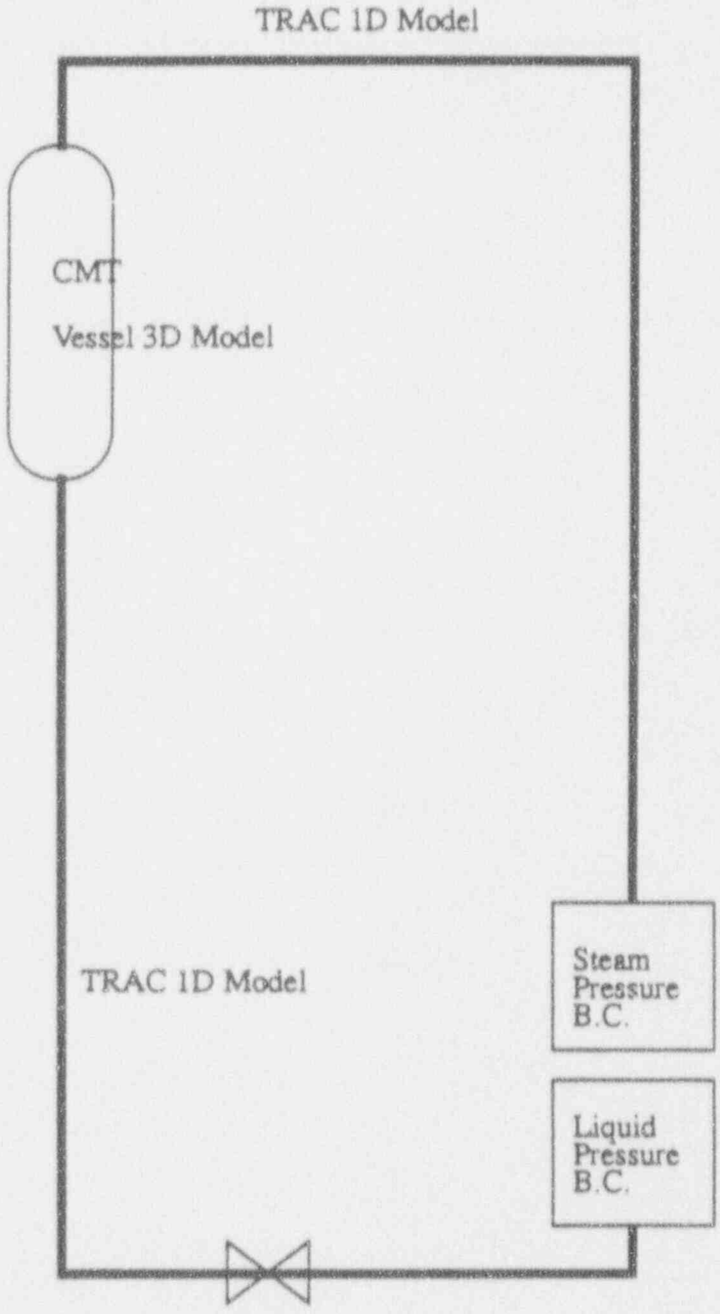
[ ]a,b

Thu., January 27, 1994: 03:26:12 PM EST UNCONFIGURED!
50 PSI CASE WITH MODEL 2 STEAM DISTRIBUTOR
b0377 CMT TEST B03 11-08-1993 14:21:16.43
——— F-SL1-BE 1 2 377 S/. 1 BEST-EST FLOW

