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PRESENTATION
TO
UNITED STATES
NUCLEAR REGULATORY COMMISSION

AP600 Passive Containment Cooling System (PCS) Analysis Program

Pittsburgh, PA

November 15, 1994

ENCLOSURE 1

Agenda

Day 1

Woodcock	1 hr.	PCS analysis program summary and status
Spencer	4 hrs.	Scaling report – methodology overview – conclusions
Spencer	0.5 hr.	PCS open items relevant to scaling report – items 1, 3
Kennedy	0.5 hr.	Test analysis and code validation reports – schedule and outlines
NRC	0.5 hr.	Feedback from previous presentations

Agenda (Cont.)

Day 2

Woodcock	0.5 hr.	Opening remarks
Kennedy	1.5 hrs.	Framework on usage of LST data – matrix of LSTs – status of data reduction
Kennedy	2 hrs.	Test 212.1 – description of tests and data – WGOTHIC lumped parameter results
Kennedy	1.5 hrs.	Test 222.1 – description of tests and data – WGOTHIC lumped parameter results
Kennedy	1 hr.	Subdivided WGOTHIC results
Kennedy	0.5 hr.	Blind test description
NRC	0.5 hr.	Feedback from previous presentations

Agenda (Cont.)

Day 3

Woodcock	0.5 hr.	Opening remarks
NRC	1 hr.	AP600 calculation results
NRC	1 hr.	LST calculation results
Woodcock	2 hrs.	PCS open items review and status
All	1 hr.	Wrap-up and action items
Orr	1 hr.	Discussion of ADS phase A test results

Purposes of Meeting

- Establish common understanding of:
  - scaling
  - test data evaluation status
  - WGOTHIC calculations status
- Address open items

Summary

The major results and conclusions of this scaling analysis are:

- All phenomena were identified and ranked in a phenomena identification and ranking table (PIRT)
- Control volume equations and closure relationships were developed for the significant phenomena and integrated into a scaling model that coupled the inside of containment to the external PCS
- The selected phenomenological models were dimensionless, scalable, and valid for application to both the LSTs and AP600

Summary (Cont.)

- Comparison of the scaling model predictions to large-scale test (LST) results validated the completeness of the PIRT and the scaling model equations

- The LSTs with the steam source in the simulated steam generator compartment were representative of a double-end cold leg guillotine (DECLG)

- Nonprototypicalities were accommodated in the analytical scaling model:

  - restricted below-deck circulation into the steam generator compartment

  - overcooled exterior

[redacted]

PCS Post-Wetting Phenomena Identification and Ranking Table

Component	Phenomena	Ranking		
		internal	riser	downcomer
Module Volume	Two component compressible gas	H	H	L
	Jets	-	-	-
	Buoyant plumes	H*	-	-
	Buoyancy	H*	H	H
	Jet-plume mixing/entrainment	H*	L	L
	Steam source superheating	M	-	-
	Flow field stability	L	L	L
Module Surface	Liquid film heat transfer	H	H	-
	Liquid film stability	L	H**	-
	Liquid film subcooling	L	M	-
	Free convection heat transfer	M	M	H
	Forced convection heat transfer	L	H	H
	Radiation heat transfer	L	H	H
	Free convection mass transfer	H	-	-
	Forced convection mass transfer	L	H	-
Module Solids	1-D transient conduction heat transfer	H	H	H
	2-or 3-D conduction	L	L	L
Inter-Module	Convection	H*	M	H
	Conduction	H	H	H
	Form and friction losses	L	H	H

* Internal phenomena that can be locally important, but were not be included in the single volume internal model. These phenomena will not change the conclusions of this scaling analysis, and thus may be considered of low importance.

** Liquid film stability is analyzed separately and the results imposed on the model.

II.1 Internal Heat Sinks

The internal heat sinks include steel structures, concrete structures, the IRWST, and the containment atmosphere. The internal heat sinks slow the initial containment pressurization rate, and later slow the depressurization rate.

- The steel was separated into 5 groups based upon thickness:
  - the steel with thicknesses less than 0.255 ft. has Biot numbers less than 1, so it can be accurately modeled as lumped masses
  - the shell steel was treated as distinct because it has a cooling water source on the outside after 11 minutes
  - the steel liner on the concrete was modeled with the concrete

II.1 Internal Heat Sinks (Cont.)

- All concrete is 2 ft. or thicker (2-ft. thick concrete has a time constant of approximately 124 hcurs)
  - the concrete was modeled with a finite element conduction model with heat capacity
  - 94% of the concrete is located below deck

II.1 Internal Heat Sinks (Cont.)

