Westinghouse Electric Corporation
Energy Systems

Box 355
Pittsburgh Pennsylvania 15230-0355

AW-94-693

July 29, 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 JULY 26-JULY 28, 1994 MEETINGS ON AP600 PASSIVE CONTAINMENT COOLING SYSTEM ANALYSES

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 customarily 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-94-693 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-94-693 and should be addressed to the undersigned.

Very truly yours,

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

/nja

cc: Kevin Bohrer NRC 12H5

1972A

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

Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

Sworn to and subscribed
before me this 28 day
of July, 1994

Rose Marie Payne
Notary Public

Notarial Seal
Rose Marie Payne, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Nov. 4, 1995
Member, Pennsylvania Association of Notaries

(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-94-4241, July 29, 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.

WESTINGHOUSE ELECTRIC CORPORATION

PRESENTATION
TO
UNITED STATES
NUCLEAR REGULATORY COMMISSION

AP600 Passive Containment Cooling System (PCS) Scaling - Iteration 1 Report Review Kickoff Meeting

MONROEVILLE, PA

JULY 26, 1994

Enclosure 4 to NTD-NRC-94-4241

AGENDA

WESTINGHOUSE/NRC MEETING
AP600 PCS Scaling - SASM Iteration 1 Report Review Kickoff

8:30	Introduction	J. Butler
8:45	Review of Westinghouse PCS Model Development and Scaling - Overview of PCS Scaling and WGOTHIC Validation - Review of Information Exchange Schedule in Support of Review - Phenomenological Report Status and Schedule - Scaling Report Schedule and Review Process	J. Woodcock
9:15	Method for Determining Film Flow Coverage for the AP600 PCCS	R. Wright
10:15	BREAK	
10:30	NRC Phenomenological Report Review Status / Comments	NRC
11:00	Preliminary Report on AP600 Scaling	D. Spencer
12:00	LUNCH	
1:00	Preliminary Report on AP600 Scaling (continued)	D. Spencer
3:00	NRC AP600 PCS Scaling Status	NRC
3:30	Meeting Wrapup, Action Items	All

INTRODUCTION

J. C. BUTLER
ADVANCED PLANT SAFETY AND LICENSING

REVIEW OF AP600 PCS MODEL DEVELOPMENT AND SCALING

J. WOODCOCK
CONTAINMENT AND RADIOLOGICAL ANALYSIS

OUTLINE

- Overview of PCS scaling and WGOTHIC validation process
- Review of "Information Exchange Schedule in Support of AP600 PCS Review," Revision 1
- Schedule status
  - Phenomenologica reports
  - PCS scaling report

Scaling

PIRT

Phenomena models
- Separate effects tests
- Select & validate correlations
- Identify impacts of any local model distortions

Π Groups

Compare LST thermal- hydraulics to AP600

Identify any distortions
- small
- can be factored into AP600 analysis

WGOTHIC development

WGOTHIC modelling of integral test (LST)

Code Matches LST

Contributions of all relevant important phenomena are understood	WGOTHIC can be used to extrapolate tests to AP600	Firm basis exists to extend test results to AP600

Scaling Application Example Objectives

Scaling

PIRT

Phenomena models

- Separate effects tests
- Select & validate correlations
- Identify impacts of any local model distortions

- **Outcome is phenomena reports, such as**
  - **liquid film heat transfer model**
  - **fog in the annulus**

Π Groups

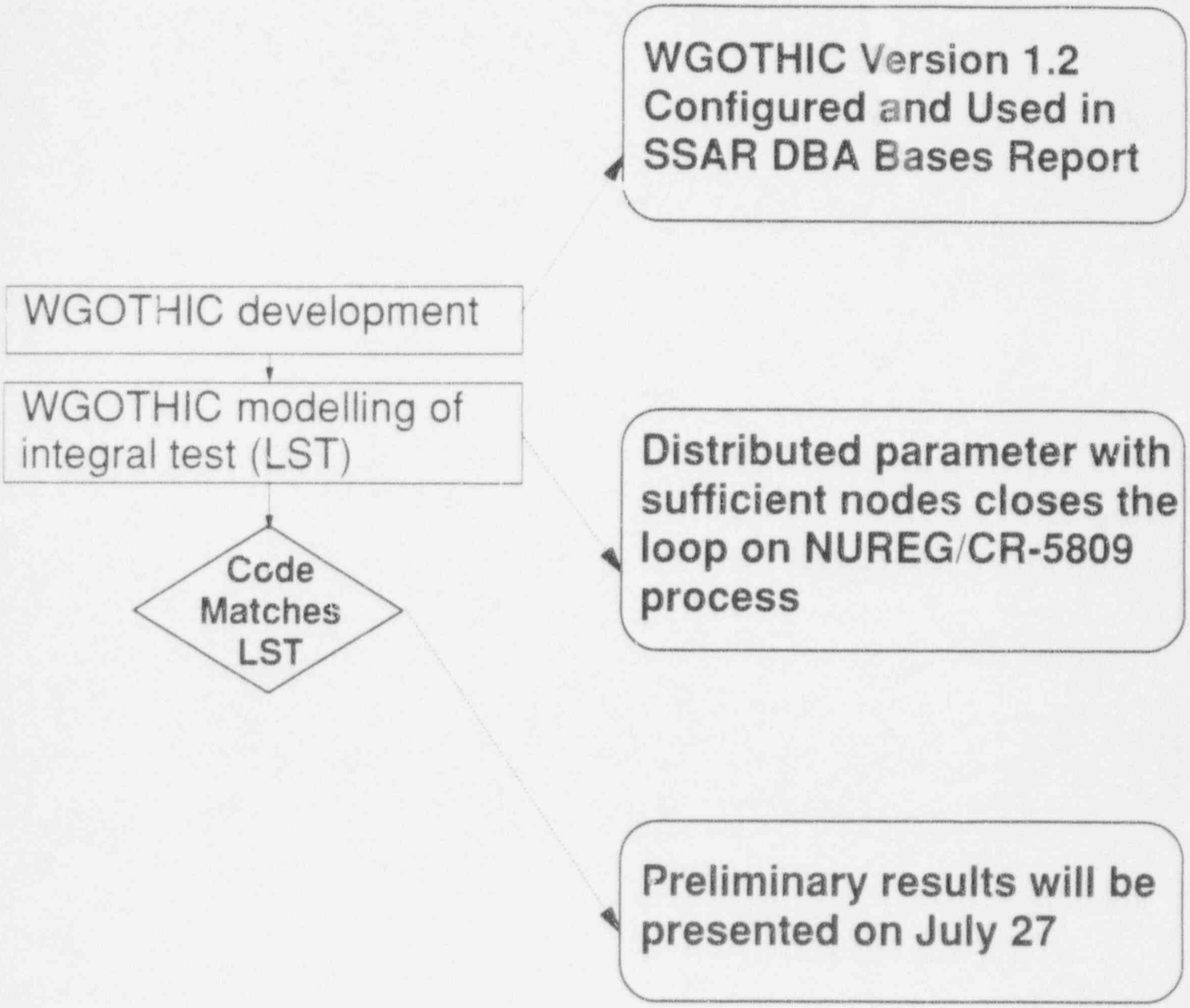
Compare LST thermal- hydraulics to AP600

Identify any distortions

- small
- can be factored into AP600 analysis

- **Ratio of Π groups from test to AP600 defines "distortions"**
- **Simple correlation models can be used to assess LST to AP600 comparisons, such as buoyant jet behaviour**

WGOTHIC Development / Distributed Parameter Modeling



Example Applications of Building Blocks

Contributions of all relevant important phenomena are understood	WGOTHIC can be used to extrapolate tests to AP600	Firm basis exists to extend test results to AP600

WGOTHIC Design Basis Analyses

- **Develop noding requirements from LST**
- **Assess effects of using simplified lumped parameter noding using LST model**
- **LST sensitivities apply to plant**
  - **parametric tests**
  - **WGOTHIC LST model sensitivities**

CONCLUSIONS

- The role of the LST in code validation has been defined
- The basis for using distributed parameter WGOTHIC model of LST has been defined
- The approach to develop simplified lumped parameter WGOTHIC noding based on LST models and comparison to distributed parameter model has been provided
- A framework has been identified in which to address all significant issues raised to date
- The PCS information exchange process is on schedule

Method for Determining Film Flow Coverage for the AP600 Passive Containment Cooling System

RICK WRIGHT
CONTAINMENT AND RADIOLOGICAL ANALYSIS

OVERVIEW

- NRC Request for Additional Information, Question 480.17
- Status of Work to Date
- Response to the RAI
- Conclusions and Recommendation

Question 480.17

External Film Pattern/Water Distribution Tests

Provide additional information on the external film/water distribution that is expected for the AP600. The Waltz Mill tests were done using a steel shell at ambient temperature. Will the film pattern be affected by heating of the shell? Is there a difference in the film behavior in the large scale test facility in cases where the shell is not heated, versus cases where the shell is heated?

Response:

The SSAR containment analyses assumed the containment wetting increased from 40% at the top to 70% over the outer portions of the dome and the side walls. These wetting fractions were determined from the Water Distribution System Test - Phase 2[1]. Reference 2, attached, presents the results of calculations with WGOTHIC which show that pressures within containment remain within acceptable limits for a case with wetting ~~from~~ 20% on the dome ~~to~~ and 40% on the side walls.

The full scale (cold) Phase 3 wetting tests at Waltz mill and the 1/8 scale heated tests are both ongoing. After completion of these tests, additional information for the hot AP600 coverage and the acceptance limits for coverage will be provided to the NRC in a revised RAI in August, 1994.

References

1. Letter, N. J. Liparulo to R. W. Borchardt (NRC), "AP600 Design and Design Certification Test Program Overview", Table 3, Revision 3, August 13, 1993.

2. M. E. Wills, D. L. Paulsen, V. Notini, G. Invernali, "Effectiveness of External Cooling and Associated Studies on W AP600 Passive Plant", INC Conference, Toronto, October 1993.

STATUS OF WORK TO DATE

- Water Distribution Tests

  - Full scale section of AP600 dome - for determining coverage
  - Un-heated
  - Prototypic flow rates
  - Phase 2 tests resulted with early weir design resulted in:

    40% Coverage for Dome
    70% Coverage for Vertical Wall

  for initial full flow

- Recently completed Phase 3 tests

  - Much more uniform flow on dome
  - 100% coverage for design flow
  - Observed flow splitting for low flow rates

STATUS OF WORK TO DATE (continued)

AP600

- Large Scale Tests
  - Heated
  - Water distribution system not uniform
  - Observed varying degrees of coverage depending on water flow and heat flux

- WGOTHIC Coverage Sensitivity Study[1]
  - Analysis shows that a large variation in coverage fraction results in a small change in the containment pressure (i.e. coverage fractions reduced from 40%-70% to 20%-40% resulted in an increase of 2 psia in the peak containment pressure)

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[1] Wills, M.E., et.al., "Effectiveness of External Cooling and Associated Studies on Westinghouse AP600 Passive Plant", INC Conference, Toronto, Ont., October 1993.

RESPONSE TO THE RAI

- Develop a model to predict coverage in AP600
- Validate model against available test data
- Show applicability to the AP600 containment
- Predict AP600 coverage fractions for expected accident conditions
- Assess the impact (if any) on containment response due to changes in coverage

COVERAGE MODEL DEVELOPMENT

- Local film thickness model
  - Film is applied at the center of the dome at a given flow rate
  - Film thins as the water flows radially outward over the dome due to the surface area change and evaporation
  - Film thins as the water flows down the vertical wall section due to evaporation

$$\Gamma_i = \frac{\dot{m}_i}{2\pi r_i}$$ Film flow rate over dome

$$\dot{m}_i = \dot{m}_{i-1} - \frac{q''_i \Delta A_i}{h_{fg}}$$ Evaporation loss

COVERAGE MODEL DEVELOPMENT

AP600

- Search of applicable film stability models
- Zuber-Staub[2] model - minimum film thickness for stable flow
  - Force balance on the liquid interface
  - Modified to include changing angle of inclination
  - Vapor thrust term is negligible - low heat flux and high flow

Momentum + Static Pressure = Surface Tension + Thermocapillary Force

$$\frac{\rho}{15}\left[g\sin\beta\,\frac{\rho}{\mu}\right]^2\delta^4 + \rho g\cos\beta\,\frac{\delta}{2} = \frac{\sigma(1-\cos\theta)}{\delta} + \frac{d\sigma}{dT}\frac{q''}{k}\cos\theta$$

$$\delta = \left[\frac{3\Gamma_{min}\mu}{g\rho^2}\right]^{1/3}$$ **Minimum Film Thickness**

Zuber, N. and Staub, F.W., "Stability of Dry Patches Forming in Liquid Films Flowing Over Heated Surfaces", Int. J. Heat Mass Transfer, Vol. 9, pp 897-906, 1966.

COVERAGE MODEL DEVELOPMENT

- To determine the local minimum stable film thickness, must know
  - Fluid properties: ρ, μ, σ
  - Surface orientation, β
  - Film thickness, δ (or Γ)
  - Heat Flux
  - Contact wetting angle for the surface, θ
- Define the ratio between the minimum film thickness, Γ_{min}, and the local film thickness, Γ

$$R = \frac{\Gamma}{\Gamma_{min}}$$

- The Zuber-Staub model for a smooth surface determined that for R>1.0, the film would remain stable

DETERMINATION OF THE CONTACT WETTING ANGLE

- No information available from paint vendor

- Wetting angle measured using an optical comparator

  - Heated and unheated surface
  - Weathered and unweathered surface

- All measurements indicate that a contact wetting angle ranging from

  $$\theta = [\qquad]^{a,c}$$

  should be used in the film stability analysis

CONTACT WETTING ANGLE

TEST RESULTS

Description of Test	Contact Angle Weathered Sample	Contact Angle Unweathered Sample
2. Room Temperature, T=80°F		(a,c)
3. Heated, T=110°F		
4. Heated, T=180°F t=0 sec.		
t=15 sec.		
t=30 sec.		
t=60 sec.		

COVERAGE MODEL DEVELOPMENT

- Two modifications to the Zuber-Staub model are proposed

  1. Determine the value of R where the flow becomes unstable for a non-smooth surface with local variations in roughness resulting in local flow maldistribution, R_{ref}.