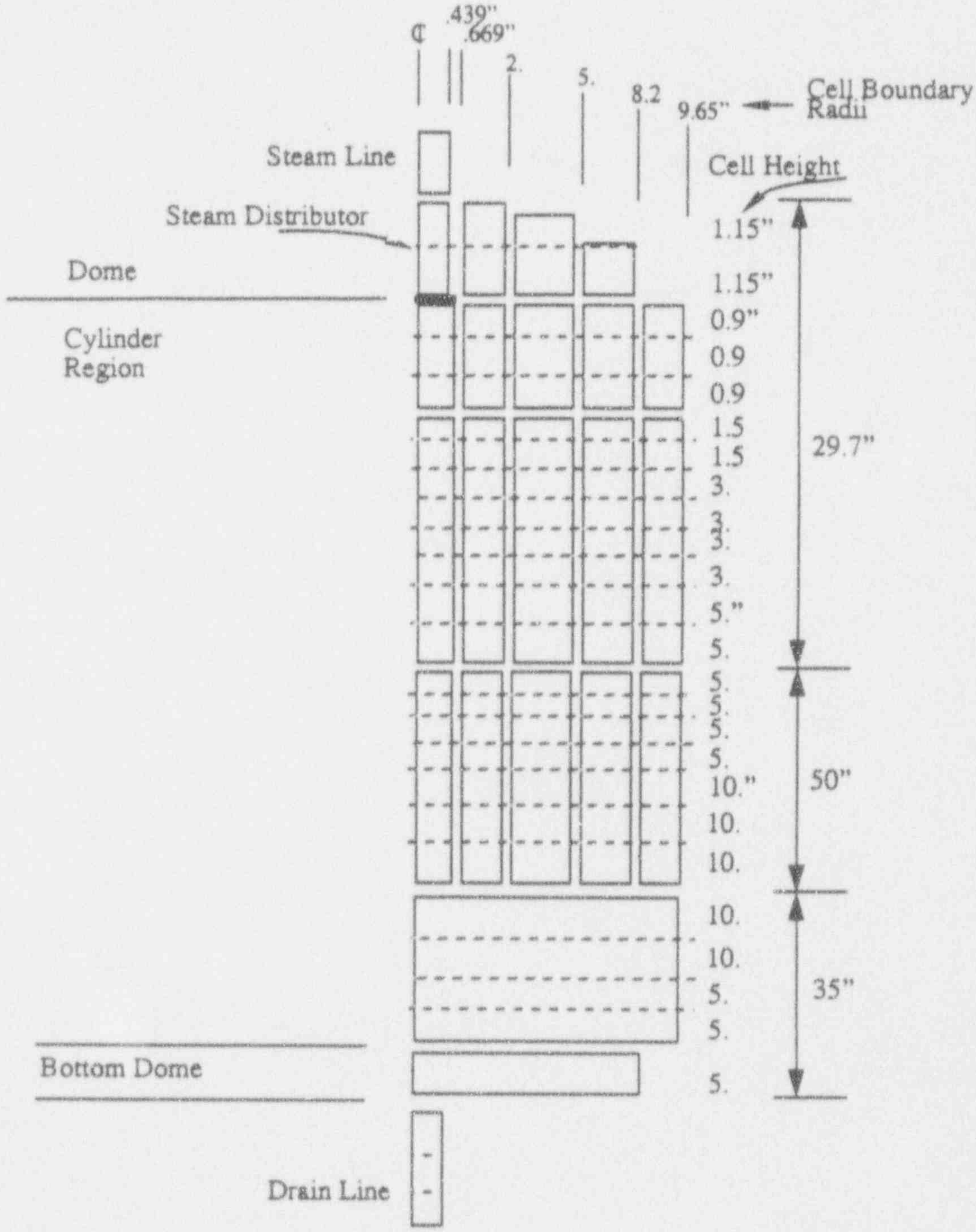
TEST DATA

a,c

WCOBRA/TRAC Model



3D WCOBRA/TRAC Nodings for CMT (axi-symmetric) Model



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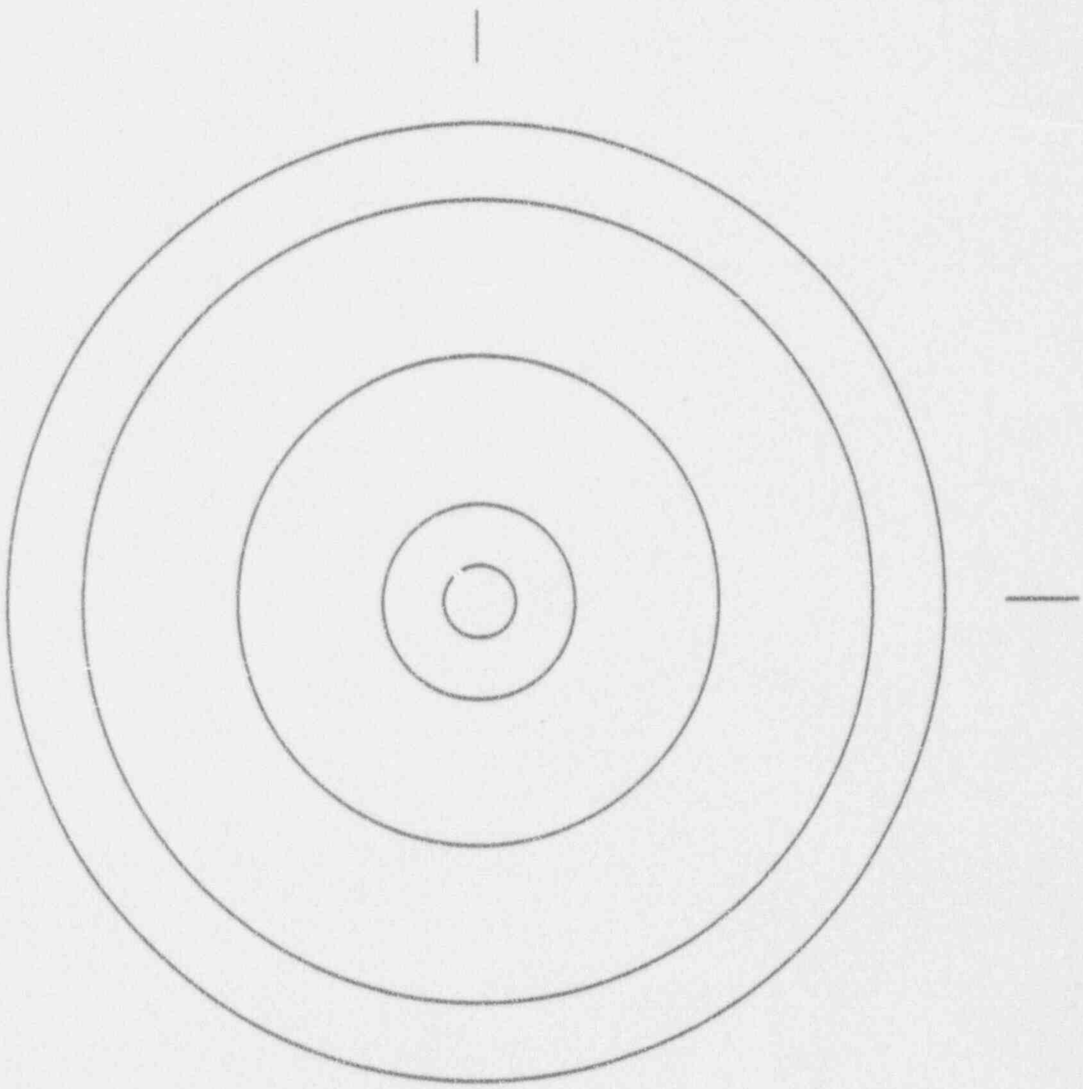
TOP VIEW OF CMT NODING



CMT Water
Steam Inlet
——— MTH00006 2 4

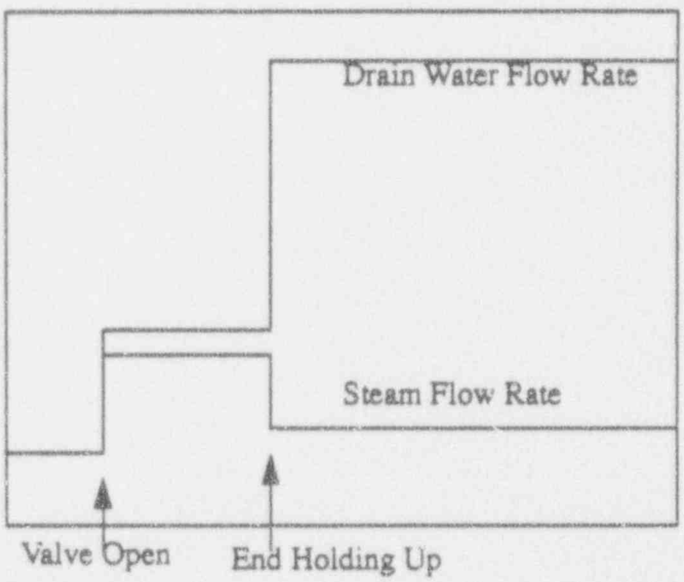
TEST vs. ANALYSIS

a,b

Analysis Results vs. Test Data

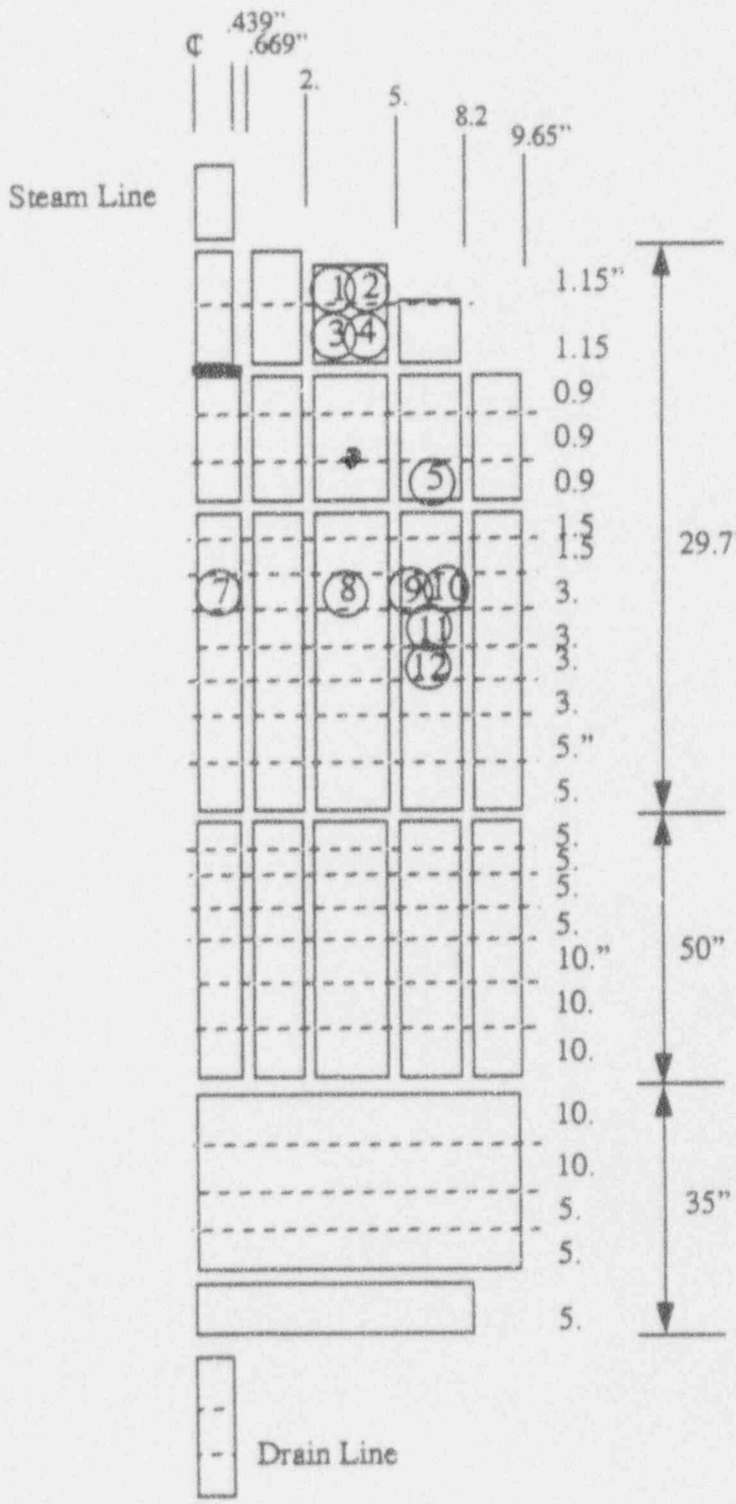
Table 3:

Test	Test Conditions		Test	Analysis
B0377	65 psia	Holding Up Time (s)	40.	40.
	70 F	Early Steam Flow (lbm/s)	0.25	0.08
		Later Liquid Drain Rate (lbm/s)	1.8	1.8