Distribution of Steel and Concrete Inside Containment

Group	1	2	3	4	5	6
Material	Steel	Steel	Steel	Steel Shell	Steel	Concrete/Liner
Thickness (ft)	<.015	.015-.051	.051-.255	0.1345	>.255	2/0.042
Area (ft^2)	44400	68828	38970	54116	1786	52622
Volume (ft^3)	591	2624	4974	7328	765	105243/2193

[redacted]

II.1 Containment Gas Volume

The containment gas volume mass and energy conservation equations can be combined and put in the following form with the time rate of change of pressure as the dependent variable:

$$\frac{V_{ct}}{(\gamma-1)}\frac{dP_{ct}}{dt} = -\frac{P_{ct}}{(\gamma-1)}\frac{dV_{ct}}{dt} + \dot{m}_{stm,in}c_{p,stm}T_{stm,in} + \dot{m}_{ct-pl}c_{p,stm}T_{pl,stm} - (\sum_{i=1}^{6}\dot{m}_{ct-lf,i} + \dot{m}_{ct-rw})c_{p,stm}T_{ct,stm}$$

$$- \sum_{i=1}^{6} h_{lf,i}A_{ct-lf,i}(T_{ct} - T_{lf,surf,i}) + h_{pl}A_{ct-pl}(T_{pl,surf} - T_{ct}) - h_{rw}A_{ct-rw}(T_{ct} - T_{rw,surf}) \quad (1)$$

Equation 1 was made dimensionless and each term of the resulting dimensionless equation was then divided by the steam source term, $\dot{m}c_pT$ to produce the time constants and pi groups

[redacted]

II.2 Shield Building Control Volume

- The time constant of the 3-ft. thick shield is over 200 hours

- It was assumed that the convection from the shield to the downcomer air is equal to the radiation from the baffle

- The shield energy equation gives one additional pi group:

$$\Pi_{sd-dc} = \frac{h_{dc-sd}A_{dc-sd}(T_{dc}-T_{sd,surf})}{(\dot{m}hg)_{sim,ic}} \qquad (18)$$

[redacted]

II.2 Air Flow Path Control Volumes

- The riser and downcomer make up the PCS air flow path
- The riser and downcomer energy equations produce no unique pi groups and have already been derived for the external film, dry shell, baffle, and shield
- The integral form of the momentum equation was derived by taking the dot product of a differential form of the momentum equation and integrating around a closed path:

$$\rho_{dc}\left(\frac{V_{dc,in}^{2}-V_{dc,out}^{2}}{2}-(K+\frac{fL_{dc}}{d_{dc}})\frac{V_{dc}^{2}}{2}\right)+\rho_{ri}\left(\frac{V_{ri,in}^{2}-V_{ri,out}^{2}}{2}-(K+\frac{fL_{ri}}{d_{ri}})\frac{V_{ri}^{2}}{2}\right)+\rho_{ch}\left(\frac{V_{ch,in}^{2}-V_{ch,out}^{2}}{2}-(K+\frac{fL_{ch}}{d_{ch}})\frac{V_{ch}^{2}}{2}\right) \quad (19)$$

$$=(\rho_{amb}-\rho_{dc})gH_{dc}-(\rho_{amb}-\rho_{ri})gH_{ri}-(\rho_{amb}-\rho_{ch})gH_{ch}$$

II.2 Air Flow Path Control Volumes (Cont.)

- The left side of Equation 19 is the total system form, acceleration, and friction loss with a value of approximately $[3.5\ \rho_{ri}v_{ri}^2/2,]^{a,c}$ so:

$$\frac{3.5\rho_{ri}v_{ri}^2}{2} = (\rho_{amb}-\rho_{dc})gH_{dc} - (\rho_{amb}-\rho_{ri})gH_{ri} - (\rho_{amb}-\rho_{ch})gH_{ch} \qquad (20)$$

- Normalizing the terms on the right side of the equal sign by the left side gives the following three pi groups:

Downcomer buoyancy	Riser buoyancy	Chimney buoyancy
$\Pi_{dc} = \frac{(\rho_{amb}-\rho_{dc})gH_{dc}}{3.5\ \rho_{ri}v_{ri}^2/2}$ (21)	$\Pi_{ri} = \frac{(\rho_{amb}-\rho_{ri})gH_{ri}}{3.5\ \rho_{ri}v_{ri}^2/2}$ (22)	$\Pi_{ch} = \frac{(\rho_{amb}-\rho_{ch})gH_{ch}}{3.5\rho_{ri}v_{ri}^2/2}$ (23)

III. Closure Relationships

Calculation of the heat and mass transfer to the individual liquid films is possible with the following assumptions:

- The inside of the AP600 containment is well mixed and can be represented by a single volume
- Air and steam are ideal gasses
- The break supplies steam and water at a saturation pressure equal to the pressure of containment
- The steam is saturated at the liquid film surface temperature