  2. Develop a method for adjusting the flow coverage if the local value of R is less than R_{ref}

  For unstable films:

$$\phi_{i+1} = \frac{\phi_i R_i}{R_{ref}}$$

- Thus for an unstable evaporating film, the coverage fraction decreases continually

- 16 Large Scale Heat Transfer Tests are predicted using various values of R_{ref}

- $R_{ref} = [\quad]^{(a,c)}$ conservatively predicts the LST coverage results

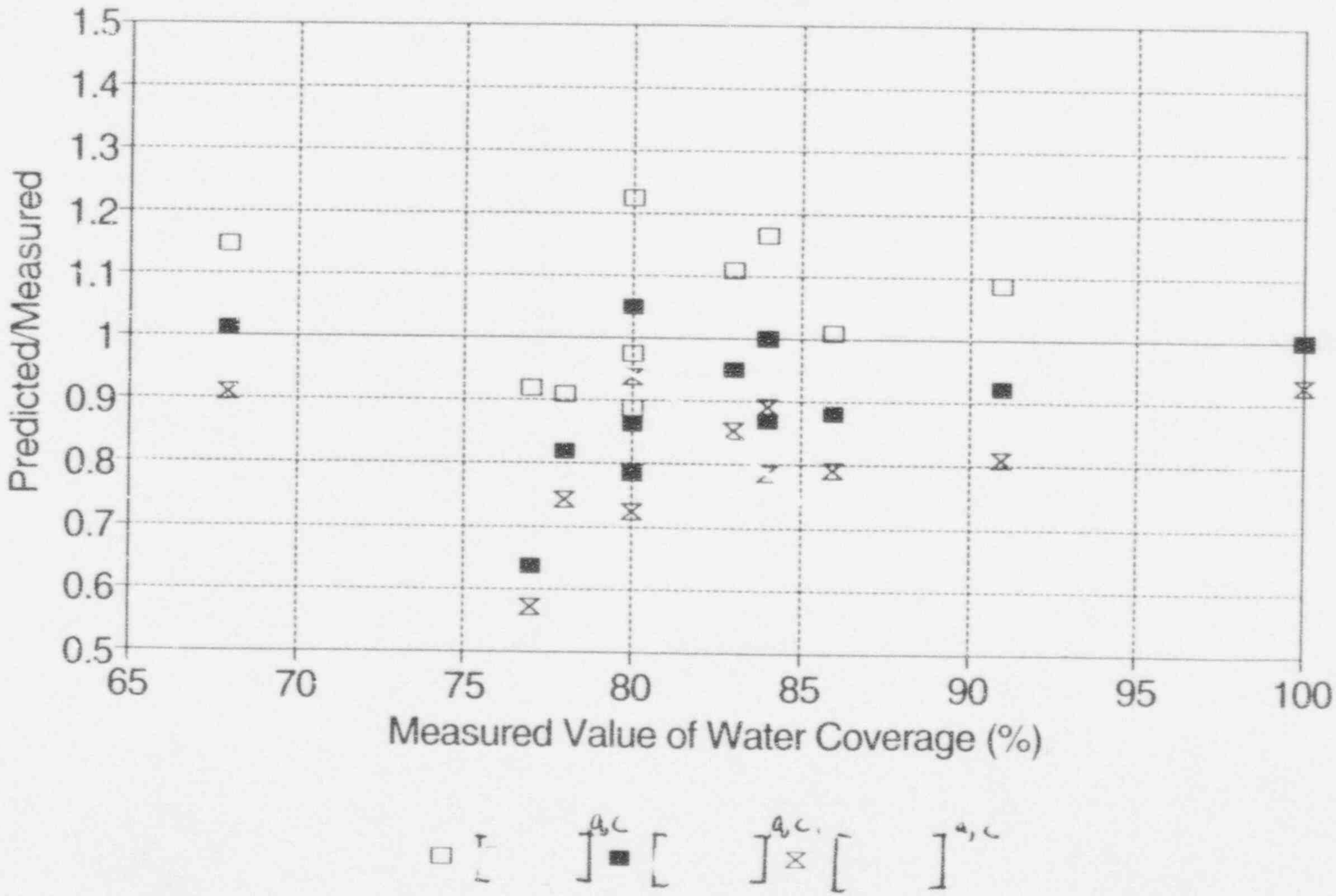
AP600 LARGE SCALE AND WATER DISTRIBUTION TESTS

Key Parameters

Parameter		Large Scale Tests	AP600 Water Distribution
Dome Major Axis (a)			
Dome Minor Axis (b)			
Vertical Wall Beneath Dome			
Water Flow Rate			
Initial Water Temperature			
Contact Wetting Angle			
Peak Heat Flux			
Heat Flux Distribution	β=0° (Top)		
	β=24°		
	β=48°		
	β=72°		
	β=90°		
	Vertical		

(a,c)

Predictions of LST Water Coverage
Zuber-Staub, Varying Reference R Value



ANALYTICAL PREDICTIONS OF AP600 PCS TEST RESULTS

Large Scale Tests (Heated)			
Test	Description	Predicted Coverage	Measured Coverage
R9L	Pressure = 10 psig		
R10L	Pressure = 30 psig		
R8L	Pressure = 43 psig		
R17AL	Pressure = 10 psig		
R34L	Pressure = 31 psig		
R27L	Pressure = 40 psig		
R24L	Pressure = 30 psig		
R23L	Pressure = 30 psig		
R26L	Pressure = 30 psig		
R21L	Pressure = 31 psig		
R22L	Pressure = 31 psig		
R28AL	Pressure = 40 psig		
R28L	Pressure = 40 psig		

(a,c)

AP600 Water Distribut … eated)			
WDT14	Flow = 55 GPM		
WDT10	Flow = 100 GPM		
WDT9	Flow = 220 GPM		
WDT11	Flow = 280 GPM		

(a,c)

AP600

a,c

APPLICABILITY TO AP600

- Proposed model depends on *local* parameters to determine stability
- Film spreading and evaporation models valid for any size containment structure
- Model is applicable for Large Scale Test and AP600

AP600 WATER COVERAGE UNDER ACCIDENT CONDITIONS

- The model can be used to calculate the AP600 water coverage expected during a postulated accident
  - Use water flow and heat flux from WGOTHIC analysis
  - Determine the water coverage for each mass flow and heat flux pair for each position along the dome and down the cylinder wall

- These values will be compared to those assumed in the SSAR analysis

a,c

COVERAGE FRACTIONS FOR DESIGN BASIS ACCIDENT

Time Hr	Flow lbm/s	q'' $\frac{Btu}{s\text{-}ft^2}$	Dome (%) Top	Dome (%) Mid	Dome (%) Bot	Cylinder (%) Top	Cylinder (%) Mid Top	Cylinder (%) Mid Bot	Cylinder (%) Bot	Exit
0.183	30.4	.990								
2.167	29.7	.728								
5.167	28.7	.473								
5.667	15.7	.473								
9.167	15.3	.393								
15.17	14.7	.331								
21.17	14.1	.301								
26.17	11.8	.288								

(a,c)

a,c

a,c

(a,c)

CONCLUSIONS AND RECOMMENDATIONS

- A model has been developed to predict the onset of film flow instability, and to predict water coverage
- The model has been validated against test data
- The model has been used to predict water coverage for the AP600 during postulated accident conditions
- Coverage values, while different from what's used in the SSAR analysis, are adequate to limit the containment pressure and temperature
  - WGOTHIC water coverage sensitivity study
  - Subsequent analysis with new coverage values confirms this to be true

NRC PHENOMENOLOGICAL REPORT REVIEW STATUS / COMMENTS

NRC

A PRELIMINARY REPORT ON AP600 SCALING

D. R. SPENCER
CONTAINMENT AND RADIOLOGICAL ANALYSIS

Scaling Analysis Approach

Part 1. Perform a scaling analysis of the AP600 PCS following the procedure specified in NUREG/CR-5809.

- **I. Safety Issue Accident Specification and Phenomena Evaluation.**
- **II. Perform Top-Down Scaling Analysis.**
- **III. Perform Bottom-Up Scaling Analysis**
- **IV. Develop Closure Relationships.**
- **V. Calculate Scaling Group Values**

Part 2. Ongoing Scaling activities:

- **I. Develop an independent computer model and compare to AP600 (WGOTHIC) and to selected large scale tests.**
- **II. Apply the results of the scaling analysis to the large scale tests to assess the extent to which they support the prototype.**

Part 1: I. Safety Issue Accident Specification and Phenomena Evaluation

1. Issue and Success Criteria

A group of design basis accidents known as high energy line breaks have the potential to challenge the design pressure of nuclear reactor containment. With no other active heat removal systems operational, the AP600 passive containment cooling system will:

Prevent the peak containment pressure from exceeding its design pressure, and

Reduce the peak pressure at 24 hours to less than half the design pressure.

2. Event Scenario

A high energy line, either a reactor cooling system line, or a steam line, breaks releasing steam and water to containment.

3. Nuclear Power Plant

The plant is the 2-loop Westinghouse AP600 with a passive containment cooling system. A schematic of the PCS is presented in Figure 1.

4. Accident Path

With the reactor at rated power a double-ended cold leg guillotine rupture occurs in a steam generator compartment. No active containment cooling systems are operational. The RCS blows down, followed by the direct injection into the reactor of water stored in the accumulators, the core makeup tanks and the IRWST.

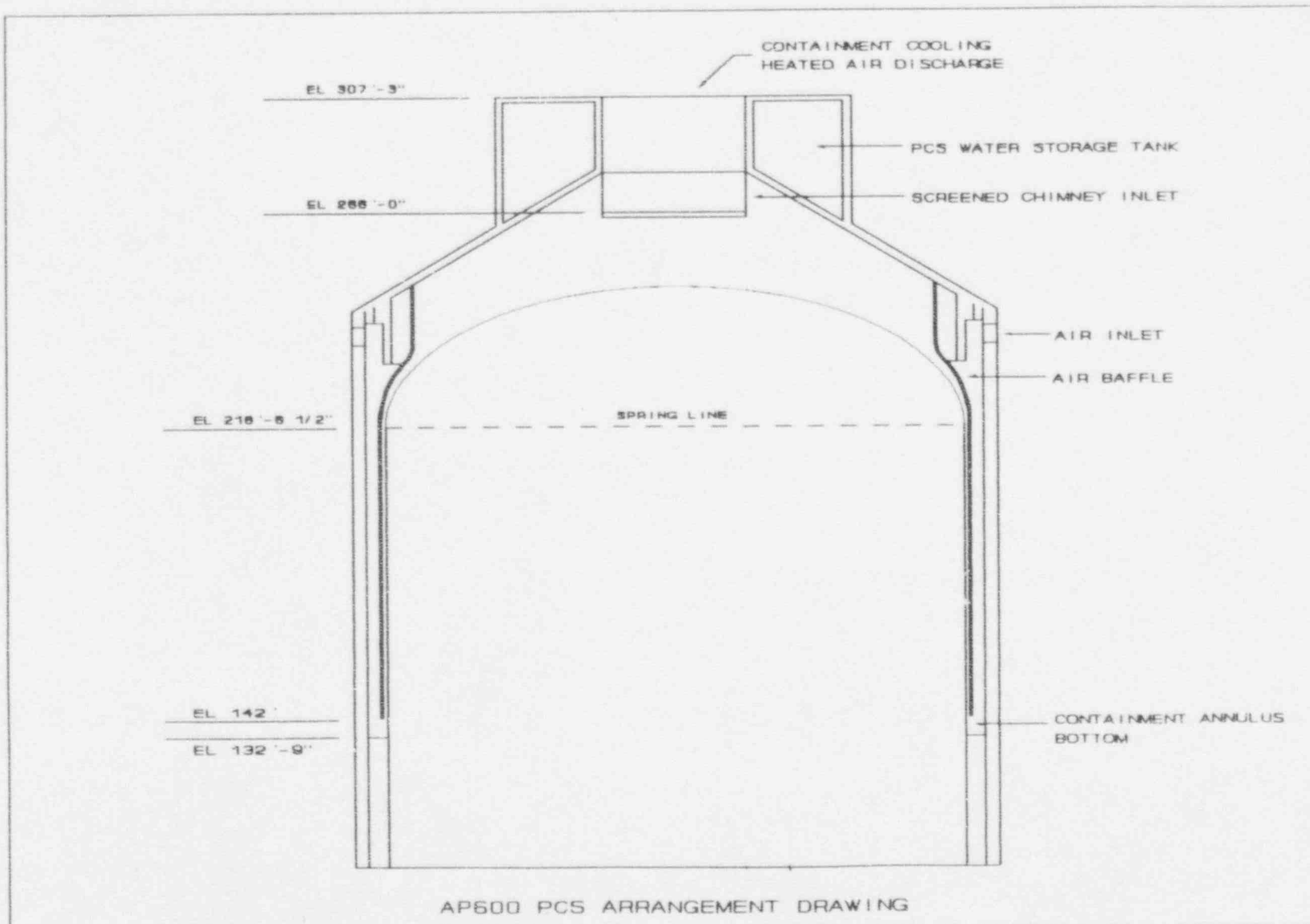


Figure 1 Schematic Drawing of AP600 Passive Containment Cooling System

5. Phenomena Identification and Ranking Table (PIRT)

The PCS is partitioned spatially and temporally to facilitate identification of important phenomena.

Spatial partitions separate the inside and outside of containment. Inside containment may be further partitioned into regions and/or compartments. Outside containment can be partitioned into the downcomer and riser. Each spatial partition can be characterized by phenomena specified for a "module" in Figure 2.

Temporal partitions include the time before external wetting, during which the inside of containment responds almost as though the outside surface of containment was adiabatic, and the blowdown phase during which mass and energy releases are at least two orders of magnitude greater than post-blowdown.

The PIRT is presented in Table I.