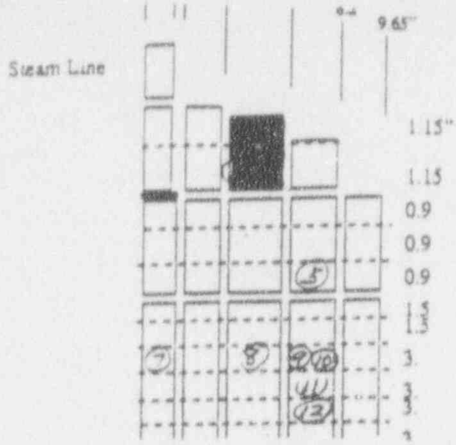
FLUID TEMPERATURE (Data vs. Analysis)

Fluid T/C Locations relative to Model Nodings



1 ... TC62
2 ... TC78
3 ... TC79
4 ... TC63
5 ... TC31

7 ... TC60
8 ... TC82
9 ... TC83
10 ... TC61
11 ... TC33
12 ... TC34



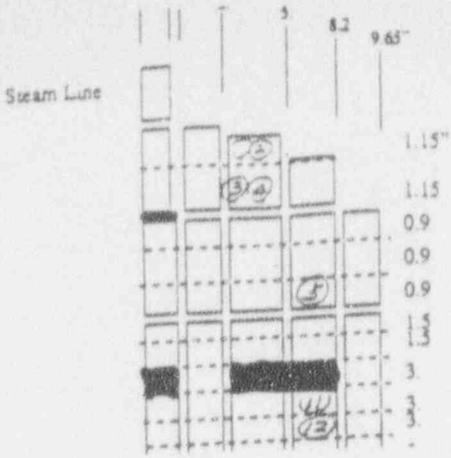
FLUID TEMPERATURE

TEST vs.
ANALYSIS
b0377
65 psia
70 F

CMT60 Water Draindown
VESSEL TOP LIQ. TEMP.

———	TL	21	2	0 LIQUID TEMPERATURE
―□―	TL	20	3	0 LIQUID TEMPERATURE
―△―	TL	20	2	0 LIQUID TEMPERATURE
―◇―	TL	19	3	0 LIQUID TEMPERATURE
―★―	TL	19	2	0 LIQUID TEMPERATURE

a,b



FLUID TEMPERATURE

TEST vs.
ANALYSIS
b0377
65 psia
70 F

CMT60 Water Draindown
VESSEL 3rd from TOP LIQ. TEMP.

TL	12	7	0	LIQUID TEMPERATURE
TL	11	7	0	LIQUID TEMPERATURE
TL	10	7	0	LIQUID TEMPERATURE
TL	9	7	0	LIQUID TEMPERATURE
TL	8	7	0	LIQUID TEMPERATURE

a,b

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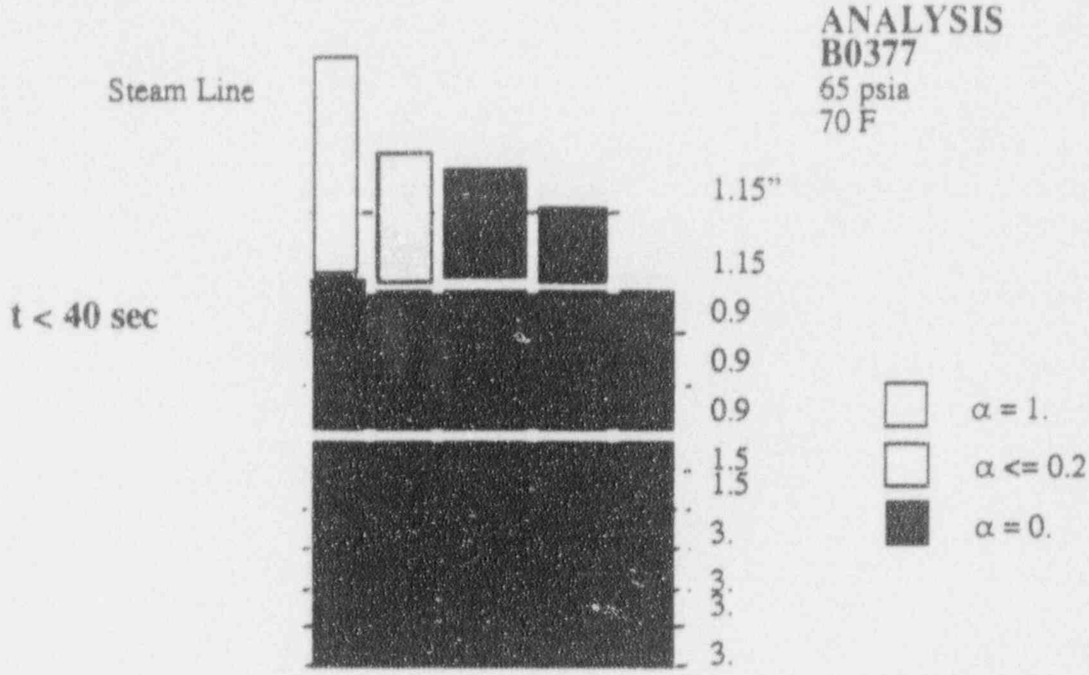
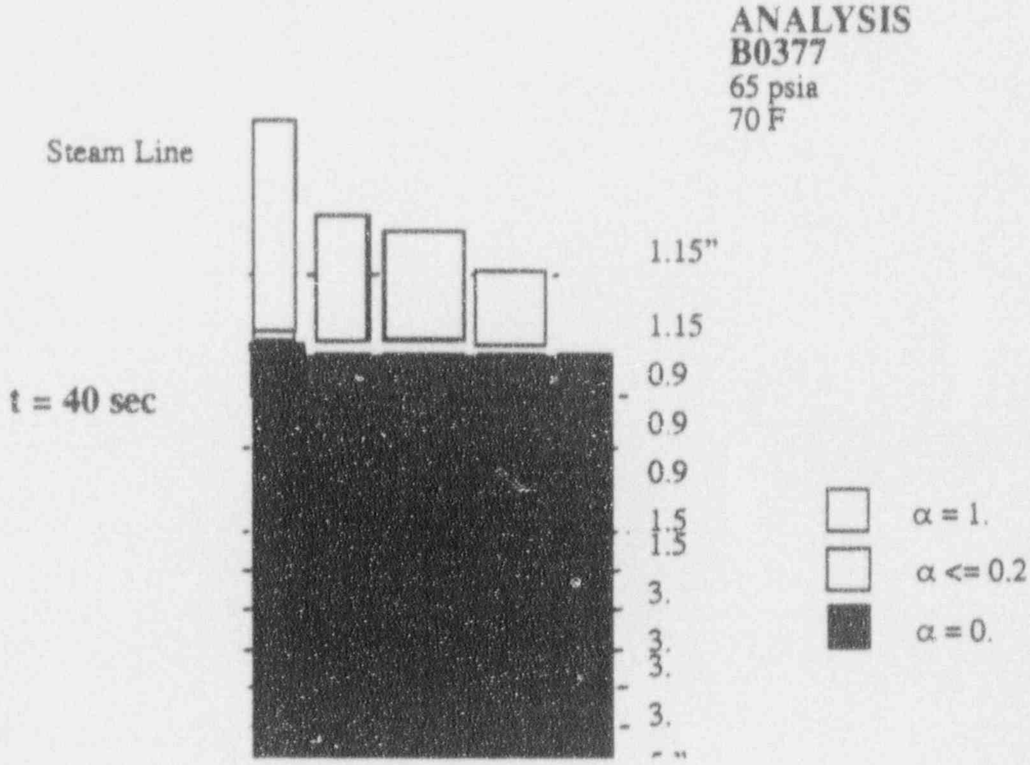
Predicted Void Fraction