The heat and mass transfer relationships are the correlations developed for use on AP600 in the WGOTHIC code, except that only free convection is used inside containment

VII. Nonprototypic Test Characteristics

There are only 2 significant nonprototypic characteristics in the LST, both of which are understood and are accommodated analytically

[redacted]

1. Entrainment into break compartment
2. Externai subcooling

[redacted]

VII.1 Entrainment into Break Compartment

- AP600 has large openings between compartments
- The LST simulated steam generator compartment was not open to the other below-deck compartments
- The result in the LST was a significant increase in the below-deck air concentration, with a modest increase in the above-deck steam concentration
- The available LST data span a sufficient range of steam and noncondensible concentrations to validate the mass transfer models for use on AP600

[redacted]

VII.2 External Subcooling

The LST external water flow rate and its supply temperature produced approximately 4 times the scaled subcooled heat transfer of AP600 (approximately 20% of the LST heat is lost by subcooled water, versus 5% in AP600)

- Part of this mismatch is due to the safety-related assumption that the AP600 source is 120°F; an AP600 water source at 60°F would reduce the mismatch to a factor of 2

- The subcooled heat capacity of the external film is easily modeled analytically and the WGOTHIC model is undergoing validation with LST results

[redacted]

Summary

The major results and conclusions of this scaling analysis are:

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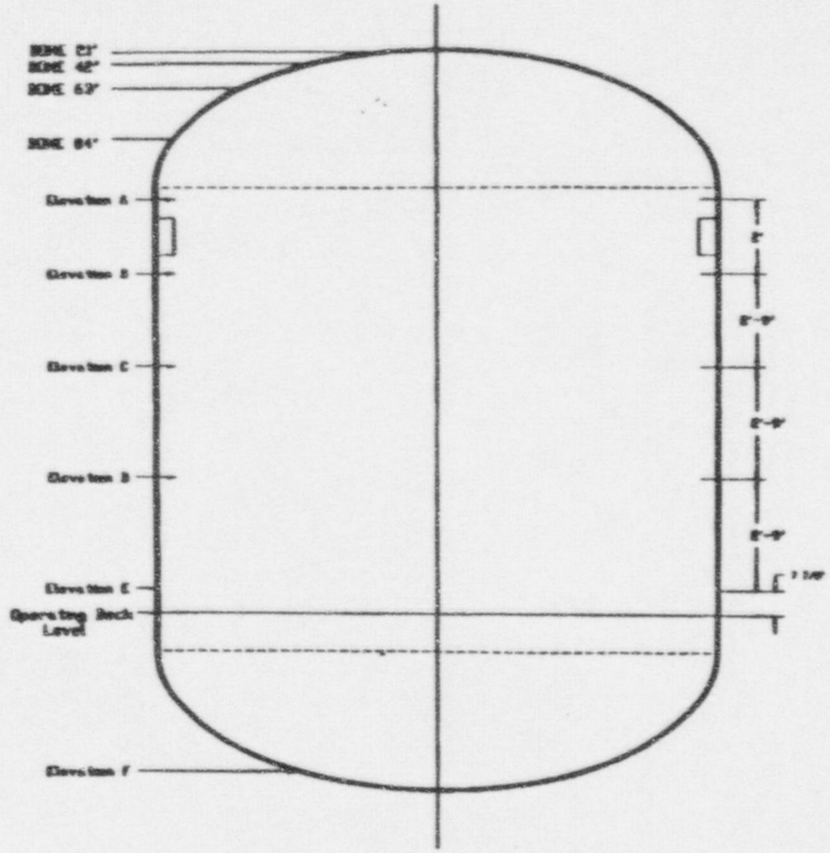
- Control volume equations and closure relationships were developed for the significant phenomena and integrated into a scaling model that coupled the inside of containment to the external PCS
- Comparison of the scaling model predictions to LST results validated the completeness of the PIRT and the scaling model equations

Summary (Cont.)