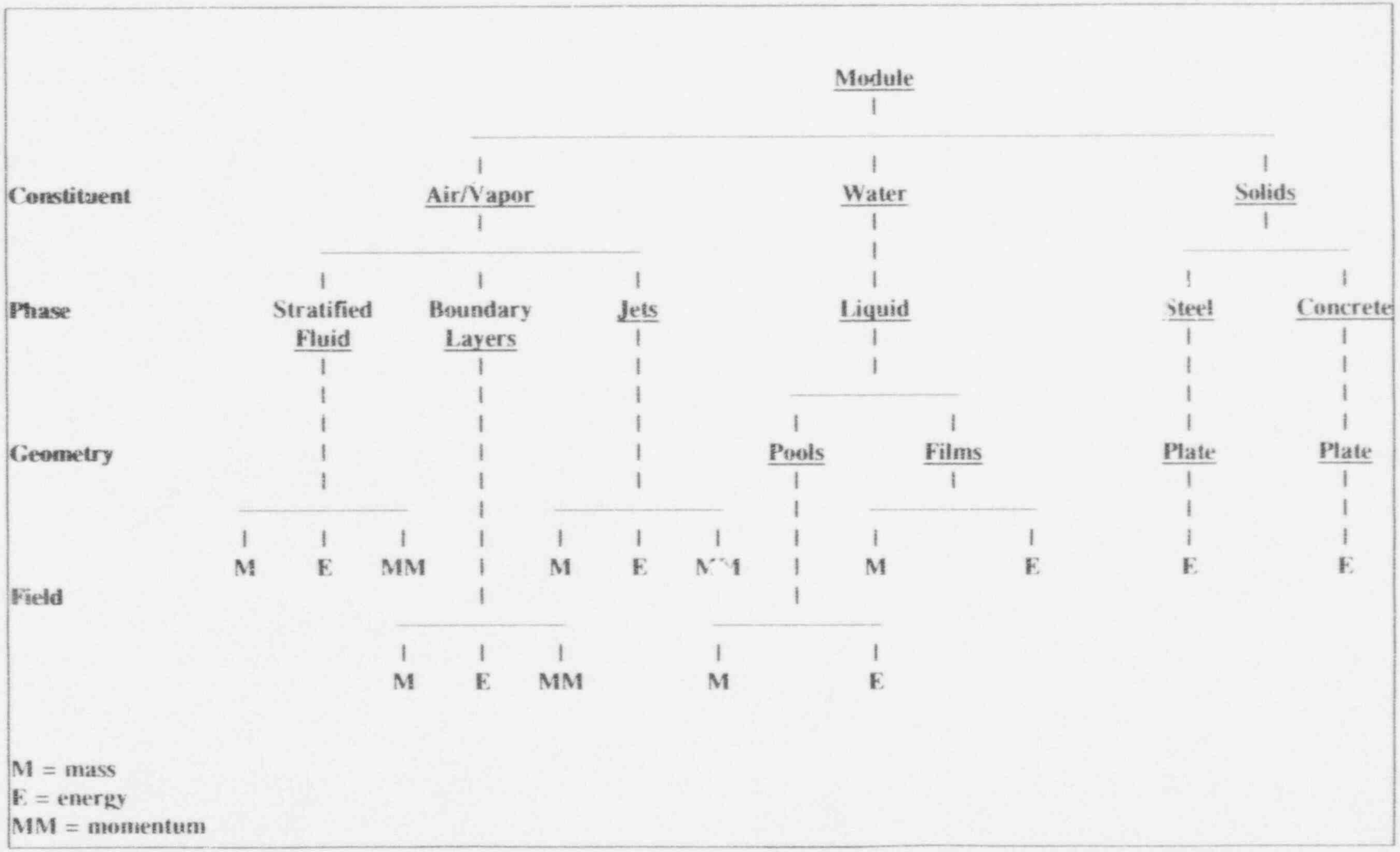


Figure 2 Module Decomposition and Architecture

Table 1
PCS Phenomena Identification and Ranking Table

Comp	Phenomena	Blow	Post-Blow/Pre-Wet			Post-Wet		
		inter	inter	riser	dwn comr	inter	riser	dwn comr
Module volume	Two component compressible gas							
	Jets							
	Buoyant plumes							
	Wall plumes							
	Stratification							
	Jet-plume mixing/entrainment							
	Steam source superheating							
	Flow field stability							
Module surface	Liquid film heat transfer							
	Liquid film stability							
	Liquid film subcooling							
	Free convection heat transfer							
	Forced convection heat transfer							
	Radiation heat transfer							
	Free convection mass transfer							
	Forced convection mass transfer							
	Jet impingement							
Module solids	One-D transient conduction heat transfer							
	Two or Three-D conduction							
Inter-Module	Convection							
	Conduction							
	Form and friction losses							

(a,c)

H = High importance
M = Moderate importance
L = Low importance

Part 1: II. Perform Top-Down Scaling Analysis

1. General Characteristics

There is a single source of mass and energy into containment. All mass input from the break remains inside containment; there is no mass transfer out. The liquid mass contributes little to containment pressure. The steam mass pressurizes containment, except for the condensed portion.

All energy is assumed to enter containment at the saturation temperature. The liquid energy contributes little to containment pressure. The gas portion energy has little effect on pressure beyond that due to the mass of gas. The energy absorbed by the internal structures and containment shell causes condensation of vapor, or vapor space mass removal. Energy absorption by structures is significant in terms of reducing containment pressure from the end of blowdown until well beyond the initiation of external cooling water.

The total mass and energy rates are given; the steam/water fractions and the steam density were determined by assuming the pressure-temperature history shown in Figure 3 from the SSAR. The mass flow rate, volume flow rate and energy flow rates of water and steam are presented in Figure 4, Figure 5, and Figure 6.

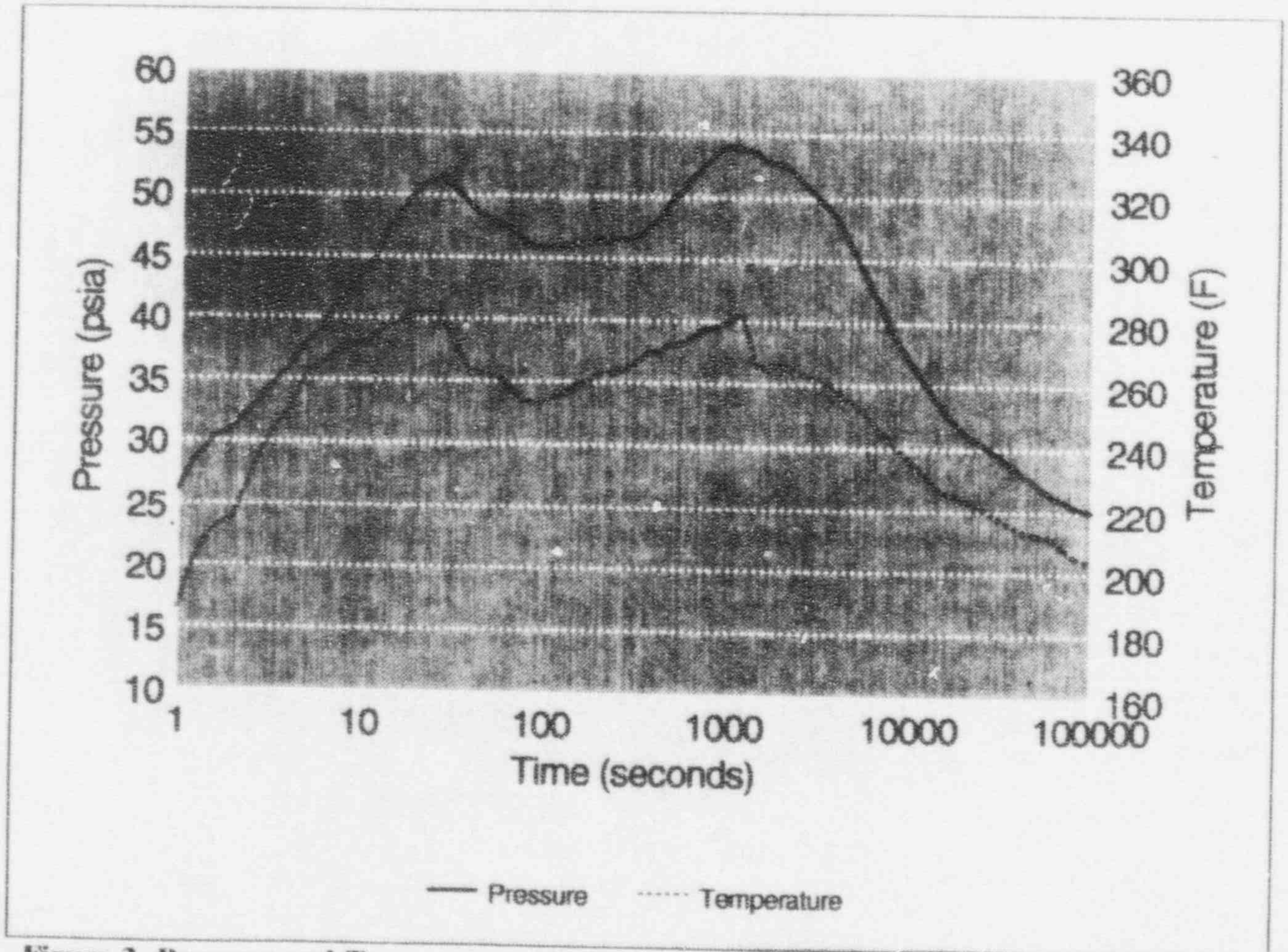


Figure 3 Pressure and Temperature Histories Predicted by <u>WGOTHIC</u> during a DECLG from the AP600 SSAR