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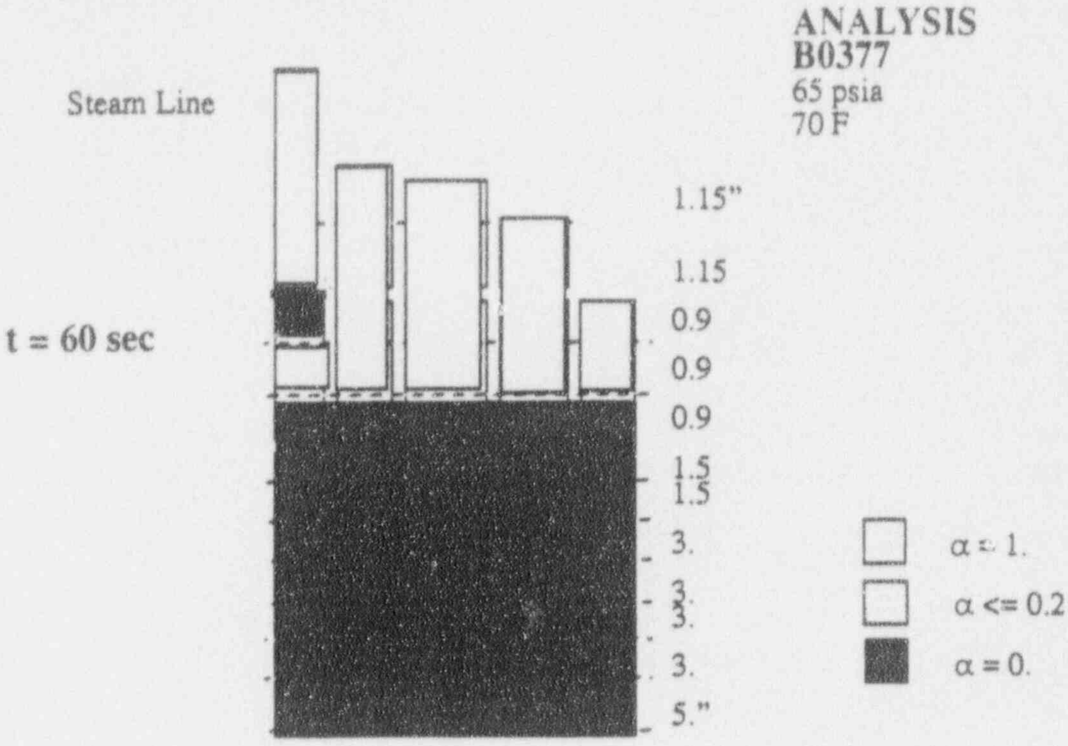
Predicted Void Fraction

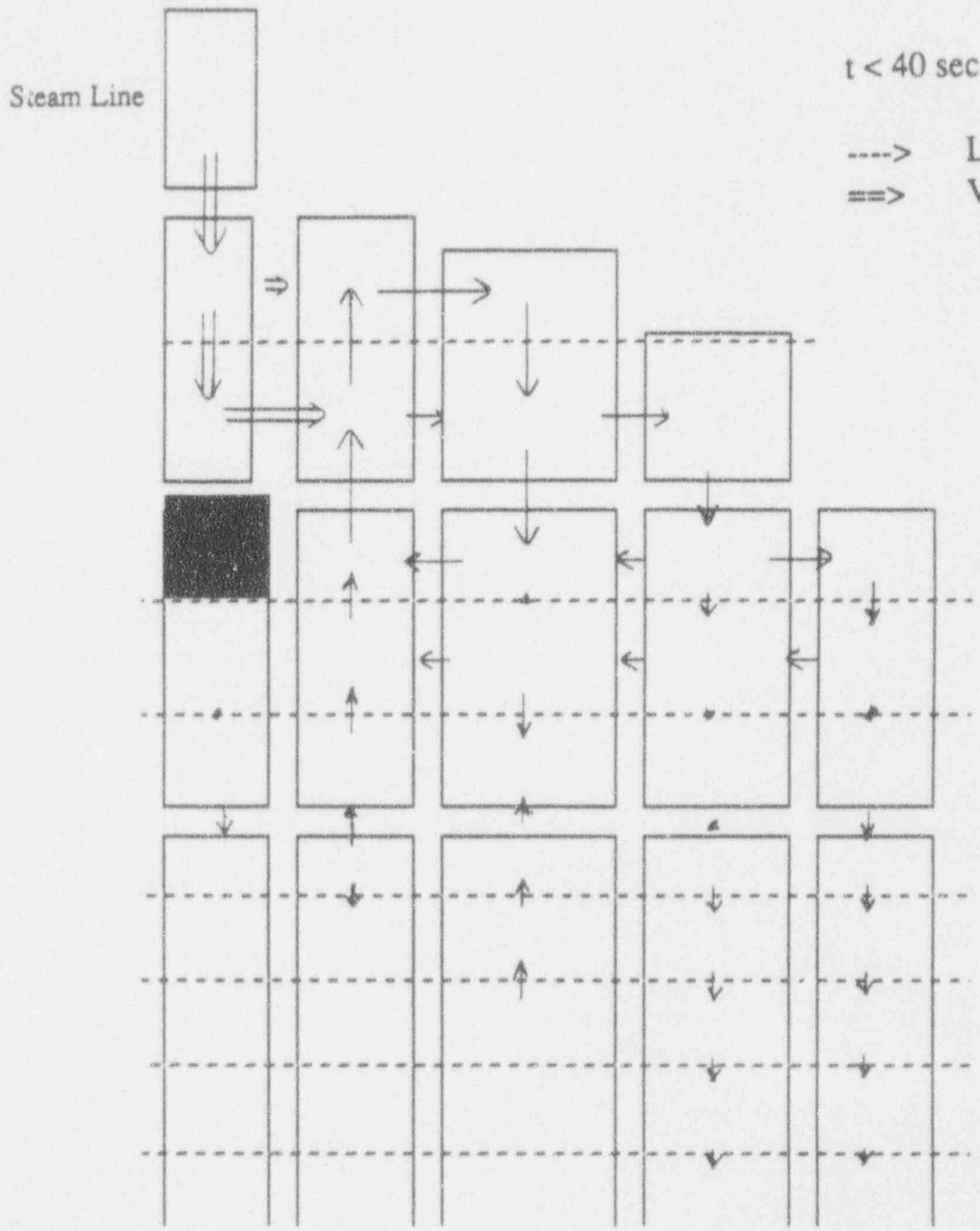


MASS FLOW (Analysis)