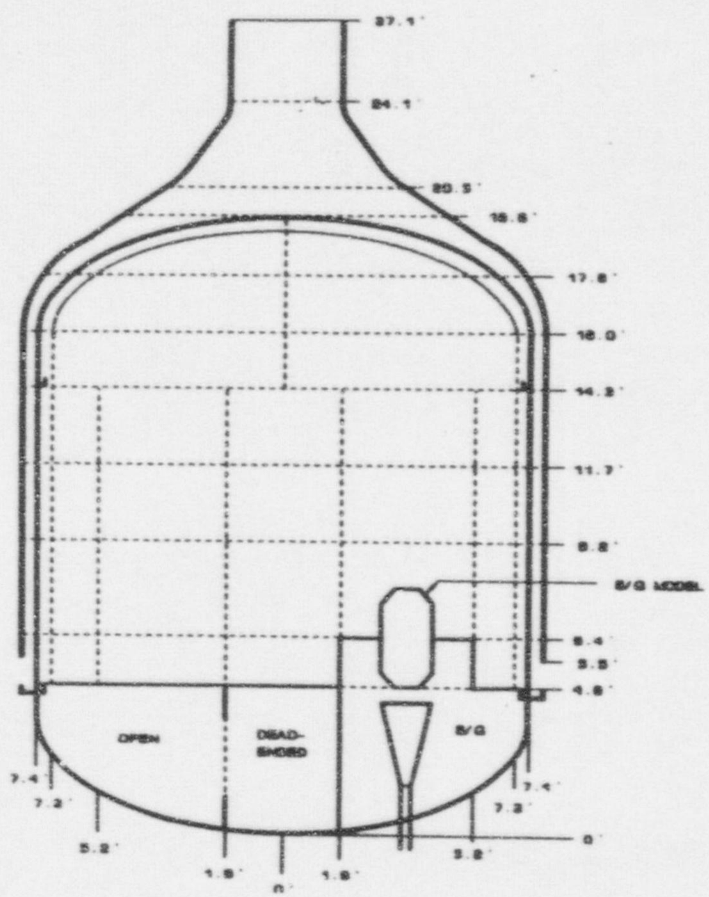
- The selected phenomenological models were dimensionless, scalable, and valid for application to both the LSTs and AP600
- The LSTs with the steam source in the simulated steam generator compartment were representative of a DECLG break
- Nonprototypicalities are accommodated in the analytical scaling model:
  - restricted below-deck circulation into the steam generator compartment
  - overcooled exterior

Test Facility Description



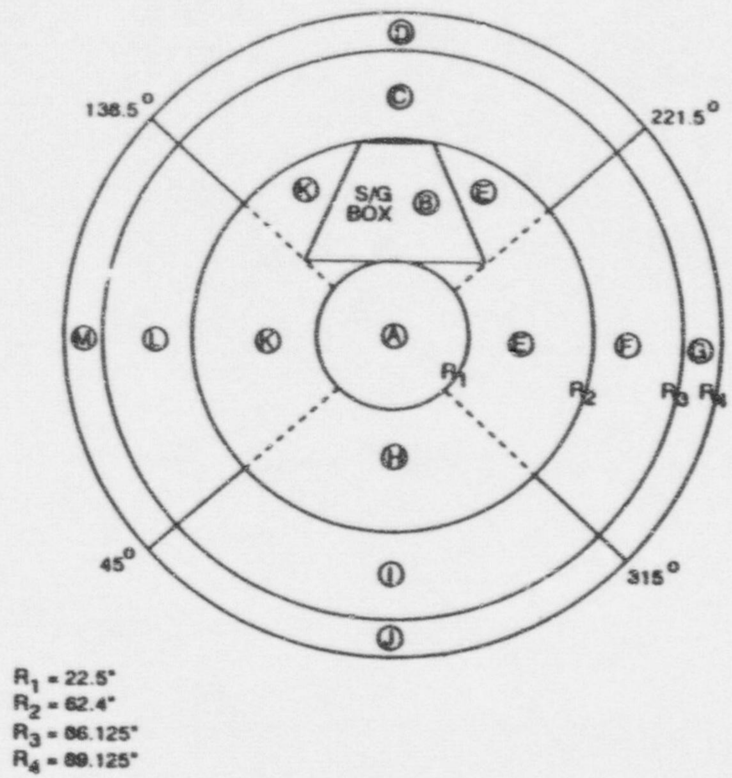
Large-Scale PCS Instrumentation Elevations

Lumped Parameter Noding



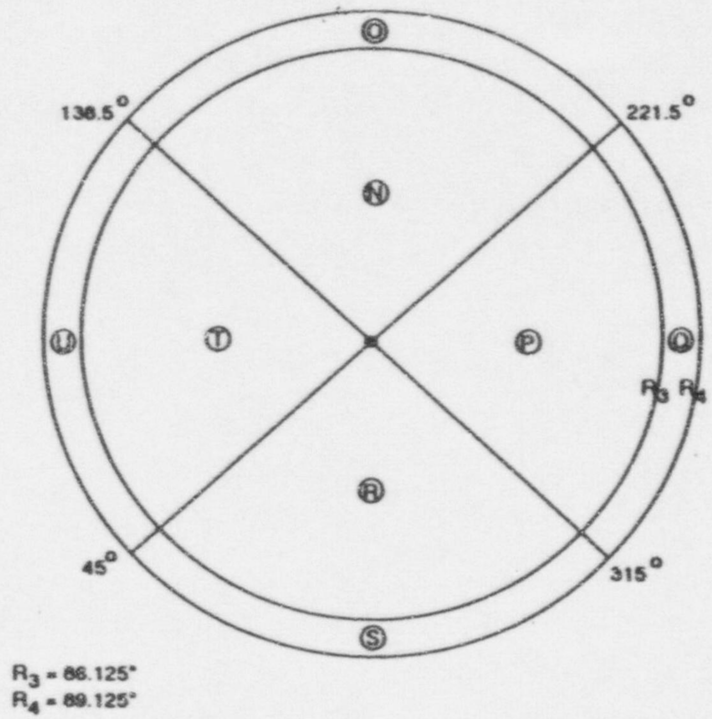
Elevation Noding Diagram of LST Lumped Parameter Model