AP600

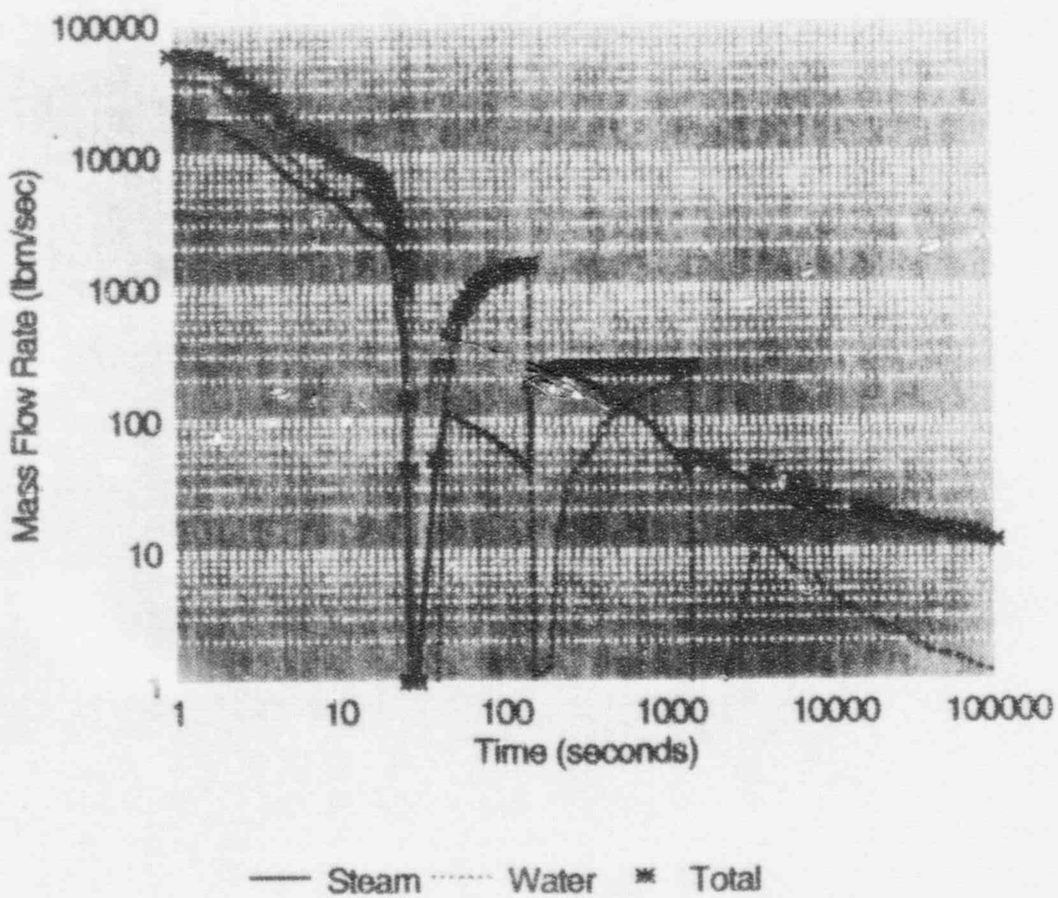


Figure 4 Steam and Water Break Mass Flow Rates in AP600 during a DECLG

AP600

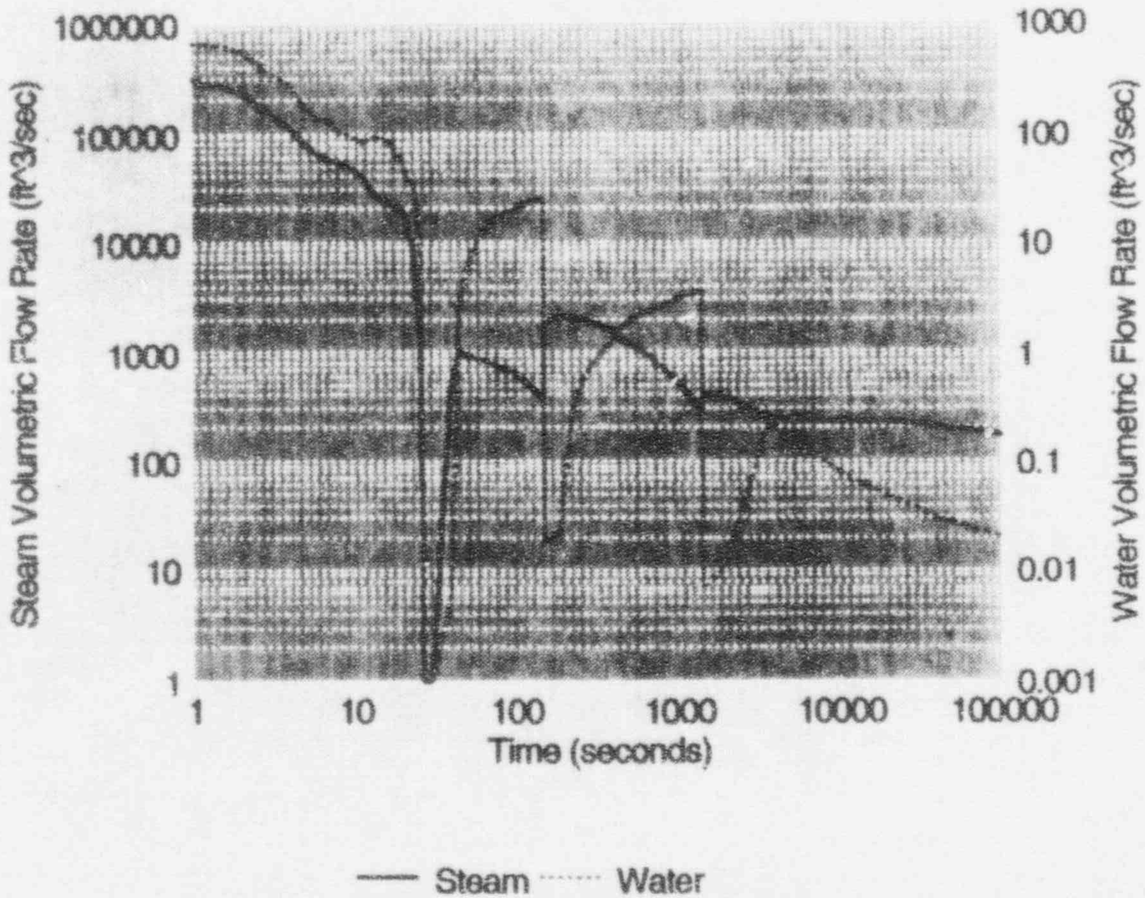


Figure 5 Steam and Water Break Volumetric Flow Rates in AP600 during a DECLG

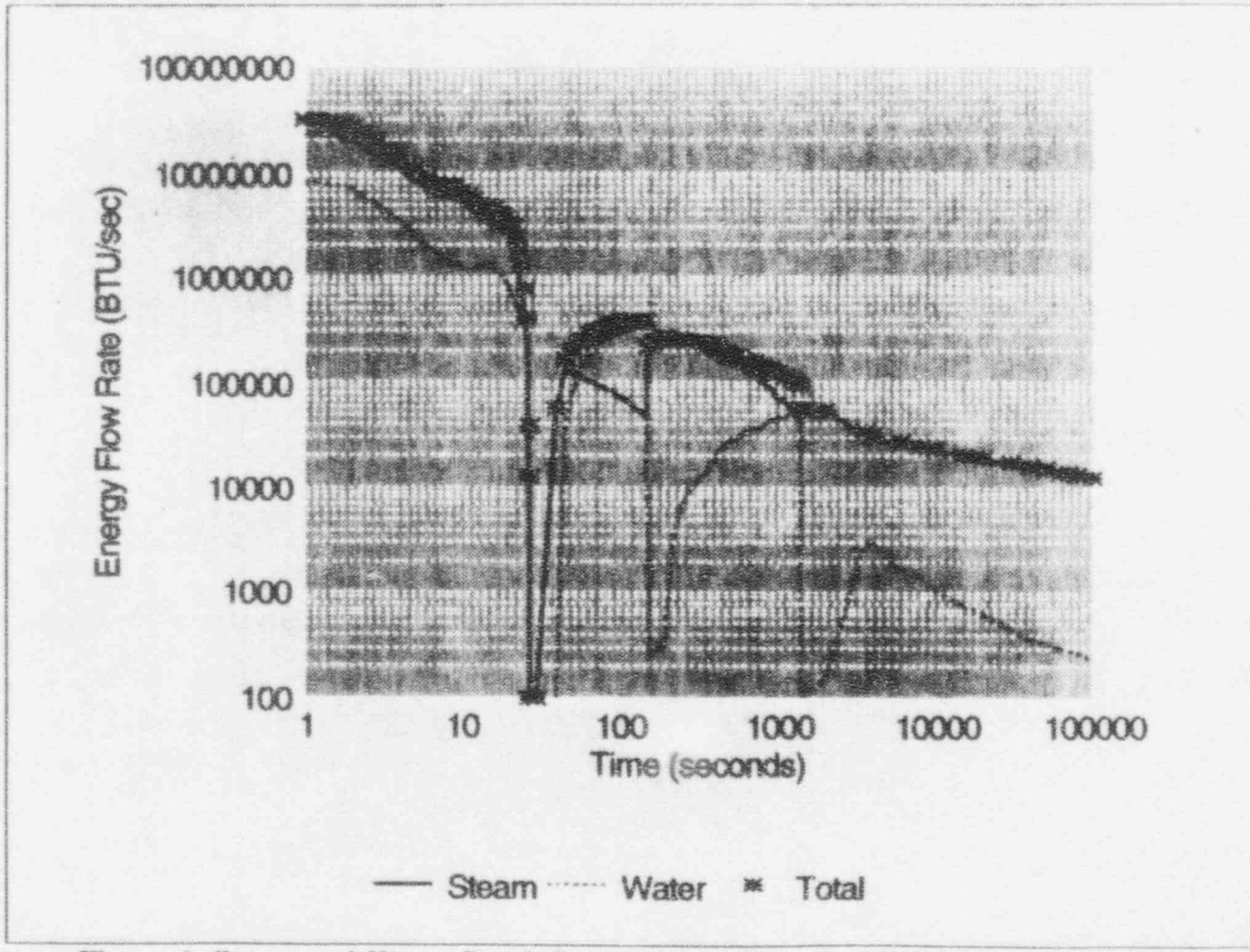


Figure 6 Steam and Water Break Energy Flow Rates in AP600 during a DECLG

2. Control Volume Equations

The control volume equations for the gas, the liquid pools and films, and the structures were developed, and the scaling groups were derived. The derivation and application of the control volume equations for mass, momentum, and energy are available from introductory level fluid mechanics texts[1] and are further demonstrated in NUREG/CR-5809[2]. The following example will illustrate the process for a control volume around the gas wall boundary layer. The wall boundary layer is shown in Figure 7.

Conservation of Mass

Conservation of mass for a control volume can be stated as: "the net efflux rate of mass through the control surface equals the rate of decrease of mass inside the control volume." If density and velocity can be represented by average values, the equation for conservation of mass in a control volume can be written:

$$\sum_{i=1}^{n} (\rho_i v_i A_i) = \frac{d}{dt}(\rho V) \tag{1}$$

Terms are required to represent the air and steam entrained into the boundary layer, the steam condensed out of the boundary layer on the liquid film, and the flow of steam and air out the bottom of the boundary layer. Using the nomenclature of the scaling report:

$$\frac{d}{dt}(V\rho)_{bl} = Q_{bl,ent}\rho_{sf} - k_g A_{bl\ lf} M_{stm}(P_{sf,stm} - P_{lf,sat}) - (Q_{out}\rho)_{bl} \tag{2}$$

Equation 2 can be made nondimensional with the following substitutions:

[ ] (a,c)

AP600

[ ]$^{(a,c)}$

The resulting dimensionless equation is:

[ ]$^{(a,c)}$ (3)

Dividing the dimensionless equation by the [entrainment flux term]$^{(a,c)}$ gives:

[1]$^{(a,c)}$ (4)

where the time constant is:

[ ]$^{(a,c)}$ (5)

the pi groups are:

(6)

(7)

and the dimensionless pressure is

(8)

\\

AP600

The group [ ]$^{(a,c)}$ is not independent of the others and is not normally evaluated.

Conservation of Energy

The equations and scaling groups can be developed for conservation of energy applied to the boundary la. control volume similar to the development for the mass equation. The energy equation will incluo. additional terms for convective heat transfer, and if we choose, for pressure. (The energy stored inside the control volume is given by the internal energy, or alternately by the relationship between internal energy and enthalpy: $u = h + p/\rho$). The energy equation is:

[ ]$^{(a,c)}$ (9)

Making the energy equation nondimensional as was done for the mass conservation equation and dividing by the entrained energy term gives:

[ ]$^{(a,c)}$ (10)

where the time constant is:

[ ]$^{(a,c)}$ (11)

the pi groups are:

[ ] (a,c)

(12)

(13)

(14)

(15)

and the dimensionless pressure and temperature are:

[ ] (a,c)

(16)

(17)

As for conservation of mass, the group [ ] is not independent and is not evaluated. (a,c)

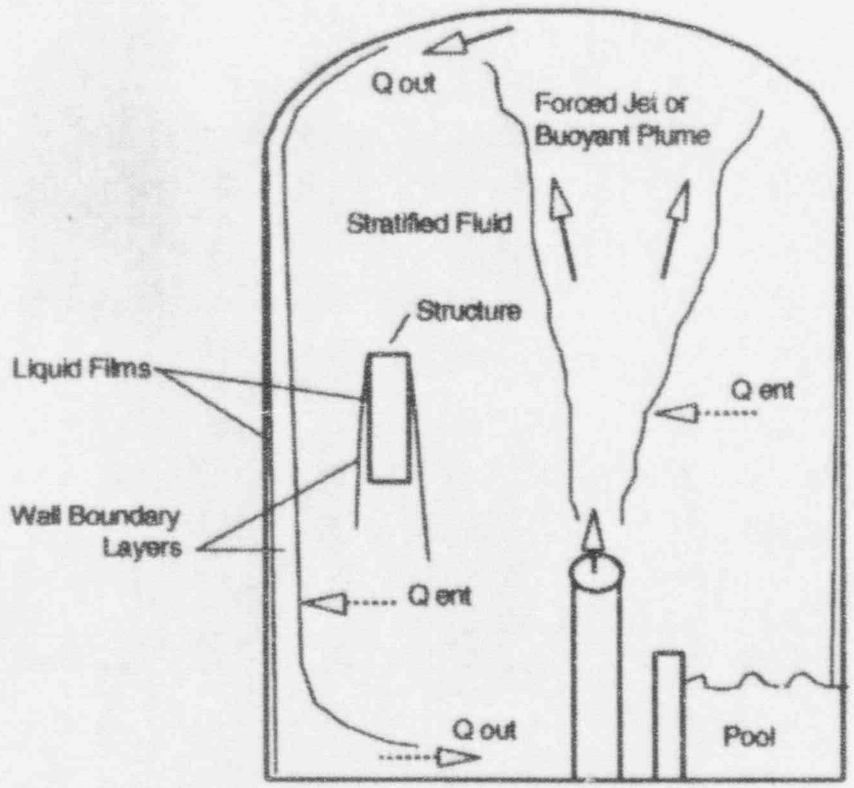


Figure 7 Schematic Model of AP600 Gas Volume Showing Stratified Fluid, Buoyant Jets, and Wall Boundary Layers

Part 1: III. Perform Bottom-Up Scaling Analysis

The top-down development of equations was described in Part 1: II. The development of equations at a higher hierarchical level is described in the following.

A single equation representing the gas interaction with pools and structures is desired, so the pressure and temperature of containment can be calculated. Constituent level gas equations can be developed by summing the three individual phase level equations for the wall boundary layer, the buoyant jet, and the stratified fluid. The resulting equations are, for the gas mixture mass:

[ ]$^{(a,c)}$ (18)

and for the gas mixture energy:

[ ]$^{(a,c)}$ (19)

(20)

and the energy equation:

(a,c)

The gas volume, V_g, is not a constant; it reduces due to displacement by the addition of liquid water from the break and leads to pressurization of containment according to Equation (22). However, the total water added to the control volume (not just moved around within the control volume) is only 13,400 ft^3 out of 1,786,300 ft^3 (0.7%) and can be neglected.

(a,c)

AP600

(a,c)

[ ]

Comparison of Equations (21) and (25) shows that while a quantity of heat represented by h_g - h_f is deposited in the structure, the quantity h_g is removed from the atmosphere. The difference, h_f, is added to the containment liquid inventory by a negligible volume of liquid. Thus the pressure effect on the containment gas of depositing h_g - h_f in the structure is equivalent to removing h_g from the atmosphere.

The constituent level gas time constant and dimensionless groups are presented in Table III. The constituent level groups are normalized to the [ ] (a,c)

Table II
Distribution of Steel and Concrete Inside Containment

Compartment		Concrete/Liner	Steel	Steel	Steel	Shell	Steel
	Thickness:	2/.042	<.015	.015-.051	.051-.255	0.1345	>.255
Above Deck	Area	2200	28200	-	15700	54116	407
	Volume	4400/92	230	-	2033	7328	136
Below Deck	Area	50422	16200	68828	23270	-	1379
Subtotal	Volume	100843/2101	361	2624	2941	-	629
Containment	Area	52622	44400	68828	38970	54116	1786
Total	Volume	105243/2193	591	2624	4974	7328	765

AP600

Table III
Time Constant and Transport Ratios for Constituent Level Gas Energy Equation

$$\left[\tau_g = \frac{(V\rho)_{g,0}}{(Q\rho)_{stm,in,0}} \right]^{(a,c)}$$

Gas time constant (26)

[ ] (a,c)

AP600

Part 1: IV. Develop Closure Relationships

Closure relationships are required to evaluate the pi groups and time constants for conservation equations. Such relationship were presented for the wall boundary layer, buoyant jet and stratified fluid in the gas volume by Peterson[4], and Peterson, Schrock and Grief[5]. The wall boundary layer, buoyant jet and stratified fluid are shown in Figure 7.

Additional relationships are required to evaluate the convective heat transfer and convective mass transfer rates. The McAdams free convection heat transfer correlation is used:

$$Nu = 0.13 Gr^{1/3} Pr^{1/3} \tag{34}$$

and the heat and mass transfer analogy is used to get a mass transfer coefficient from the heat transfer coefficient:

$$Sh = Nu\left(\frac{Sc}{Pr}\right)^{2/3} \tag{35}$$

Detailed partial pressure and partial density information is required to evaluate the common dimensionless groups (Richardson, Grashof, etc.) appearing in the flux ratios and the mass flux equation. A number of simplifying assumptions were made to facilitate the calculation of required properties, the key assumptions being:

Air and steam are ideal gasses.

[ ]$^{(a,c)}$

Part 1: V. Calculate Scaling Group Values

A spreadsheet calculation was performed to quantify the magnitude of the time constants and flux groups for the gas, liquid and structures inside containment. Although the spreadsheet did not include external heat rejection or concrete heat sinks, the results are valid for all internal heat sinks for all time, and are valid for the containment shell for time less than approximately 1000 seconds. The results presented in Table IV show that:

The thermal interaction between the gas atmosphere and the pool is negligible until approximately 10,000 seconds, when it may become significant.

The thermal interaction between the gas atmosphere and the IRWST is negligible. The values for the IRWST were much less than for the pool and are not shown in Table IV.

Heat absorption by the structures is a dominant process from the end of blowdown to after the application of external water.

Convective heat transfer into structures is negligible in comparison to mass transfer. Convective heat transfer out of structures (negative pi values) is only by convection (no mass transfer).

Table IV
AP600 Time Constant and Transport Ratios for Gas Constituent Level

Time Constant and Transport Ratios	Time into Transient (seconds)						
	5	25	100	500	1000	10,000	100,000

(a, c)

Part 2: I. Develop Independent Computer Model

A simple, independent computer model of AP600 is under development to facilitate the scaling analysis and maintain independence from WGOTHIC. The model includes the internal steel and concrete heat sinks, and external heat rejection by radiation, convection and evaporation. Preliminary results for containment pressure are shown in Figure 8, and agree well with WGOTHIC calculations. The magnitude of heat removal by the steel and concrete structures is shown in Figure 9. The combined heat removal by all structures and external heat losses are shown in Figure 10.

Part 2: II. Scale the Large Scale Test

Future work will include a scaling comparison of the large scale test and AP600, and validation of important phenomena by modeling AP600 and selected large scale tests with the independent computer model. This work will be reported in second scaling iteration report.

References

1.I. H. Shames, *Mechanics of Fluids*, McGraw-Hill Book Company, 1962.

2. NUREG/CR-5809 EGG-2659, "An Integrated Structure and Scaling Methodology for Severe Accident Technical Issue Resolution", INEL, EG&G Idaho, Inc.

3. NTD-NRC-94-4100 (Docket No. STN-52-003) Letter, N. J. Liparulo (Westinghouse) to R. W. Borchardt (NRC), "AP600 Passive Containment Cooling System Letter Reports."

4. P. F. Peterson, "Scaling and Analysis of Mixing in large stratified Volumes", *International Journal of Heat and Mass Transfer*, Vol 37, Suppl. 1, pp. 97-106, 1994.

5. P. F. Peterson, V. E. Schrock, R. Greif, "Scaling for Integral Simulation in Large, Stratified Volumes", NURETH 6, Sixth International Topical Meeting on Nuclear Thermal Hydraulics, October 5-8, 1993, Grenoble, France.