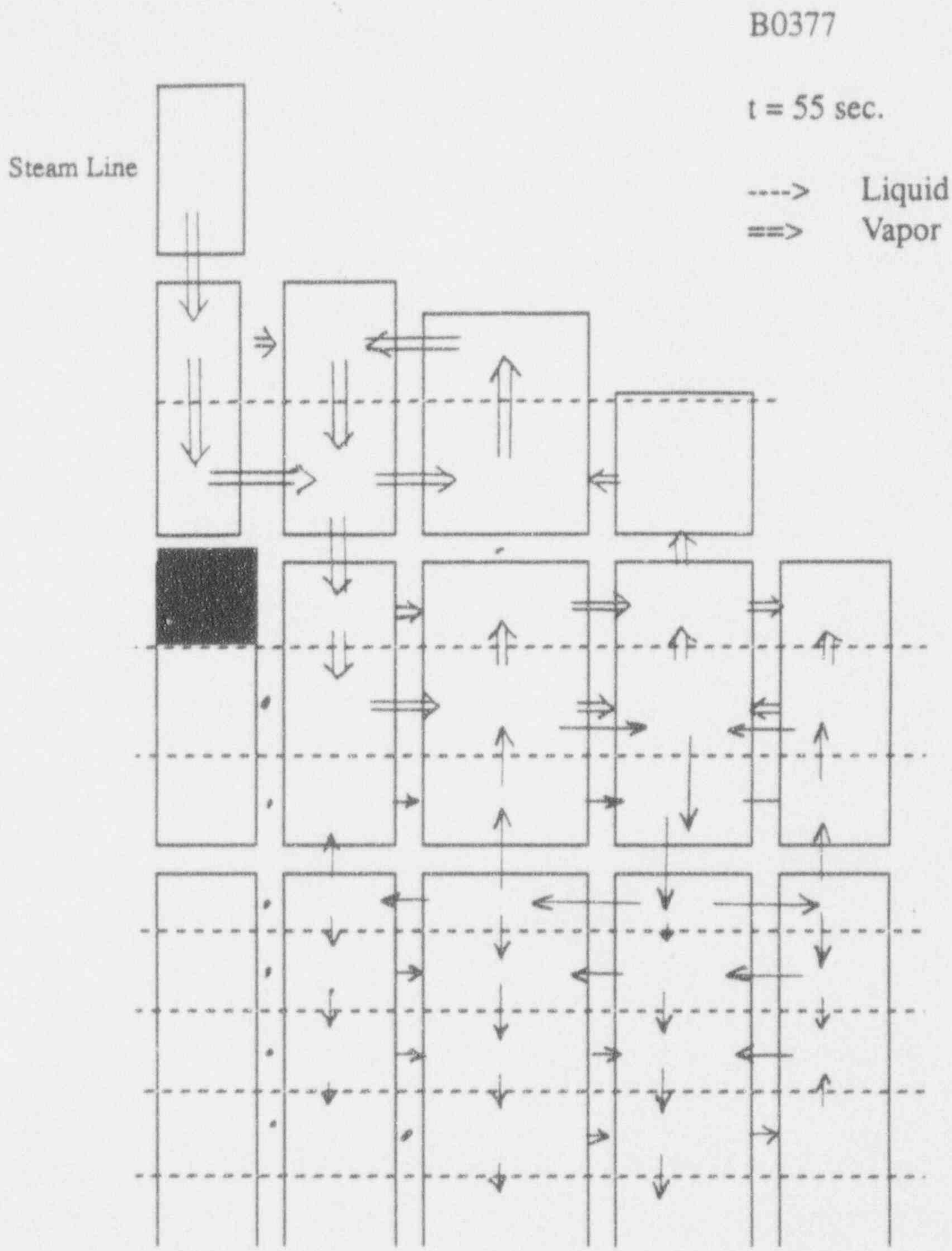
B0377

t < 40 sec.

----> Liquid
==> Vapor



MASS FLOW (Analysis)



CONCLUSIONS :

- o <u>W</u>COBRA/TRAC Vessel Component model captures the key phenomena observed in the test.

- o Condensation rates are significantly greater than the current code models.

- o Use of 3-D Vessel component model will support the application of One-dimensional TRAC and NOTRUMP models.

WCOBRA/TRAC 1-D COMPONENT MODELING OF CMT TEST

James P. Cunningham

Westinghouse Electric Corporation

March 14-15, 1994

WCOBRA/TRAC 1-D COMPONENT MODELING OF CMT TEST

Application of a standard safety analysis code with noding similar to a plant safety analysis

- Overall model and noding
- Results of Analysis compared to tests
- Conclusions

WCOBRA/TRAC 1-D COMPONENT MODEL DESCRIPTION

CMT

- Cell heights = SSAR model
- Detailed wall heat conduction. Heads are separated to model correct surface area and mass
- Constant wall condensation heat transfer coefficient
- Pressurizer-type level sharpening model
- Standard Best-Estimate interfacial heat transfer

WCOBRA/TRAC 1-D COMPONENT MODEL DESCRIPTION

Steam-water Reservoir
- Standard tee components for branching
- Detailed wall heat conduction

Piping

[ ] a,c

Valves
- Open slowly

Pressure boundary condition
- Supplies saturated steam to steam-water reservoir

CMT TEST WCOBRA/TRAC 1-D COMPONENT MODEL

a,c

Preliminary Results for Pre-operational Test B0377

CMT Cold Draindown 50 psig Nominal

——— PT1-ABS 1 2 377 S/W RES PRESS TO PCV
- - - - WC/T 1-D 10 2 reservoir pressure

a,b

Preliminary Results for Pre-operational Test B0377

CMT Cold Draindown 50 psig Nominal

———— PT5-ABS 1 2 377 CMT VESSEL PRESSURE

- - - - WC/T 1-D 15 1 CMT pressure

a,b

Preliminary Results for Pre-operational Test B0377

CMT Cold Draindown 50 psig Nominal

———	F-DIS	1	2	377 DISCHARGE LINE FLOW
- - - -	WC/T 1-D	15	1	Mass flow out of CMT

a,b

CMT Cold Draindown 50 psig Nominal

——— M-CMTOUT 1 2 377 CMT INT. OUTLET FLOW
– – – – WC/T 1-D 15 1 Integr.flow out of CMT

a,b

Preliminary Results for Pre-operational Test B0377

CMT Cold Draindown 50 psig Nominal

Comparison of Fluid temperatures in Upper half of CMT
——— Test temperature at 111.6 inch level TCBO
- - - - TLN 15 1 0 LIQUID TEMPERATURE

[ ]a,b

CMT Cold Draindown 50 psig Nominal

Comparison of Fluid temperatures in Upper half of CMT

——— Test temperature at 102.6 inch level TC33.61

- - - - TLN 16 1 0 LIQUID TEMPERATURE

a, b

Preliminary Results for Pre-operational Test B0377

CMT Cold Draindown 50 psig Nominal

Comparison of Fluid temperatures in Upper half of CMT

——— Test temperature at 80.5 inch level TC41.42

– – – – TLN 16 3 0 LIQUID TEMPERATURE

a,b

CMT Cold Draindown 50 psig Nominal

Comparison of Fluid temperatures in Upper half of CMT

——— Test temperature at 57.5 inch level TC46-48

- - - - TLN 16 5 0 LIQUID TEMPERATURE

[ ] a, b

WCOBRA/TRAC 1-D COMPONENT MODEL OF CMT TEST

Conclusions

The 1-D component model captures the key thermal/hydraulic effects, including the time of draindown, for this test.

Westinghouse will compare the model with tests over a wide range of conditions

NOTRUMP CALCULATIONS OF

PRE-OPERATIONAL TEST BO377

J. JAROSZEWICZ
INSTITUTE OF ATOMIC ENERGY, SWIERK/WARSAW

J. P. CUNNINGHAM

L. E. HOCHREITER

0756LH-031094

- THE CORE MAKEUP TANK TEST WAS MODELED WITH NOTRUMP USING THE SAME NODALIZATION AS THE SSAR CALCULATIONS

- PRE-OPERATIONAL CONSTANT PRESSURE CMT DRAINDOWN TEST B0377 WAS MODELED

- INITIAL CONDITIONS

  - CMT IS INITIALLY FULL FILLED WITH COLD WATER (TEMPERATURE OF WATER AND WALL ARE TAKEN FROM TEST DATA: b03 11-09-1993)
  - STEAM LINE 1 INITIALLY CLOSED, OPEN TO START TRANSIENT
  - STEAM/WATER RESERVOIR LIQUID LEVEL WILL BE ABOVE THE EXTENDED END OF STEAM LINE 2 PIPE (65 psi, SATURATED)
  - ACCUMULATOR FILLED DRY STEAM AT 65 psi
  - CMT DISCHARGE LINE IS OPENED