Lumped Parameter Noding



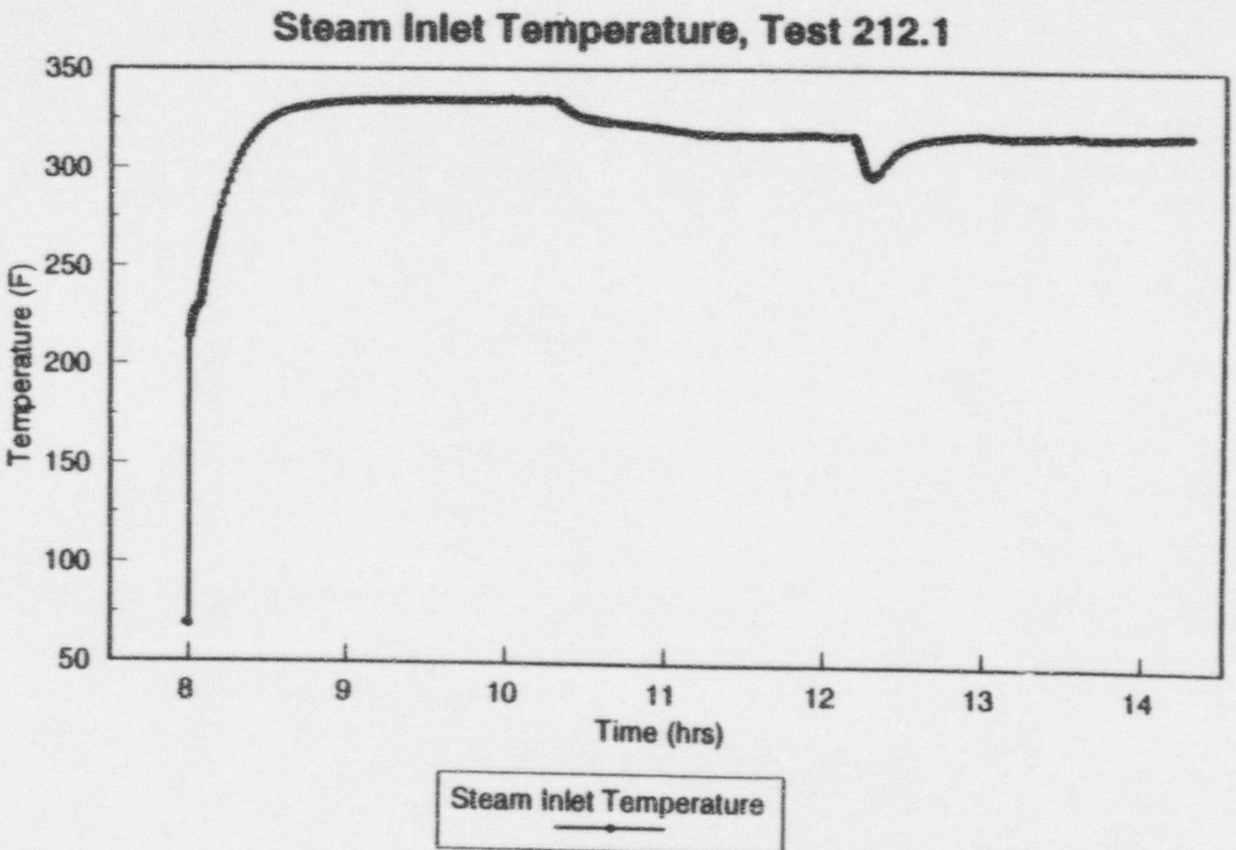
Plan View of LST Vessel Lumped Parameter Noding from Operating Deck to Upper Internal Gutter

Lumped Parameter Noding



Plan View of LST Vessel Lumped Parameter Noding from Upper Internal Gutter to Top of Vessel