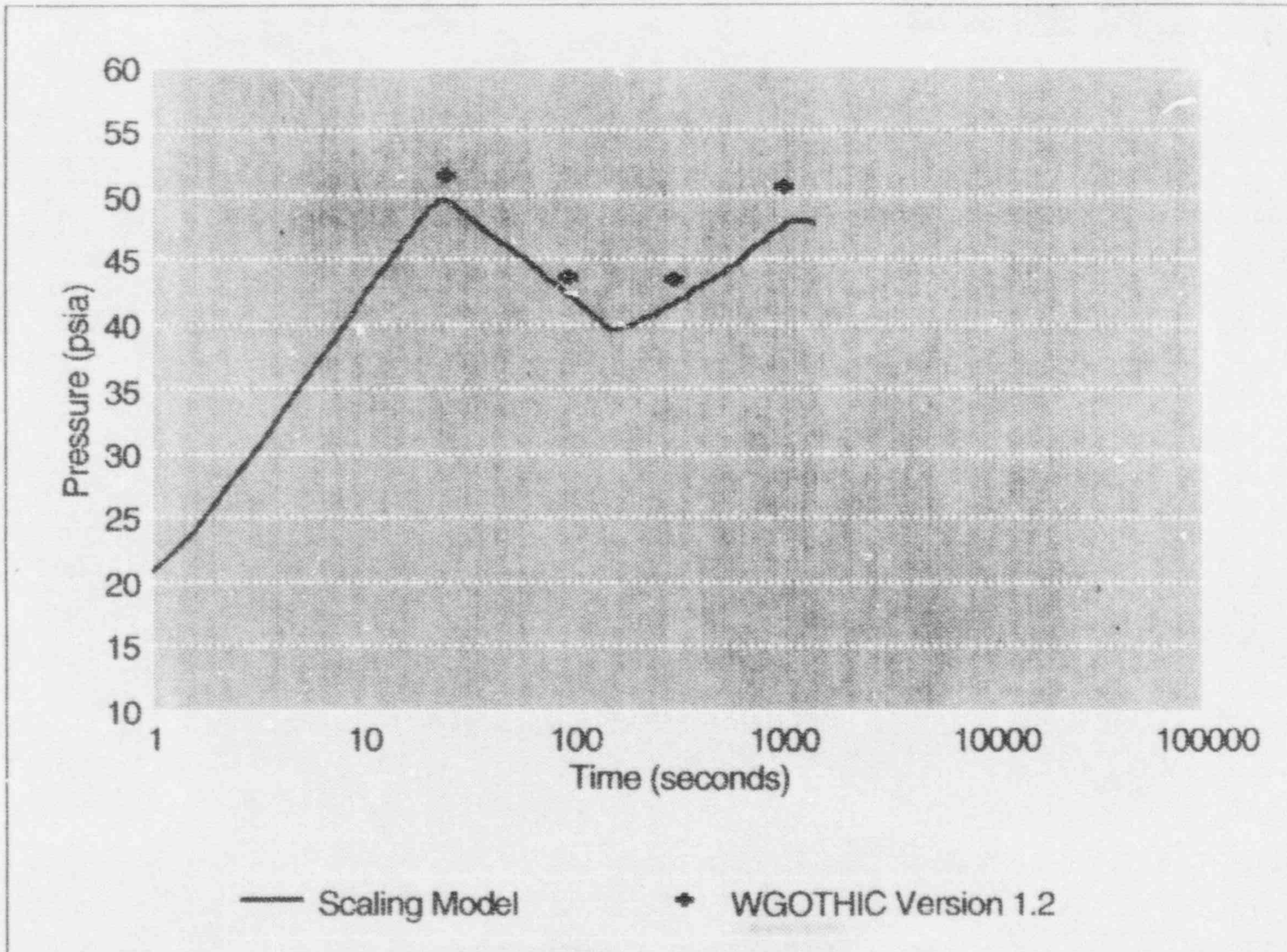


Figure 8 Pressure and Temperature History for AP600 Calculated with Independent Computer Model

AP600

(a,c)

AP600

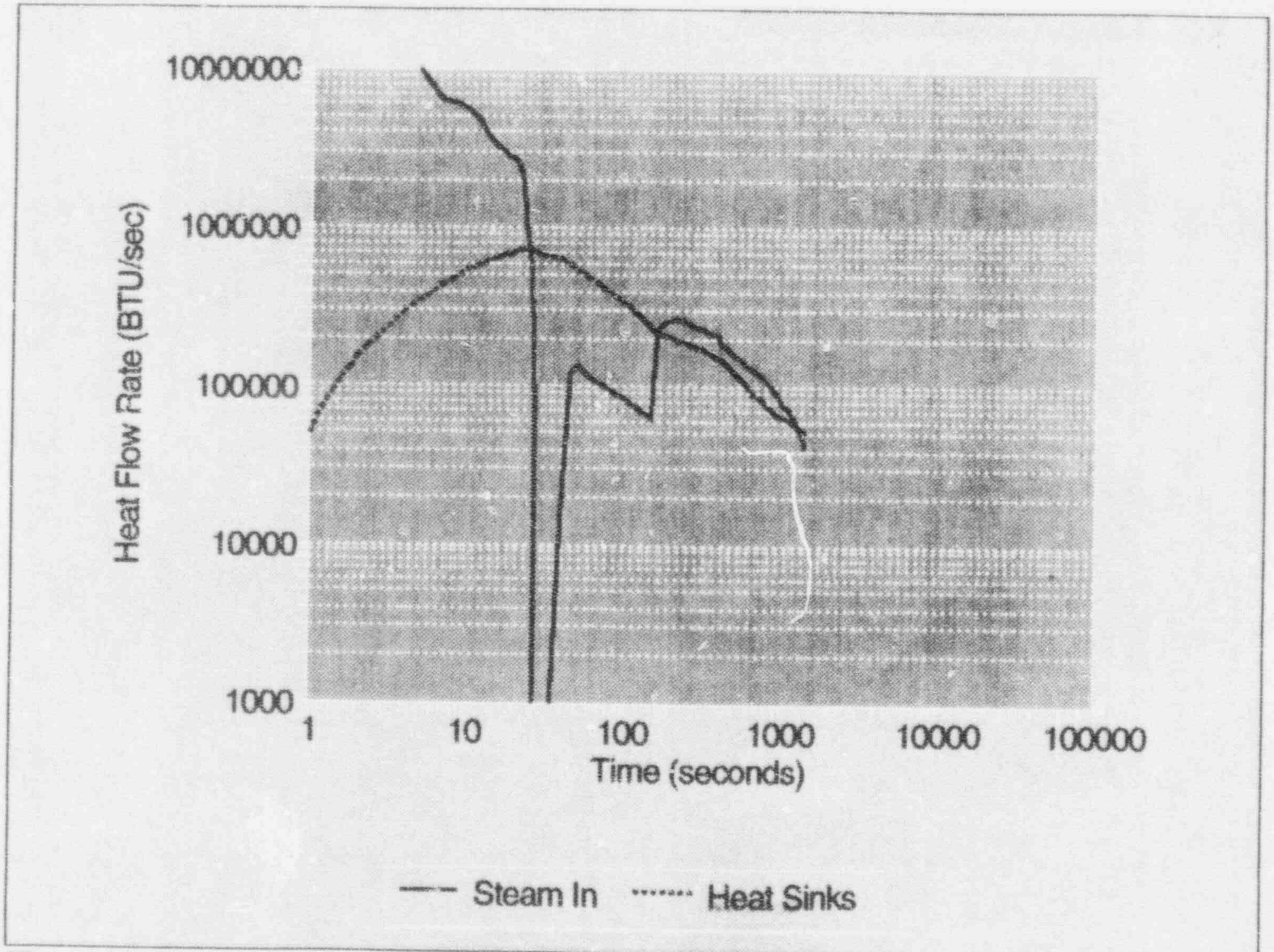


Figure 10 Combined Heat Removal by Structures with External Shell Heat Removal

NRC AP600 PCS SCALING STATUS

NRC

MEETING ACTION ITEMS

	DESCRIPTION	RESPONSIBLITY	DUE
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			

WESTINGHOUSE ELECTRIC CORPORATION

PRESENTATION
TO
UNITED STATES
NUCLEAR REGULATORY COMMISSION

AP600 Passive Containment Cooling System (PCS) Computer Code Validation (Mid Stage 2) Meeting

MONROEVILLE, PA

JULY 27, 1994

AGENDA

WESTINGHOUSE/NRC MEETING
AP600 PCS Computer Code Validation (Mid Stage 2)

8:30	Introduction	J. Butler
8:45	LST WGOTHIC Modelling Plans	M. Kennedy
9:00	NRC WGOTHIC Review Status	NRC
9:30	WGOTHIC Lumped Parameter LST Results Summary	M. Kennedy
BREAK		
10:30	WGOTHIC Validation Results and Status - Input and Modelling Methodology - Comparison to LST 212.1	M. Kennedy
LUNCH		
1:30	NRC CONTAIN Validation Results and Status - Input and Modeling Methodology - Comparison to LST 212.1	NRC
3:30	NRC Data Needs Discussion	All
4:00	Meeting Wrapup, Action Items	All

INTRODUCTION

J. C. BUTLER
ADVANCED PLANT SAFETY AND LICENSING

LST WGOTHIC MODELING PLANS

M. KENNEDY
CONTAINMENT AND RADIOLOGICAL ANALYSIS

REVIEW OF WGOTHIC LST MODELLING PLANS

LST TASKS and OBJECTIVES

Task	Node Type	Test	Code Version	Objective
A	Lumped	Baseline	Version 1.0	V&V WCAP-13246, Rev. 0
B	Lumped	Baseline	Version ~~1.1~~ 1.2	Support DSER and show net effect of new (version ~~1.1~~ 1.2) models. It will justify the acceptability of the SSAR Rev 0 models with respect to the correlation upgrades.
C	Subdivided	Phase 2/3	Version 1.2	Show phenomena are modelled correctly and all the important phenomena are modelled. (Two tests will be run and detailed local comparisons made.)
D	Lumped	Phase 2/3	Version 1.2	Show effect of noding and momentum equation on pressure. Demonstrate that using lumped model is acceptable for vessel pressure and temperature response by comparison to C and to measured data
E	Lumped	Blind	Version 1.2	Add confidence to our modelling techniques by performing blind prediction.
~~F~~	~~Lumped~~	~~Phase 2/3~~	~~Version 1.0~~	~~Show net effect of version 1.2 models. Demonstrate acceptability of the SSAR Rev 0 models with respect to the correlation upgrades.~~

Note: Task F will be removed since version 1.2 was used in Task B which was reported in PCS-GSR-001 submitted to the U.S. NRC on June 30, 1994.

NRC WGOTHIC REVIEW STATUS

NRC

WGOTHIC LUMPED PARAMETER LST RESULTS SUMMARY

M. KENNEDY
CONTAINMENT AND RADIOLOGICAL ANALYSIS

(a,c)

Figure 9 Plan View of Model Below Operating Deck

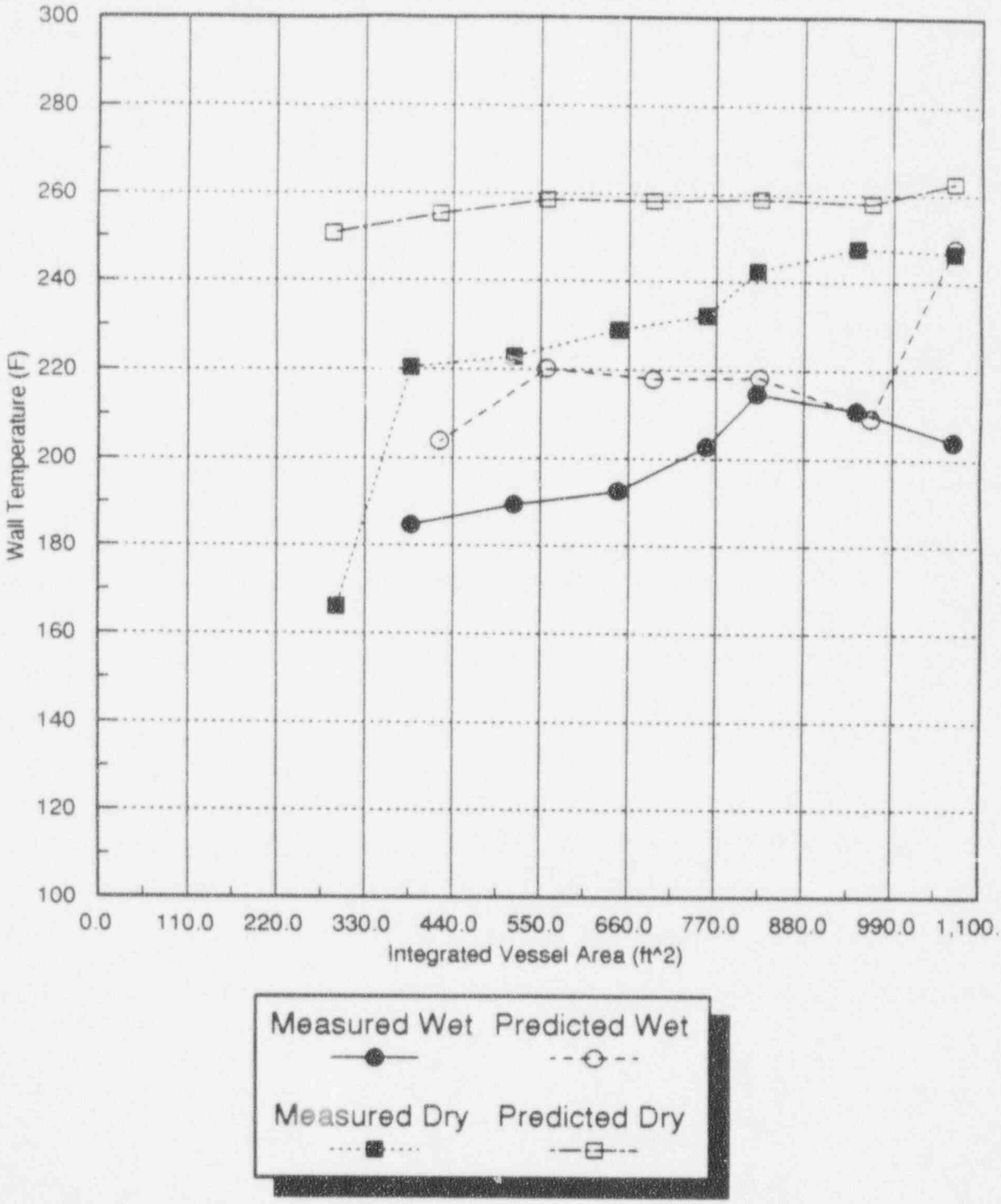
WGOTHIC LUMPED PARAMETER LST RESULTS SUMMARY FROM "AP600 PCS DBA MODEL AND MARGIN ASSESSMENT " REPORT