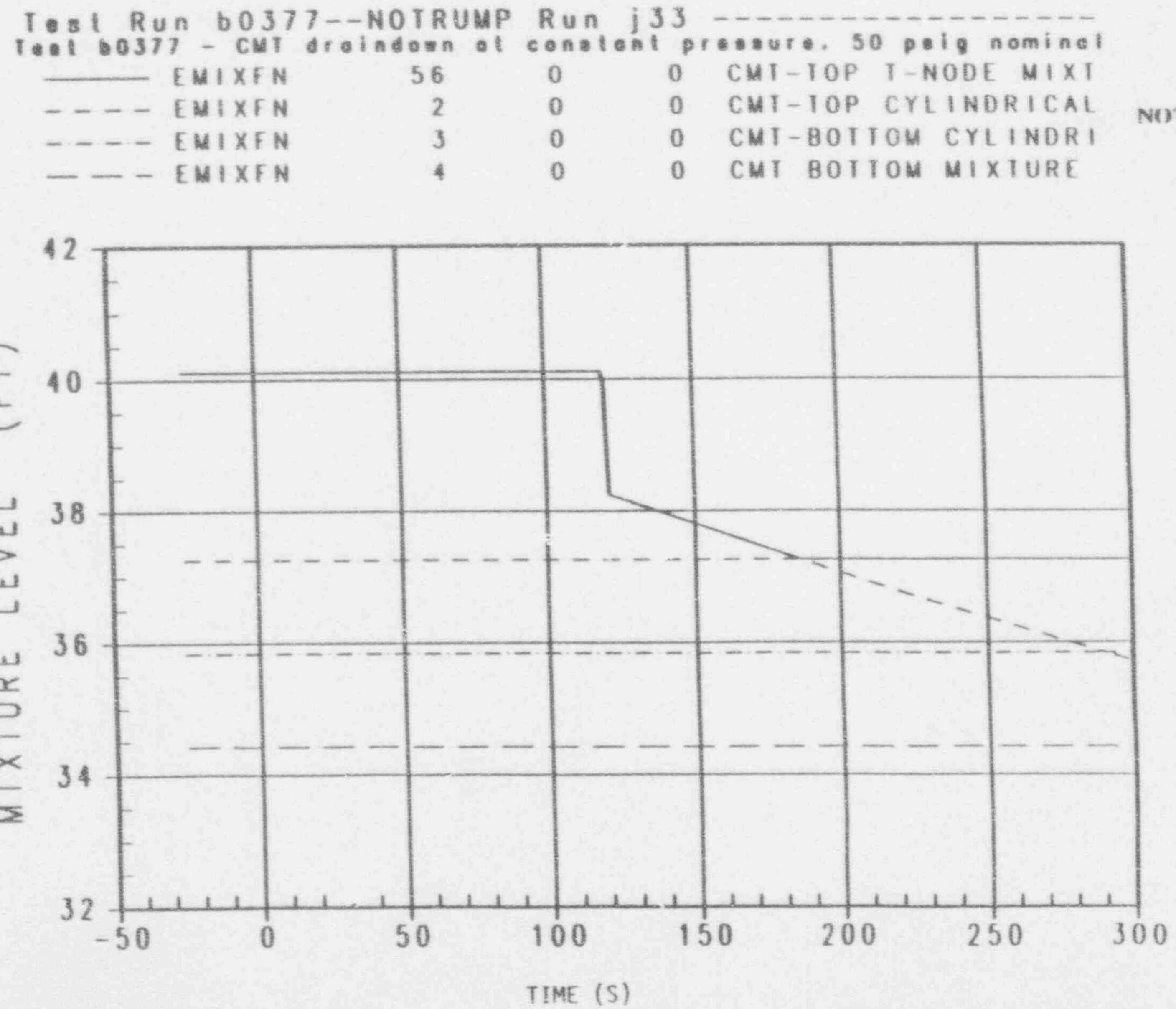
- TEST RUNS ARE INITIATED BY OPENING STEAM LINE NO. 1 AND INITIATED FLOW THROUGH DISCHARGE LINE TO STEAM/WATER RESERVOIR (AFTER 30.19 sec.)

a,c

Figure 1. CMT Test Facility - Noding scheme

a,c

Figure 2. CMT nodes: Fluid Nodes and Metal Nodes



Test Run b0377--NOTRUMP Run j33
Test b0377 - CMT draindown at constant pressure, 50 psig nominal
EMIXFN 56 0 0 CMT-TOP T-NODE MIXT
EMIXFN 2 0 0 CMT-TOP CYLINDRICAL
EMIXFN 3 0 0 CMT-BOTTOM CYLINDRI
EMIXFN 4 0 0 CMT BOTTOM MIXTURE
MIXTURE LEVEL (FT)
42
40
38
36
34
32
-50
0
50
100
150
200
250
300
TIME (S)

NOTRUMP

Test Run b0377--NOTRUMP Run j33 ---------------------

Test b0377 - CMT draindown at constant pressure. 50 psig nominal

———	PT5-ABS	1	2	377	CMT VESSEL PRESSURE
- - - -	PFN	56	0	0	CMT-TOP T-NODE PRES

a,b

AP600

Test Run b0377--NOTRUMP Run j33

Test b0377 - CMT draindown at constant pressure. 50 psig nominal

———	F-SL1-BE	1	2	377	S/L 1 BEST-EST FLOW
- - - -	WGFL	11	0	0	PIPE 11 TO CMT TOP

a,b

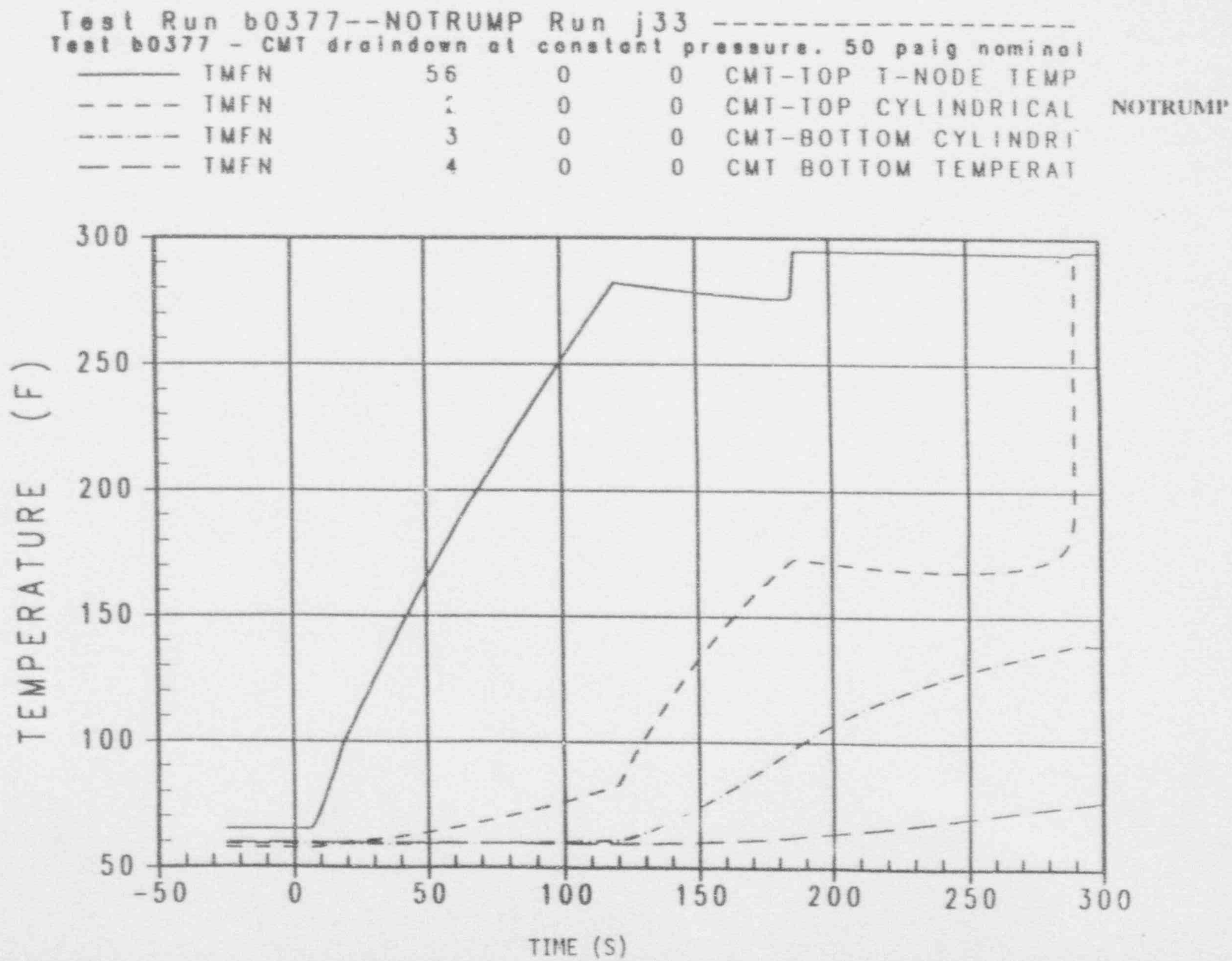
AP600

Test Run b0377--NOTRUMP Run j33

Test b0377 - CMT draindown at constant pressure. 50 psig nominal

———	F-DIS	1	2	377	DISCHARGE LINE FLOW
- - - -	WFL	4	0	0	CMT BOTTOM TO PIPE

a,b


Test Run b0377--NOTRUMP Run j33
Test b0377 - CMT draindown at constant pressure. 50 psig nominal
TMFN 56 0 0 CMT-TOP T-NODE TEMP
TMFN 2 0 0 CMT-TOP CYLINDRICAL
TMFN 3 0 0 CMT-BOTTOM CYLINDRI
TMFN 4 0 0 CMT BOTTOM TEMPERAT
TEMPERATURE (F)
TIME (S)
NOTRUMP