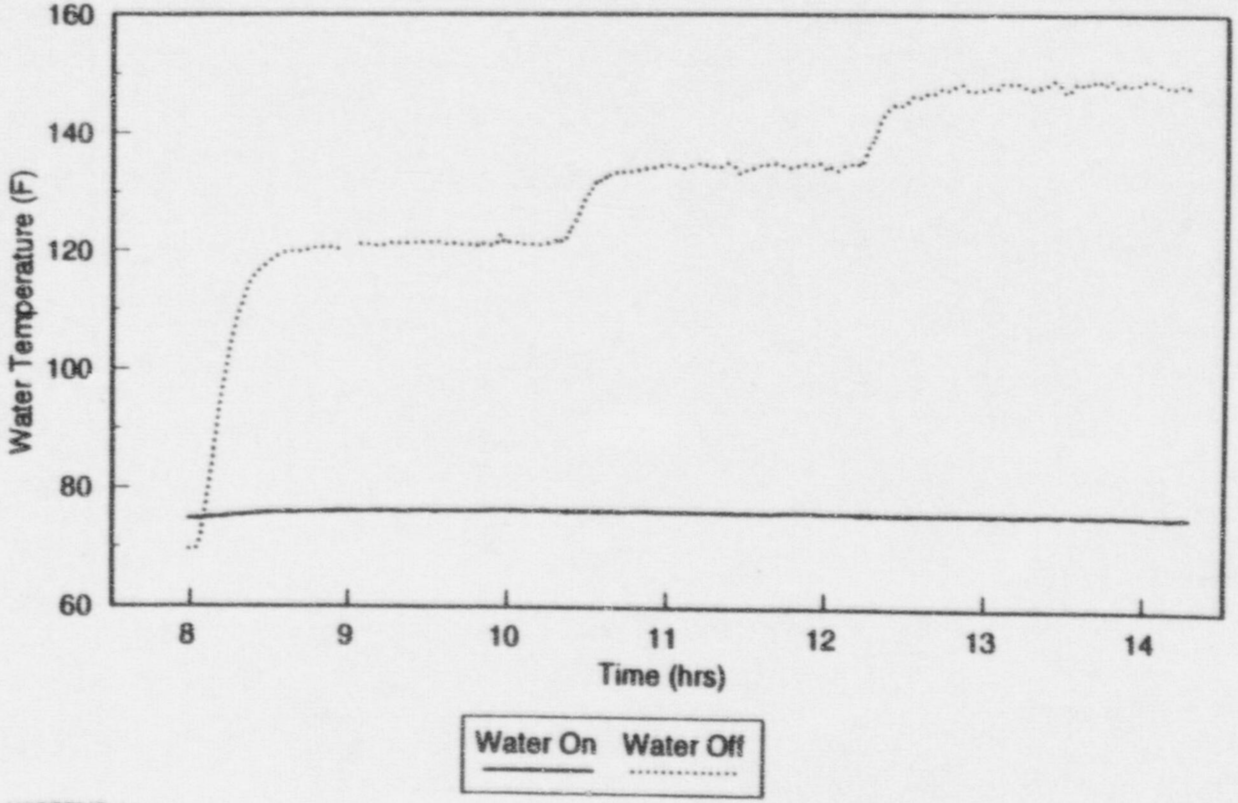
Test 212.1



STMTEMP.drw

Test 212.1

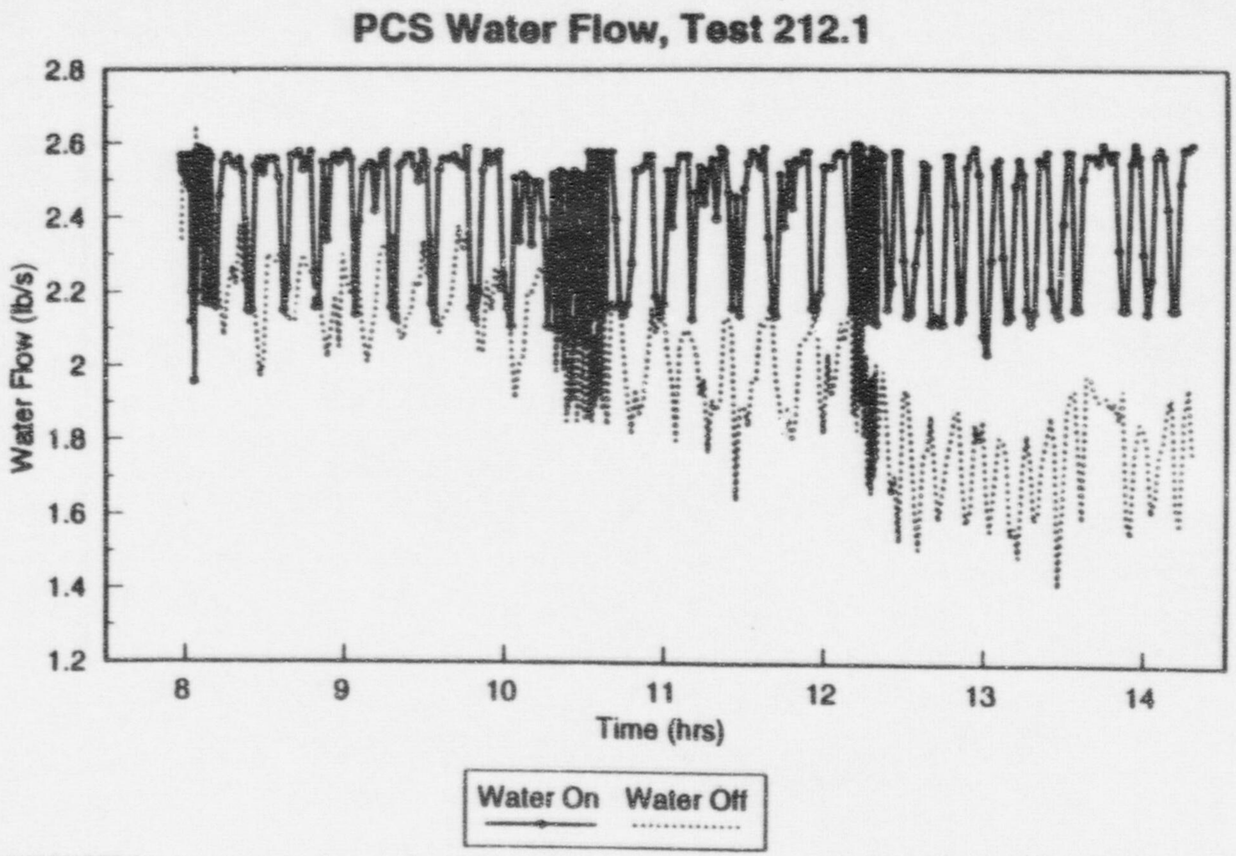