OVERVIEW:

- Relevant test conditions for baseline LST
- Results of test using WGOTHIC Version 1.0 with and without simulating subcooling (Reported in WCAP-13246, Rev. 0)
- Vessel pressure results with Version 1.0 (Reported in WCAP-13246, Rev. 0)
- Code and input changes made from version 1.0 to version 1.2
- Results of test using WGOTHIC Version 1.2 (Reported in PCS-GSR-001, "AP600 PCCS DBA Model and Margin Assessment", 6/30/94)
- Vessel pressure results with Version 1.2 (Reported in PCS-GSR-001)
- Conclusions

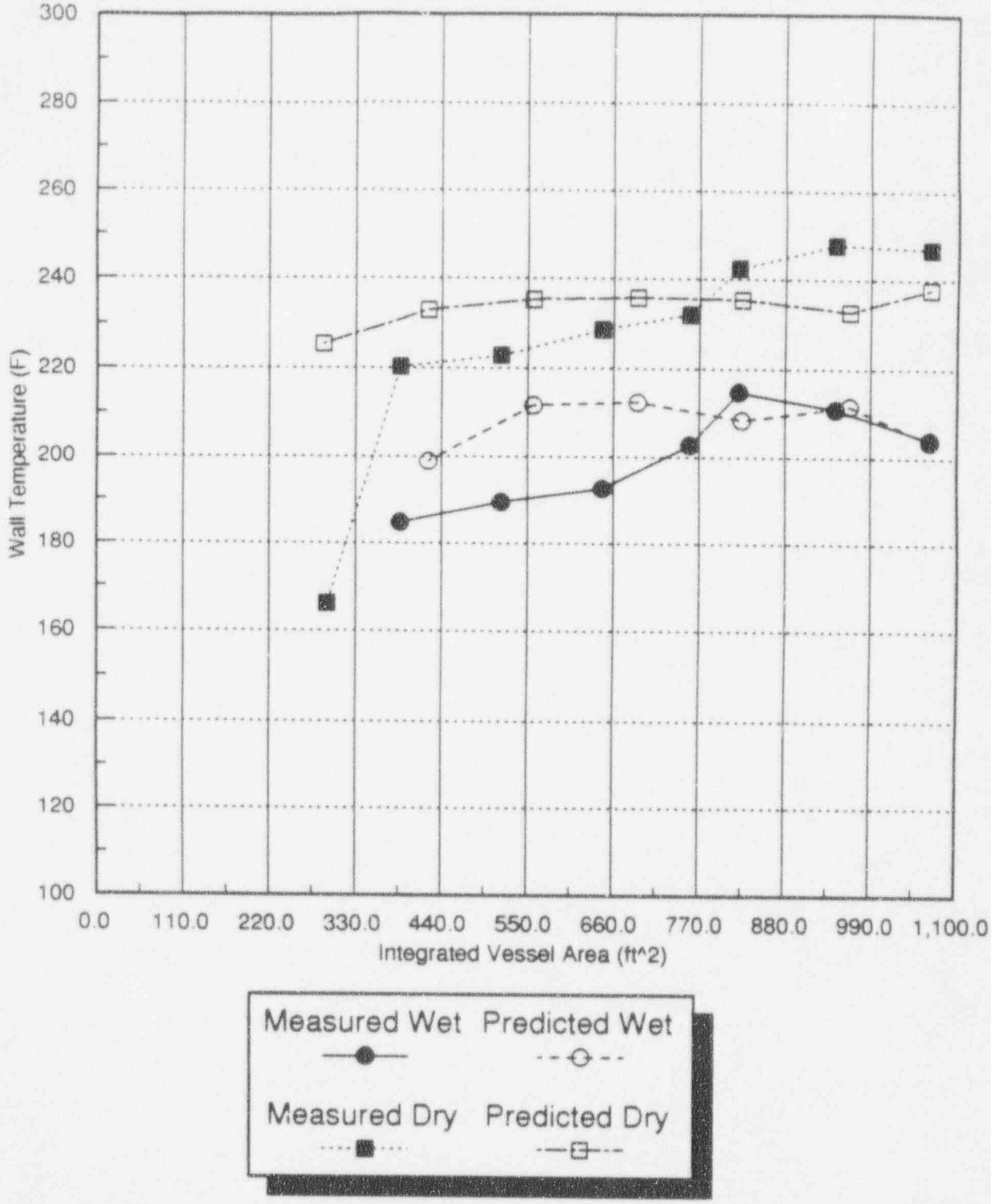
Relevant Measured Baseline LST Conditions

Test Number	Vessel Pressure (psia)	Steam Flow Rate (lb/hr)	Vessel Wetted %	External Film Water Temperature
R7L	92.9	658	0%	N/A
R11L	42.8	3610	67%	86°F
R12L	43.7	3976	71%	66°F
R9L	23.4	1304	100%	50°F



Measured Pressure = 42.79 psia
Predicted Pressure = 57.8 psia

Figure 1 Measured and Predicted Vessel Inner Surface Temperatures Using Version 1.0 Without Simulating Subcooling for LST R11L
(Reference Figure 30 p. 117 WCAP-13246)



Measured Pressure = 42.79 psia
Predicted Pressure = 44.1 psia

Figure 2 Measured and Predicted Vessel Inner Surface Temperatures Using Version 1.0 Simulating Subcooling for Test R11L (Reference Figure 39 p.126 WCAP-13246)

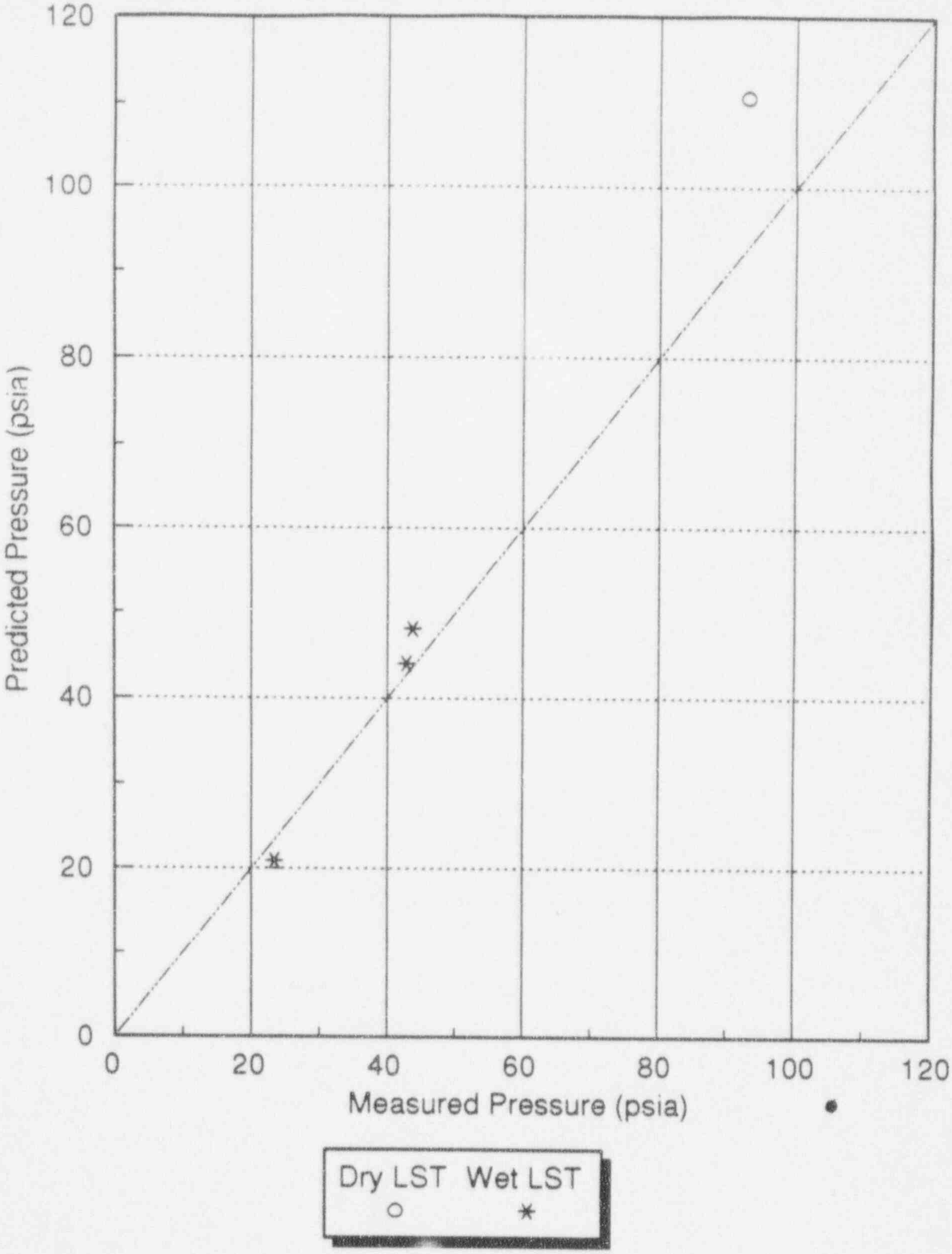


Figure 3 Large Scale Test WGOTHIC Version 1.0 Predicted Versus Measured Vessel Pressure (Reference Figure 46 p.133 WCAP-13246)

Code Programming Changes from Version 1.0 to 1.2

- Entrance effects multiplier on heat and mass transfer coefficients primarily to model separate effects tests

- Addition of a log-mean noncondensable pressure term to the boundary layer mass transfer correlation

- Liquid film enthalpy transport to directly account for convective heat transport in liquid film

- Mixed convection correlation

Input Changes Made from Version 1.0 to 1.2

- Heat and mass transfer multipliers to account for entrance effects in the annulus were calculated and applied to the lower volumes of the annulus.

$$M_{en} = 1 + \left(\frac{C\, D_h (y_2^{0.3} - y_1^{0.3})}{L_e^{0.3} (y_2 - y_1)} \right)$$

- The annulus hydraulic diameter was changed to standard definition to be consistent with entrance effect multipliers applied.

$$D_h = 4 \frac{A}{P_w}$$

- Inner vessel wall heat transfer multipliers were computed and applied to the inside surface of the containment to convert from the Colburn correlation to the flat plate correlation.

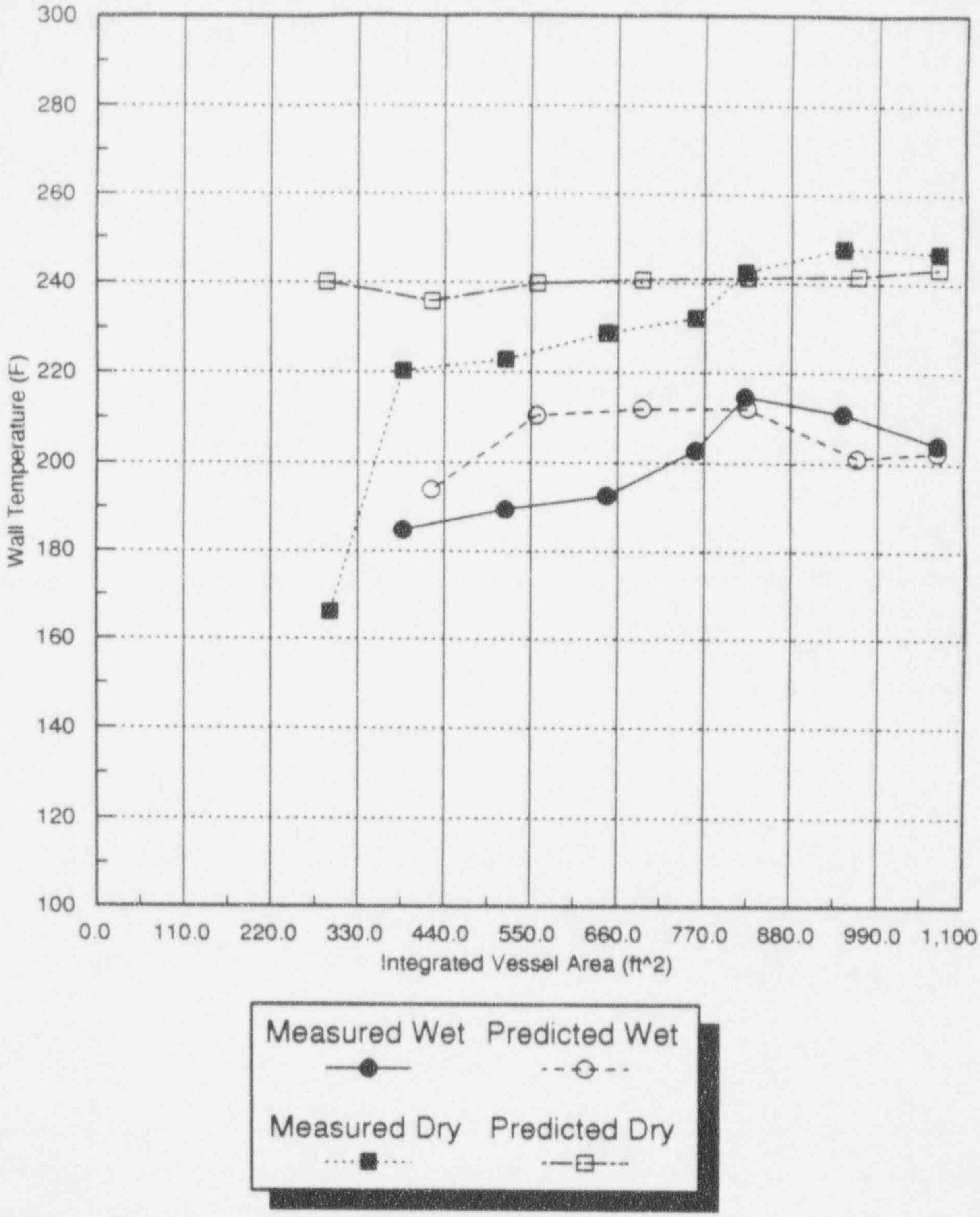
$$M_{fl} = \frac{h_{cL}}{h_{cD}} = \frac{0.0296}{0.023} \left(\frac{D_h}{L} \right)^{0.2}$$

Input Changes Made from Version 1.0 to 1.2 (continued)

- Mixed convection chosen.

- The annulus flow path inertia lengths were modified to balance the steady state volume average velocity with the corresponding flow path velocity.

- Simulation of subcooling no longer needed. Mechanistic correlations used to model subcooling on the dome since liquid film enthalpy transport model is available.