AP600 CMT Test
NOTRUMP Regions & Fluid Thermocouple Locations

a, c

CMT WITH T/C'S AVERAGED FOR NOTRUMP

Test Run b0377--NOTRUMP Run j33 ------------------

Test b0377 - CMT draindown at constant pressure. 50 psig nominal

———	T-CMT4-L	1	2	377	CMT S.R.4 TEMP
- - - -	TMFN	56	0	0	CMT-TOP T-NODE TEMP

a,b

CMT WITH T/C'S AVERAGED FOR NOTRUMP

Tes. Run b0377--NOTRUMP Run j33 ------------------

Test b0377 - CMT draindown at constant pressure. 50 psig nominal

———	T-CMT3-L	1	2	377	CMT S.R.3 TEMP
----	TMFN	2	0	0	CMT-TOP CYLINDRICAL

a,b

CMT WITH T/C'S AVERAGED FOR NOTRUMP

Test Run b0377--NOTRUMP Run j33 ------------------

Test b0377 - CMT draindown at constant pressure, 50 psig nominal

——— T-CMT2-L	1	2	377	CMT S.R.2 TEMP
- - - - TMFN	3	0	0	CMT-BOTTOM CYLINDRI

a,b

CMT WITH T/C'S AVERAGED FOR NOTRUMP

Test Run b0377--NOTRUMP Run j33 ------------------

Test b0377 - CMT draindown at constant pressure. 50 psig nominal

———	T-CMT1-L	1	2	377	CMT S.R.1 TEMP
- - - -	TMFN	4	0	0	CMT BOTTOM TEMPERAT

a,b

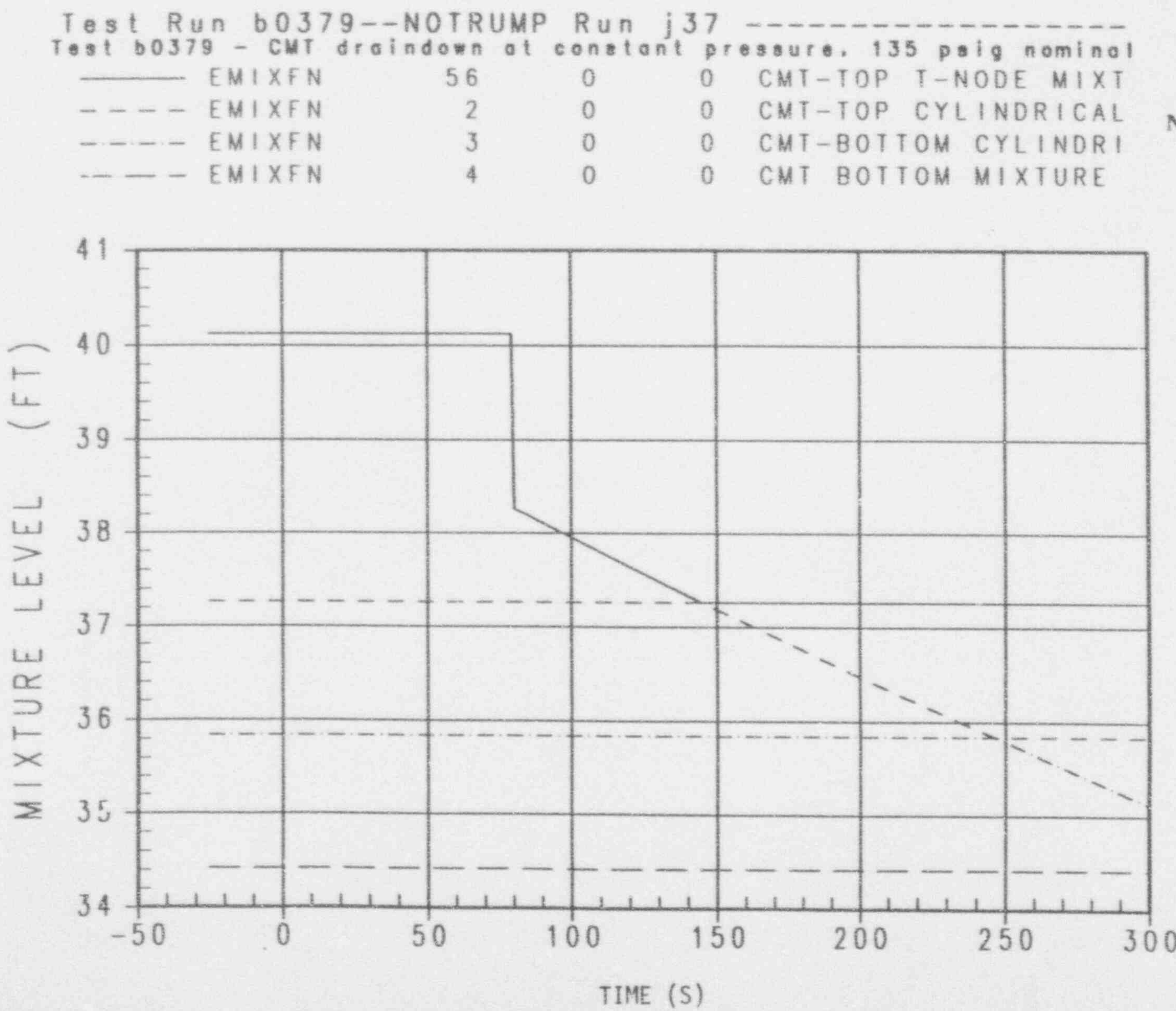
AP600 CORE MAKEUP TANK TEST - NOTRUMP CALCULATIONS

CMT DRAINDOWN TEST AT CONSTANT PRESSURE (test: b03?/?)

INITIAL CONDITIONS ARE AS FOLLOWS:

- CMT IS INITIALLY FULL FILLED WITH COLD WATER (TEMPERATURE OF WATER AND WALL ARE TAKEN FROM TEST DATA: b03 11-09-1993),
- STEAM LINE 1 INITIALLY CLOSED, OPEN TO START TRANSIENT,
- STEAM LINE 2 CLOSED,
- STEAM/WATER RESERVOIR LIQUID LEVEL WILL BE ABOVE THE EXTENDED END OF STEAM LINE 2 PIPE (135psig, SATURATED),
- ACCUMULATOR FILLED DRY STEAM AT 135psig,
- CMT DISCHARGE LINE IS OPENED.

TEST RUNS ARE INITIATED BY OPENING STEAM LINE NO.1 AND INITIATED FLOW THROUGH DISCHARGE LINE TO STEAM/WATER RESERVOIR (AFTER 30.19 sec). INITIAL TOTAL MASS FLOW RATE IS EQUAL 0 (i.e. WFL=0.0 FOR EACH FLOW LINK).


Test Run b0379--NOTRUMP Run j37
Test b0379 - CMT draindown at constant pressure, 135 psig nominal
EMIXFN 56 0 0 CMT-TOP T-NODE MIXT
EMIXFN 2 0 0 CMT-TOP CYLINDRICAL
EMIXFN 3 0 0 CMT-BOTTOM CYLINDRI
EMIXFN 4 0 0 CMT BOTTOM MIXTURE
MIXTURE LEVEL (FT)
TIME (S)
41
40
39
38
37
36
35
34
-50
0
50
100
150
200
250
300