PCS Water Temperature, Test 212.1



H2OTEMP.drw

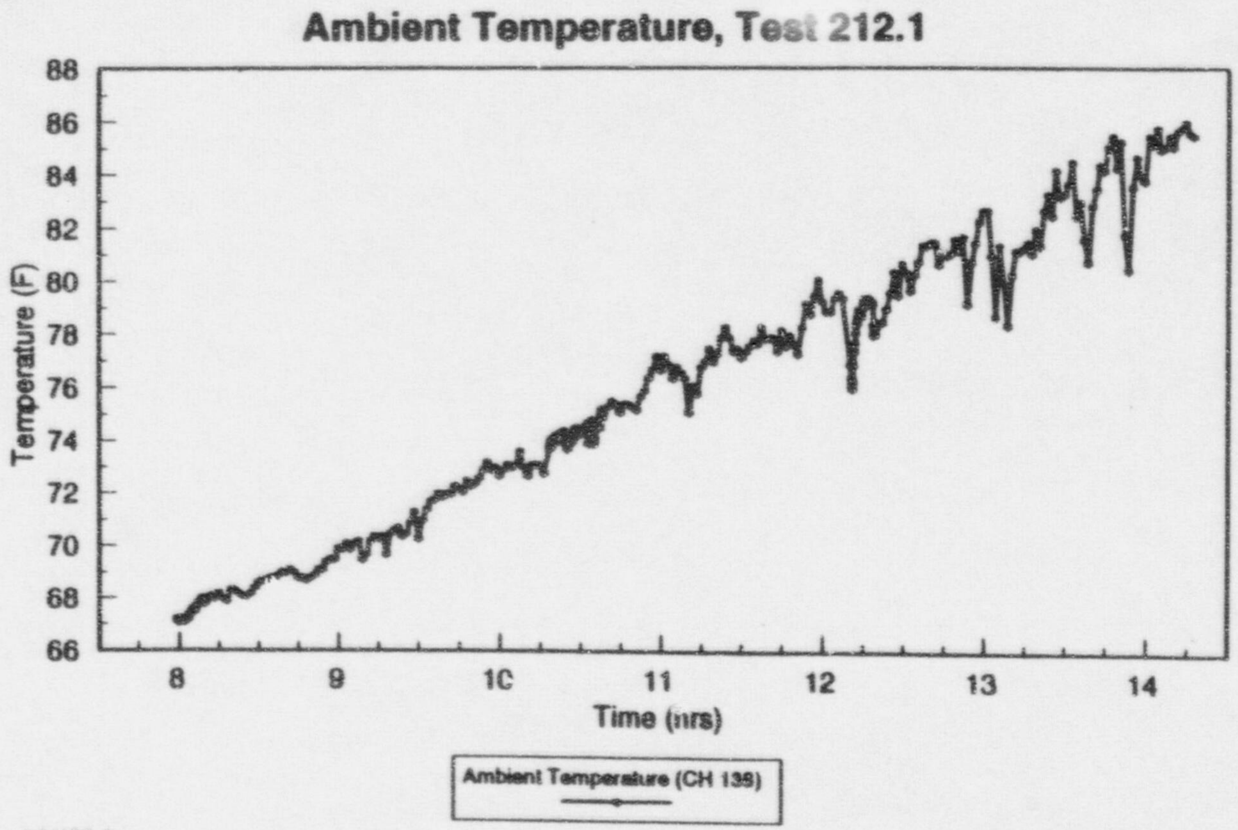
[redacted]