Measured Pressure = 42.79 psia
Predicted Pressure = 46.2 psia

Figure 4 Measured and Predicted Vessel Inner Surface Temperature with Version 1.2 for test R11L (Reference Figure 3 p.14 of PCS-GSR-001)

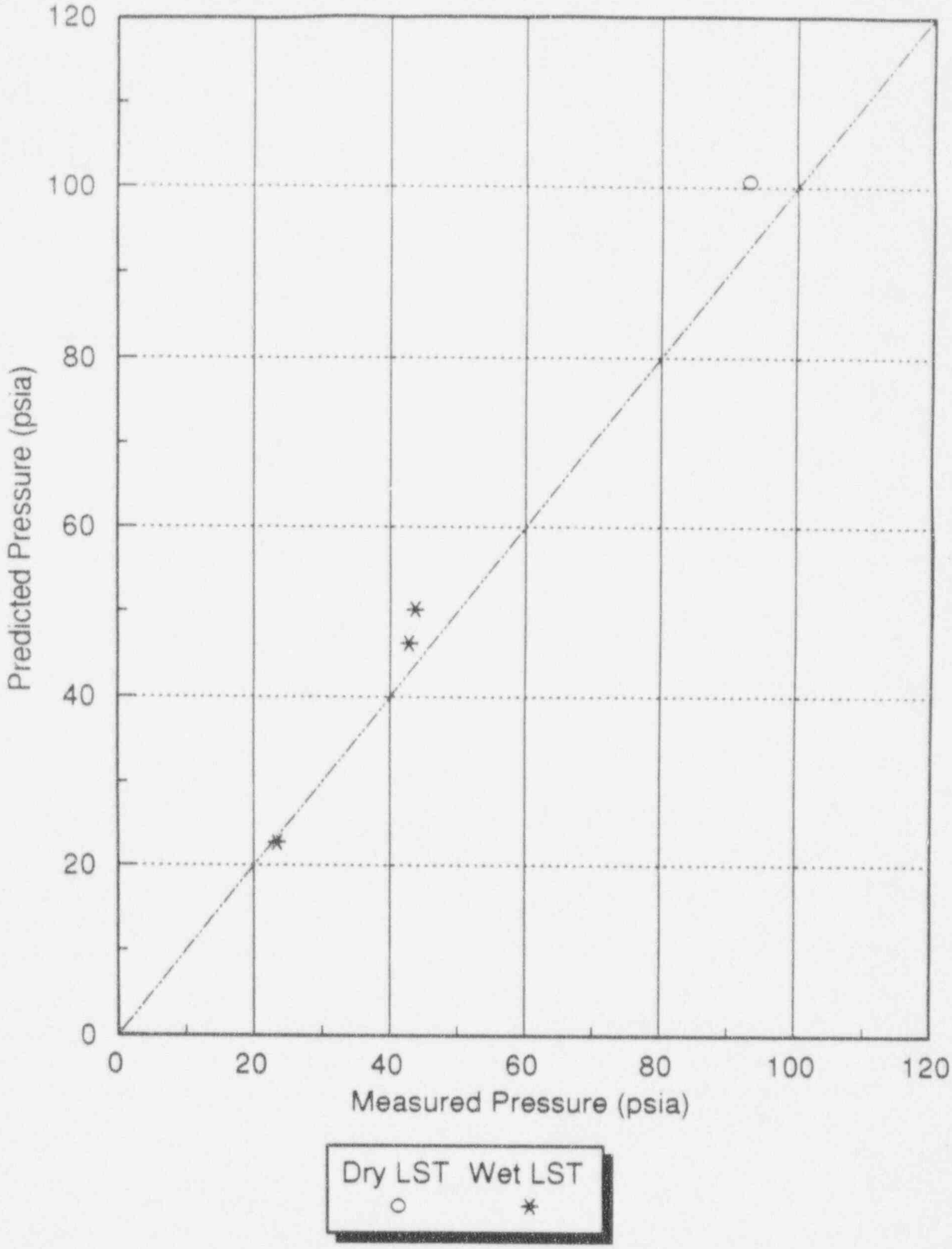


Figure 5 Large Scale Test WGOTHIC Version 1.2 Predicted Versus Measured Vessel Pressures (Reference Figure 6 p. 17 PCS-GSR-001)

Conclusions

Lumped parameter Version 1.2 results in good agreement with the large scale test data and further supports the conclusions made in WCAP-13246 that:

- WGOTHIC gives a conservative pressure response
- WGOTHIC is an acceptable code for containment analyses

WGOTHIC VALIDATION RESULTS AND STATUS

M. KENNEDY
CONTAINMENT AND RADIOLOGICAL ANALYSIS

WGOTHIC LST VALIDATION RESULTS AND STATUS BASED ON DISTRIBUTED PARAMETER MODELLING

OVERVIEW:

- Objective
- Data comparison formats per May 25, 1994 meeting
- Noding Methodology
- Boundary and initial conditions for test 212.1A
- Preliminary steady state comparisons for test 212.1A
- Preliminary transient comparisons for test 212.1A
- Conclusions

Objectives of Distributed Parameter LST

- Show all the important phenomena are modelled correctly and that we understand their impact on pressure predictions.

- Serve as basis for comparison to demonstrate WGOTHIC lumped parameter SSAR models are conservative.

Suggested LST Data Comparison Format

(per May 25, 1994 NRC Meeting)

Westinghouse Plans

Lumped Parameter Runs (To be presented at future meeting)

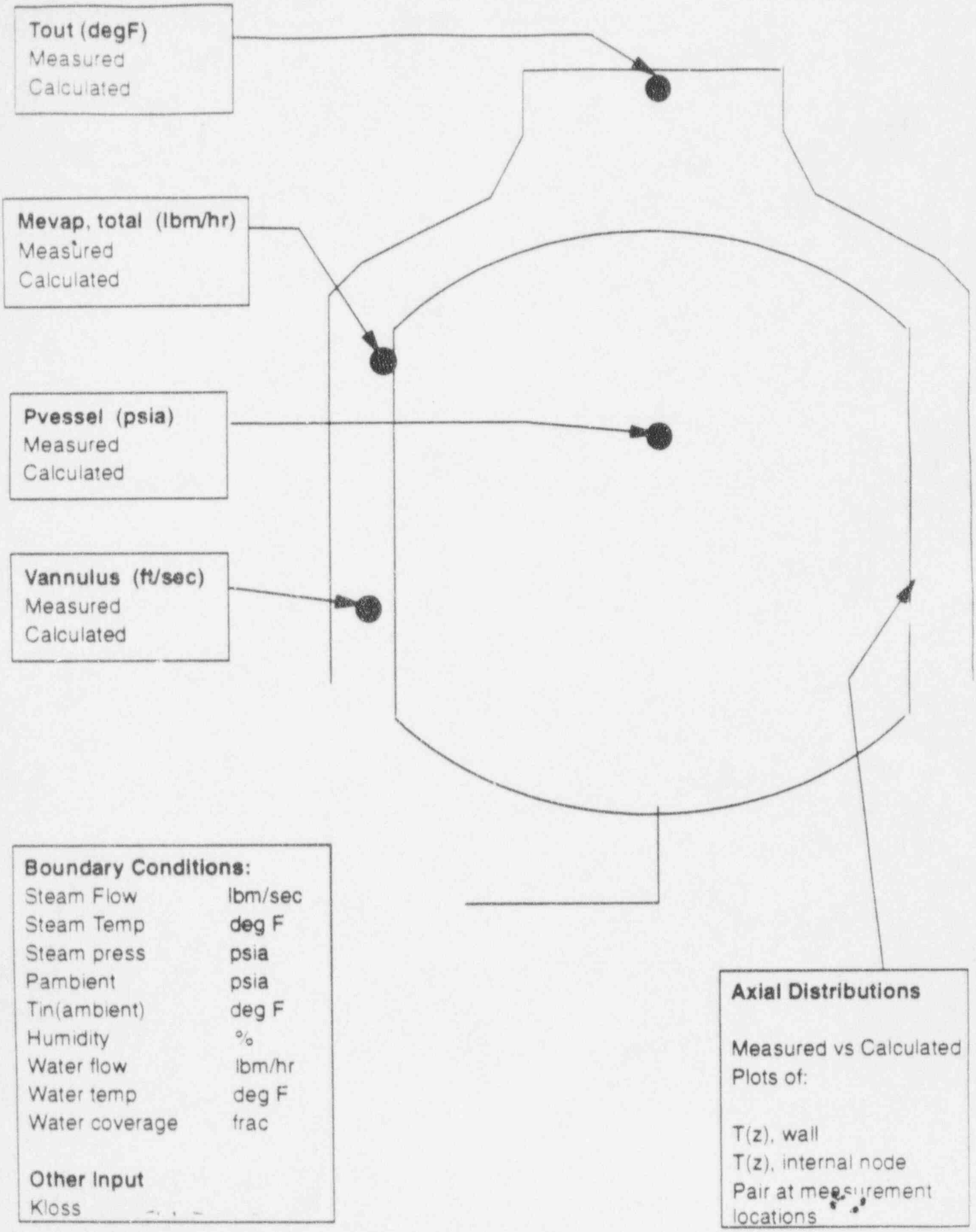
Pmeas vs Ppredict to show conservative underestimate of total heat removal

Subdivided (Preliminary Results to be presented today)

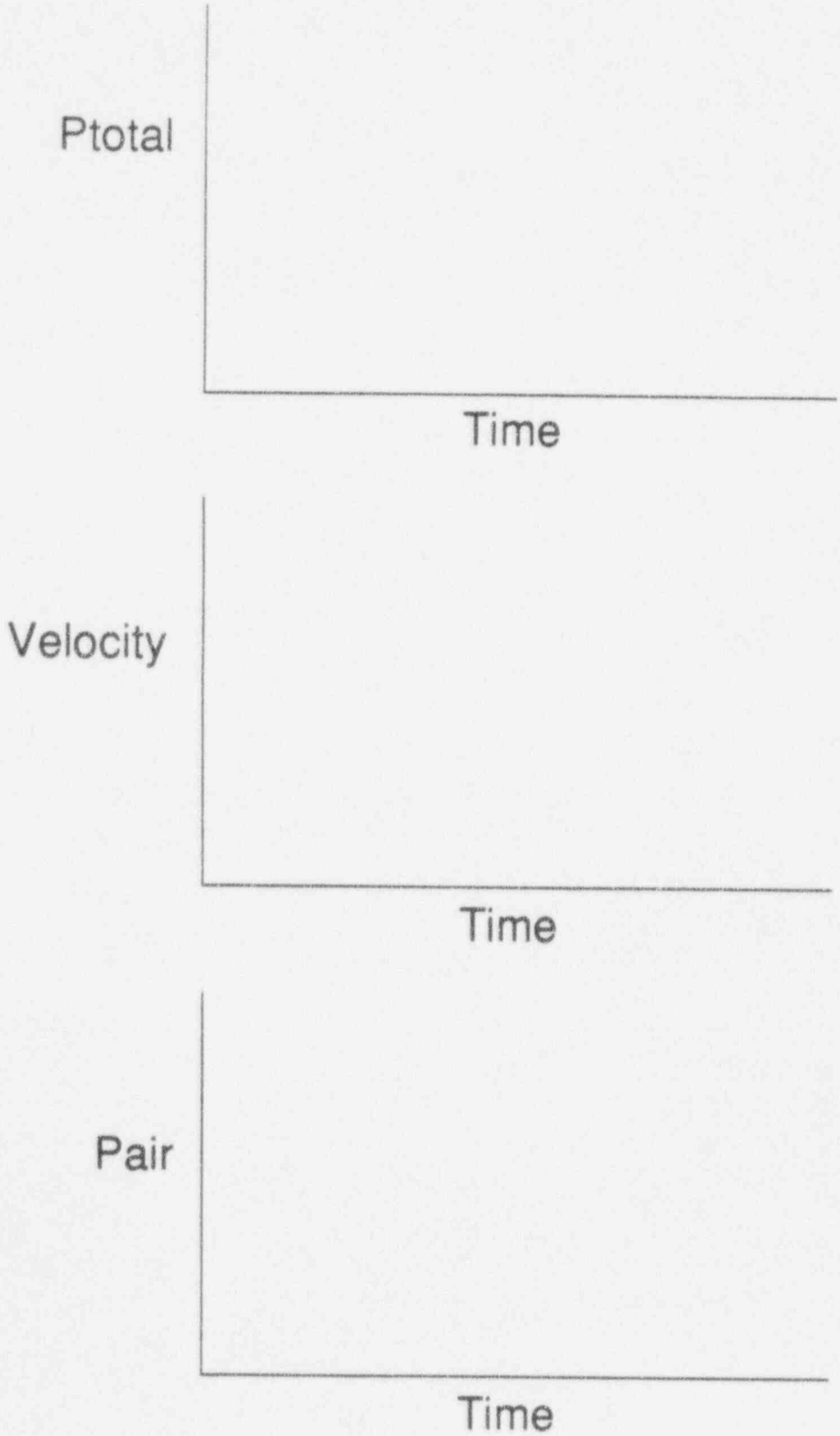
Detailed comparisons to test data will be made to demonstrate agreement with test data to meet stated objectives

Attached format shows information on code results that will be presented at this meeting.