NOTRUMP

Test Run b0379--NOTRUMP Run j37 ------------------

Test b0379 - CMT draindown at constant pressure. 135 psig nominal

———	PT5-ABS	1	2	379	CMT VESSEL PRESSURE
– – – –	PFN	56	0	0	CMT-TOP T-NODE PRES

a,b

Test Run b0379--NOTRUMP Run j37 ------------------

Test b0379 - CMT draindown at constant pressure. 135 psig nominal

———	F-SL1-BE	1	2	379	S/L 1 BEST-EST FLOW
- - - -	WGFL	11	0	0	PIPE 11 TO CMT TOP

a,b

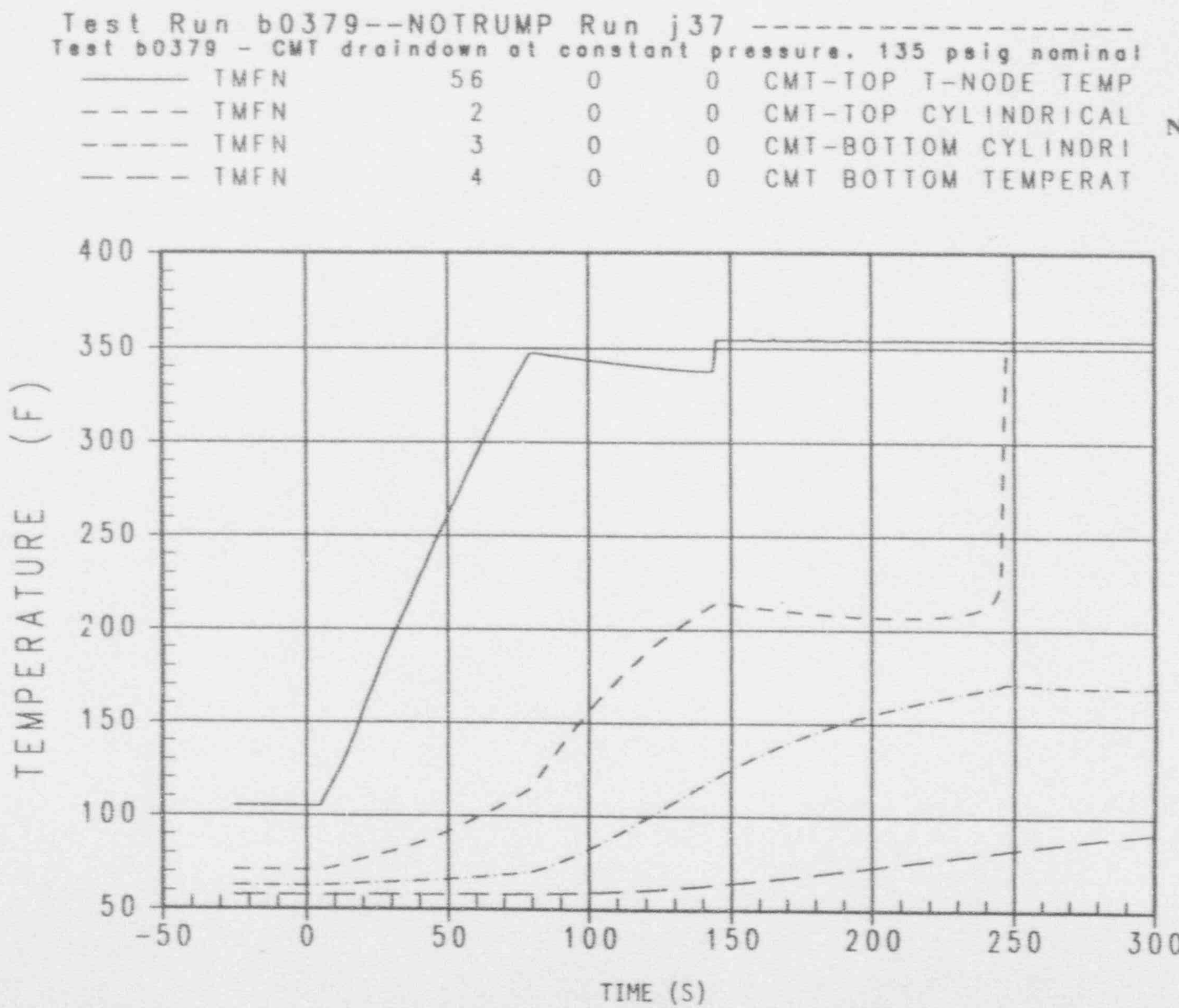
Test Run b0379--NOTRUMP Run j37 ------------------

Test b0379 - CMT draindown at constant pressure. 135 psig nominal

——— F-DIS 1 2 379 DISCHARGE LINE FLOW

- - - - WFL 4 0 0 CMT BOTTOM TO PIPE

a,b


Test Run b0379--NOTRUMP Run j37
Test b0379 - CMT draindown at constant pressure, 135 psig nominal
TMFN 56 0 0 CMT-TOP T-NODE TEMP
TMFN 2 0 0 CMT-TOP CYLINDRICAL
TMFN 3 0 0 CMT-BOTTOM CYLINDRI
TMFN 4 0 0 CMT BOTTOM TEMPERAT
TEMPERATURE (F)
400
350
300
250
200
150
100
50
-50
0
50
100
150
200
250
300
TIME (S)

NOTRUMP

Test Run b0379--NOTRUMP Run j37 ------------------

Test b0379 - CMT draindown at constcn; pressure, 135 psig nominal

————	T-CMT4-L	1	2	379	CMT S.R.4 TEMP
- - - -	TMFN	56	0	0	CMT-TOP T-NODE TEMP

a,b

Test Run b0379--NOTRUMP Run j37 ------------------

Test b0379 - CMT draindown at constant pressure. 135 psig nominal

——— T-CMT3-L 1 2 379 CMT S.R.3 TEMP

- - - - TMFN 2 0 0 CMT-TOP CYLINDRICAL

a,b

Test Run b0379--NOTRUMP Run j37 ------------------

Test b0379 - CMT draindown at constant pressure, 135 psig nominal

———— T-CMT2-L	1	2	379	CMT S.R.2 TEMP
- - - - TMFN	3	0	0	CMT-BOTTOM CYLINDRI

a,b

Test Run b0379--NOTRUMP Run j37 ------------------
Test b0379 - CMT draindown at constant pressure, 135 psig nominal

———	T-CMT1-L	1	2	379	CMT S.R.1 TEMP
- - - -	TMFN	4	0	0	CMT BOTTOM TEMPERAT

a,b

CONCLUSIONS

- COARSE NODING USED IN NOTRUMP CAPTURES THE KEY THERMAL-HYDRAULIC BEHAVIOR IMPORTANT FOR PWR ANALYSIS

  - RAPID CONDENSATION -----> STEAM FLOW
  - DELAY IN INJECTION
  - HEATUP OF UPPER NODE

- BASIS FOR THERMAL-HYDRAULIC PROCESSES WERE SHOWN IN MORE DETAILED CALCULATIONS

- TWO STEP APPROACH:

  - MORE DETAILED CALCULATIONS FOR UNDERSTANDING
  - SIMPLER MODELS FOR PLANT ANALYSIS

- APPROACH WILL BE VERIFIED WITH INTEGRAL TESTS

INTEGRATION OF TESTS/ANALYSIS FOR CMT

L. E. HOCHREITER
NUCLEAR SAFETY ANALYSIS AND STRATEGIC DEVELOPMENT

- INTEGRATION OF TEST/ANALYSIS FOR CMT
  - OBJECTIVE IS TO USE THE CMT TEST TO DEVELOP/VERIFY THE CMT MODELS IN NOTRUMP AND WCOBRA/TRAC
    - BOTH CODES WILL BE USED TO MODEL THE TESTS
    - CODE-TO-CODE COMPARISONS WILL BE PERFORMED
    - TESTS WILL COVER ALL OPERATING MODES OF CMT
  - USING THE FINAL MODELS FROM THE CMT TESTS;
    - SPES SYSTEMS TESTS AND OSU SYSTEMS TESTS WILL BE ANALYZED
    - BLIND TEST ANALYSES ARE PLANNED
    - IF DEFICIENCIES EXIST, FOR THIS MODEL, THE ORIGINAL CMT TESTS WILL HAVE TO BE REINVESTIGATED
    - THE INTENT IS TO NOT USE THE SPES OR OSU DATA TO ADJUST MODELS BUT TO USE THESE TESTS FOR VERIFICATION

SUMMARY

SUMMARY

AP600

- CMT SCALING LOGIC INDICATES THAT THE TEST WILL CAPTURE THE KEY THERMAL-HYDRAULIC PHENOMENA

- CMT TEST IS OPERATIONAL AND IS PRODUCING USEFUL DATA

- DATA ANALYSIS OF THE TESTS IS PROGRESSING AND WE CAN CALCULATE THE THERMAL-HYDRAULIC PARAMETERS OF INTEREST FROM THE DATA

- ANALYSIS OF THE CMT TESTS IS ALSO IN PROGRESS

  - DETAILED ANALYSIS WILL BE USED TO HELP UNDERSTAND THE DATA AND CMT BEHAVIOR AND TO SUPPORT THE APPLICATION OF SIMPLER MODELS FOR PLANT ANALYSIS