Steady State Data Comparisons



Transients



Noding Methodology for Subdivided LST Model

General Guidelines Followed:

[ ] (a,c)

Noding Determination for Subdivided LST Model

Other Considerations:

[ ]^(a,c)

(a,c)

Figure 7 Noding Diagram of Subdivided LST

Boundary and Initial Conditions for Test 212.1A

(at 9.7728 hours or 6600 seconds into transient)

(a,b)

Preliminary Steady State Comparisons for Test 212.1A

(at 9.7728 hours or 6600 seconds into transient)

[ ] (a,b)

Preliminary Steady State Comparisons for Test 212.1A

(at 9.7728 hours or 6600 seconds into transient)

(a,c)

Preliminary Axial Temperature Distribution Comparisons for Test 212.1A

- Local measured and predicted vessel inner surface wall temperatures

- Local internal vessel fluid temperatures

  - Above operating deck, fluid temperatures shown are measured 1" from inner surface of vessel wall
  - Below deck, fluid temperatures shown are measured inside the compartment because there are no measurements 1" from inner wall
  - All temperature predictions shown are for the node along the wall

(a,b)

Measured 90 Measured 270 Predicted Predicted

Predicted: Above 90-135,270-225;45-90,270-315
Predicted: Below 90-167,193-270;45-90,270-315

Figure 10 Measured and Predicted Vessel Inner Surface Temperature at Locations 90° and 270°

(a,b)

Vessel Height (ft)

Measured 0 ○ Measured 330 □ Measured 30 △ Predicted - -●-

Predicted: Above Deck 0-45,315-360

Predicted: Below Deck 0-45,315-360

Figure 11 Measured and Predicted Vessel Inner Surface Temperature at Locations 0°, 30°, 330°

(a,c)

Measured 180 Predicted

○ --●--

Predicted: Above Deck 167-180,180-193

Predicted: Below Deck 167-180,180-193

Figure 12 Measured and Predicted Vessel Inner Surface Temperature at Location 180°

(a,b)

Measured 210 Measured 150 Predicted

Predicted: Above Deck 135-157.5, 202.5-225
Predicted: Below Deck 90-167,270-193

Figure 13 Measured and Predicted Vessel Inner Surface Temperature at Locations 150° and 210°

(a,b)

Measured 120 Measured 240 Predicted

○ □ ----●----

Predicted: Above Deck 90-135, 270-225

Predicted: Below Deck 90-167, 193-270

Figure 14 Measured and Predicted Vessel Inner Surface Temperature at Locations 120° and 240°

(a,b)

Measured 60 ○ Measured 300 □ Predicted ····●····

Predicted: Above Deck 45-90, 270-315
Predicted: Below Deck 45-90, 270-315

Figure 15 Measured and Predicted Vessel Inner Surface Temperature at Locations 60° and 300°

(a,b)

Measured 90 Measured 270 Predicted Predicted

○ □ ····●···· – –■–

Predicted: Above 90-135,107-115; 45-90,270-315
Predicted: Below 90-167,193-270; 45-90,270-315

Figure 16 Measured and Predicted Internal Fluid Temperature at Locations 90° and 270°

(a,b)

Measured 0 Measured 30 Predicted

○ □ ····●····

Predicted: Above Deck 0-45,315-360

Predicted: Below Deck 0-45,315-360

Figure 17 Measured and Predicted Internal Fluid Temperature at Locations 0°, 30°

(a,b)

Measured 180 Predicted

Predicted: Above Deck 167-180,180-193
Predicted: Below Deck 167-180,180-193

Figure 18 Measured and Predicted Internal Fluid Temperature at Location 180°

(a, b)

Measured 210 ○ Measured 150 □ Predicted ····●····

Predicted: Above Deck 135-157.5, 202.5-225

Predicted: Below Deck 90-167, 193-270

Figure 19 Measured and Predicted Internal Fluid Temperature at Locations 150° and 210°

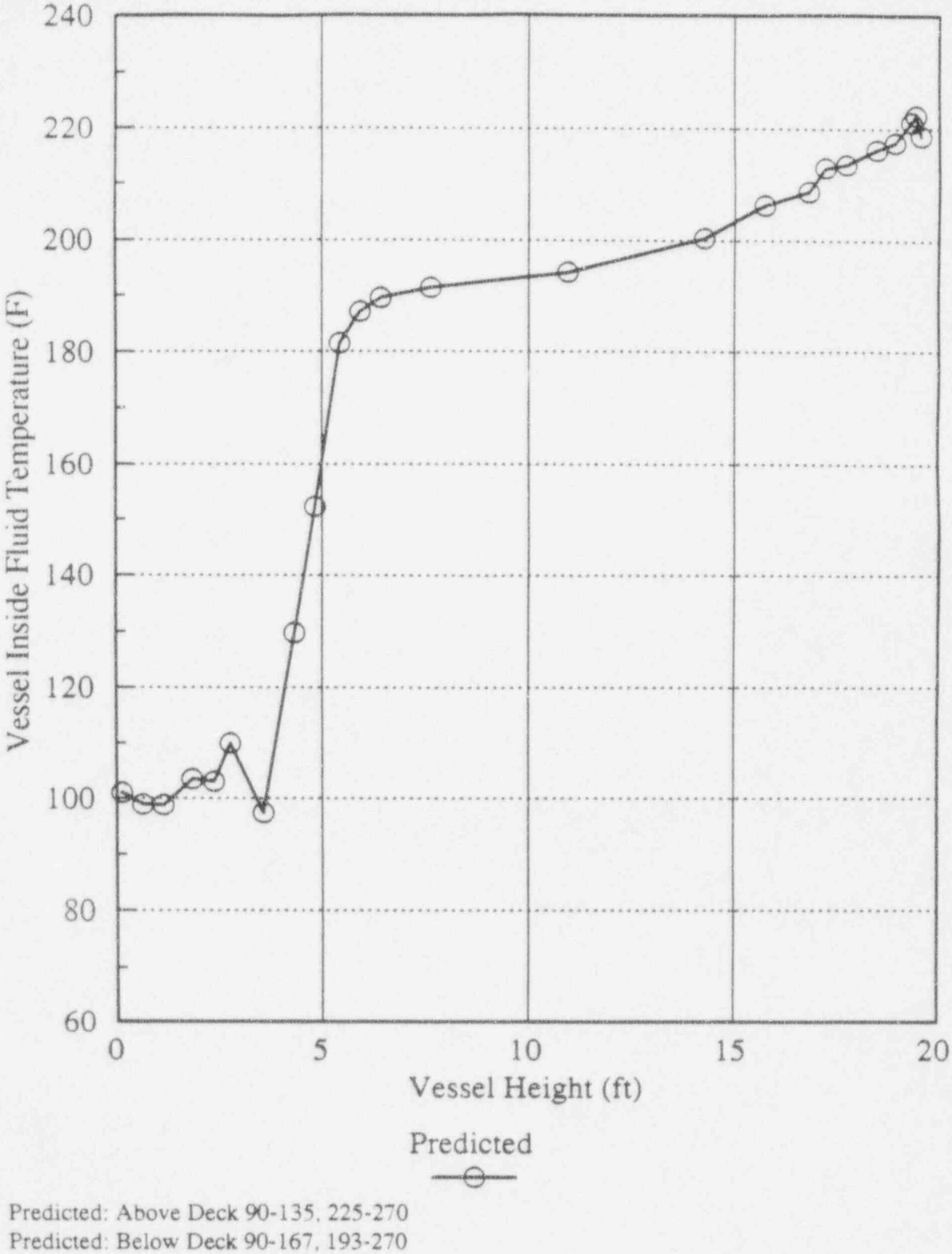
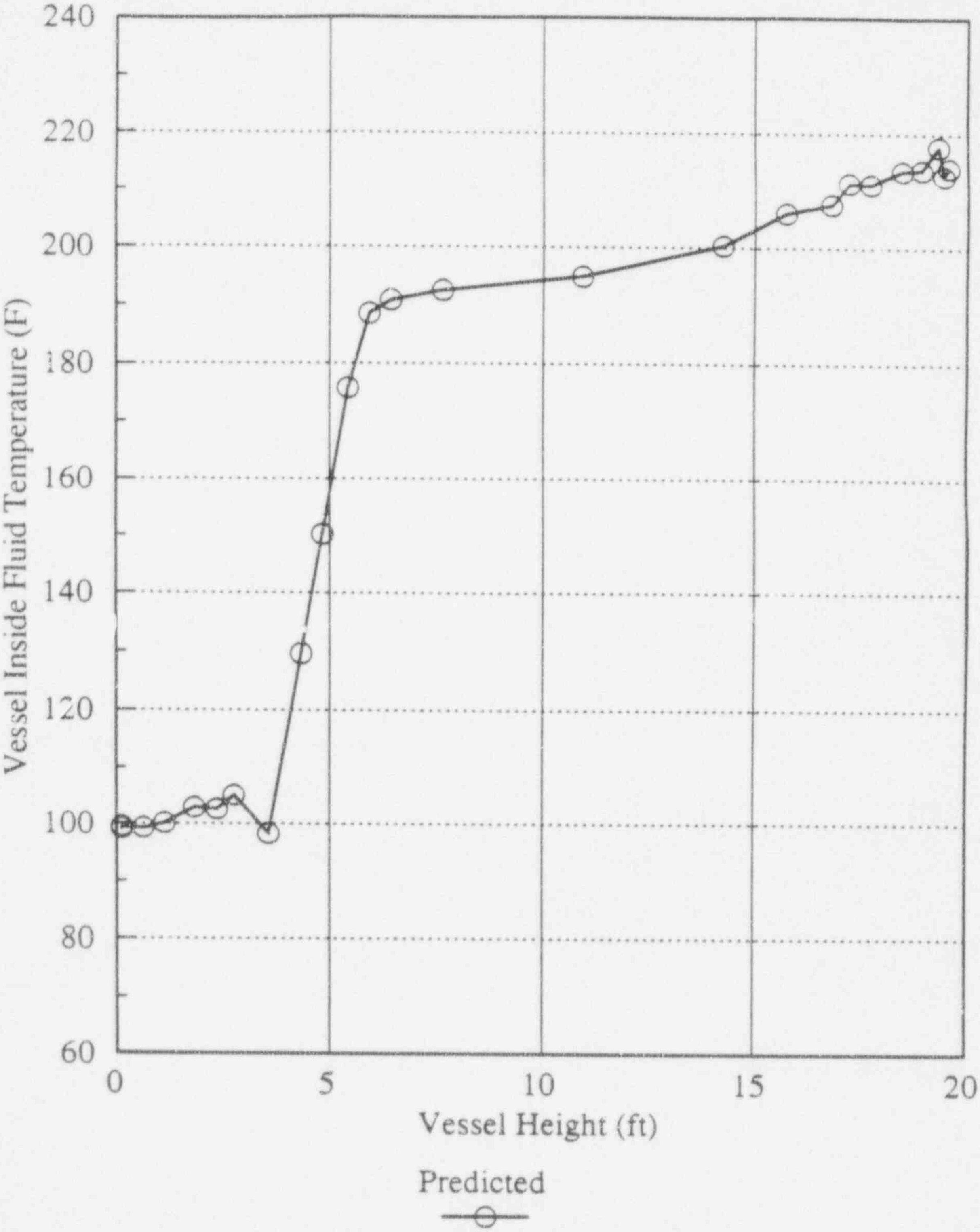


Figure 20 Predicted Internal Fluid Temperature at Locations 120° and 240°
Note: There was no measurement at these locations



Predicted: Above Deck 45-90, 270-315
Predicted: Below Deck 45-90, 270-315

Figure 21 Predicted Internal Fluid Temperature at Locations 60° and 300°
Note: There was no measurement at these locations

(a,b)

Figure 22 Preliminary Measured and Predicted Vessel Pressure for Test 212.1A

Noncondensable Measurements

Air partial pressure was measured at two locations for Test 212.1A:

- Dome-90^{o}-63"-3"
- F-0^{o}-6"

The measurements (taken from Figure 4.1-2, p.40 of QLR) are presented on the following figures as air pressure ratio to be consistent with WGOTHIC output. Air pressure ratio is defined as the air partial pressure divided by the total vessel pressure.

(a,b)

Figure 23 Measured and Predicted Air Pressure Ratio at Location Dome-90°-63"-3"

Figure 24 Measured and Predicted Air Pressure Ratio at Location F-0°-6" (Below Operating Deck)

Velocity Meters

- Give *indication* of velocity and flow direction parallel to the vessel wall.

- Höntzsch meters have an integral directional output.

- Pacer velocity meters have no integral directional output.

- Pacer meters were not as reliable as the German meters. The Pacer meters located at elevations D and E did not function for a majority of the tests.

- For the velocity meters located in the dome there is an uncertainty introduced as to their specific orientation relative to the wall.

- The type of meter at each location and the direction of flow indicated by each meter for test 212.1 is given below.

Locations	Type	Direction
Dome-42"-165°-1.5"	Höntzsch	Up
A-90°-1.5"	Höntzsch	Down
Dome-42"-345°-1.5"	Pacer	No direction
D-180°-2"	Pacer	No output
E-30°-2"	Pacer	No output

(a,b)

Measured Predicted

Figure 25 Measured and Predicted Internal Velocity at Location Dome-42-165°-1.5" (German meter and WGOTHIC have up flow)

(a,b)

Measured　Predicted (45-90)　Predicted (90-135)

Figure 26 Measured and Predicted Internal Velocity at Location A-90^{0} (German meter and WGOTHIC have down flow)

(a,b)

Measured Predicted

Figure 27 Measured and Predicted Internal Velocity at Location Dome-42"-345-1.5" (Pacer meter has no direction indication)

Subdivided LST Results Summary and Conclusions

- Conservative more rapid predicted pressurization is believed to be a result of using the conservative Uchida correlation for internal heat sinks.

- Predicted pressure reaches accurate pressure plateau.

- Accurate prediction of temperature rise through air annulus.

- The cause for the difference (of less than 20%) between the measured and predicted evaporation flow rate needs to be further investigated. It may be remedied by taking a predicted time averaged evaporation rate like was done for the measurements.

- Axial wall temperature distribution prediction agrees very well with measurements.

- WGOTHIC accurately models noncondensible distribution.

- Internal velocity predictions consistent with available data.

- The data is taken from QLR which is preliminary. Final results will use data from final test report.

NRC CONTAIN VALIDATION RESULTS AND STATUS

NRC

NRC DATA NEEDS DISCUSSION

ALL

MEETING ACTION ITEMS

AP600

DESCRIPTION	RESPONSIBLITY	DUE
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		

WESTINGHOUSE ELECTRIC CORPORATION

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AP600 Passive Containment Cooling System (PCS) Blind Test - Baseline Input Definition Meeting

MONROEVILLE, PA

JULY 28, 1994

AGENDA

WESTINGHOUSE/NRC MEETING
AP600 PCS Blind Test - Baseline Input Definition

8:30	Introduction	J. Butler
8:45	PCS Blind Test Basis - Basis for Blind Test Lumped Parameter Model - Nodalization Basis	M. Kennedy
9:30	Basis and Assumptions for WGOTHIC Blind Test Input - Baseline Table of WGOTHIC Input, Revision 0 - Discussion - Mechanisms for freezing data and changing input assumptions	M. Kennedy
12:00	Meeting Wrapup, Action Items	All

INTRODUCTION

J. C. BUTLER
ADVANCED PLANT SAFETY AND LICENSING

PCS BLIND TEST BASIS

M. KENNEDY
CONTAINMENT AND RADIOLOGICAL ANALYSIS

Basis for Blind Test Lumped Parameter Model

- Lumped parameter is consistent with SSAR and WCAP modelling techniques.

- Lumped parameter noding is easier to set up for complex AP600 geometry.

- The comparisons to test data thus far show that lumped parameter is adequate for design basis accidents.

- The blind test model will use lumped parameter model to maintain consistency with AP600 modelling methods:

    - to show it is conservative with respect to pressure
    - to build confidence in our current design basis modelling techniques.

Nodalization Bases for Blind Test

(a,c)

Similarities Between AP600 and LST Model

(a,c)

Differences Between AP600 and LST Model

(a,c)

BASES AND ASSUMPTIONS FOR WGOTHIC BLIND TEST INPUT

M. KENNEDY
CONTAINMENT AND RADIOLOGICAL ANALYSIS

Categories of WGOTHIC Input

- Volumes
- Flow paths
- Thermal Conductors
- Boundary Conditions
- Initial Conditions
- Control Parameters
- Climes