Test 212.1



H20ONOFF.drw

Test 212.1



ambt138.drw
rc048138.wk3

[redacted]

Test 212.1

Velocity Meters

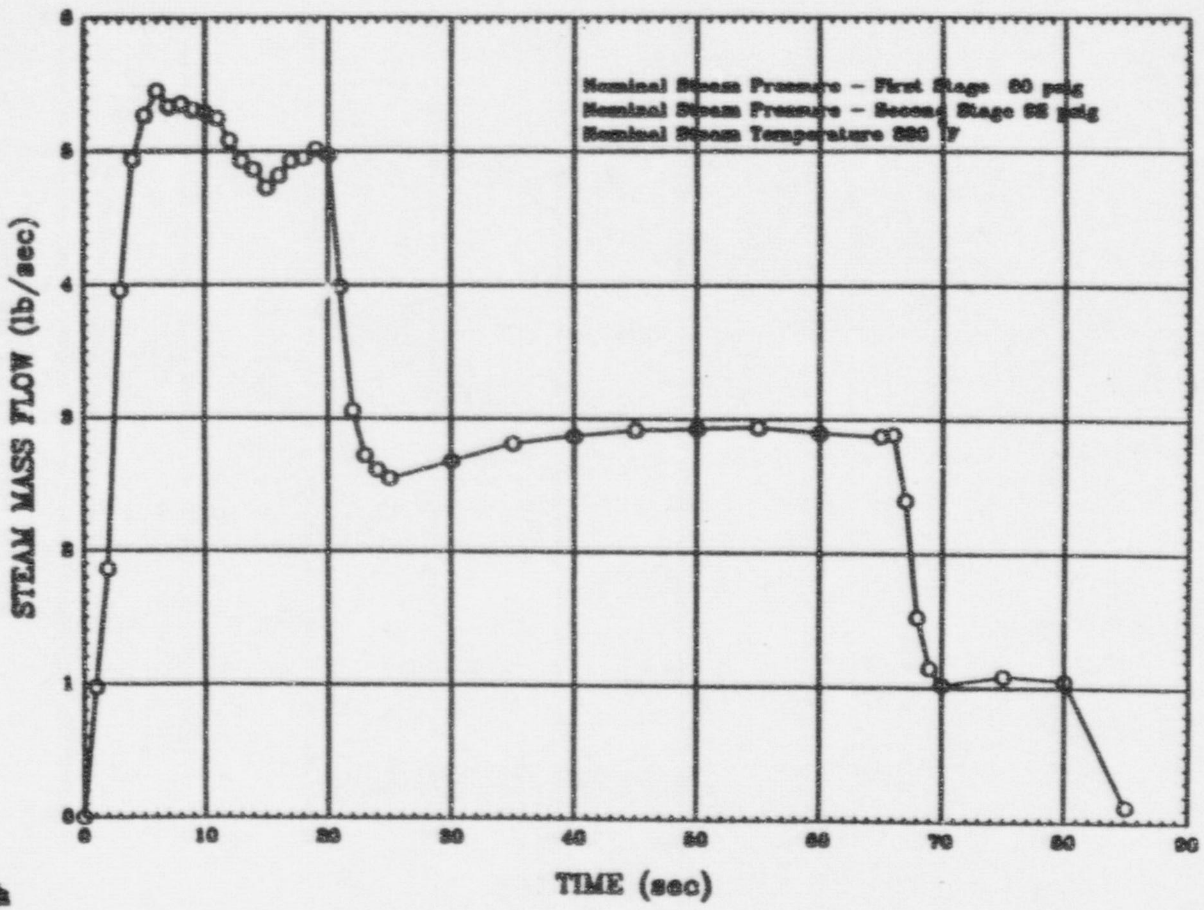
- Dome - 42" - 165° - 1.5" anemometer read an average velocity of 2.5 ft./s
- A - 90° - 1.5" anemometer read an average velocity of 1 ft./s
- Dome - 42" - 345° - 1.5" anemometer read an average velocity of 2 ft./s
- D - 180° - 2" and E - 30° - 2" anemometers have either failed or the velocities are below the sensor threshold

Test 212.1 [redacted]

Observations

- Internal velocity meters along the wall indicated the following:
  - at locations DO-165° and DO-345°, velocities are 2-3 ft./s
  - at location A-90°, the velocity is 1 ft./s in the downward direction

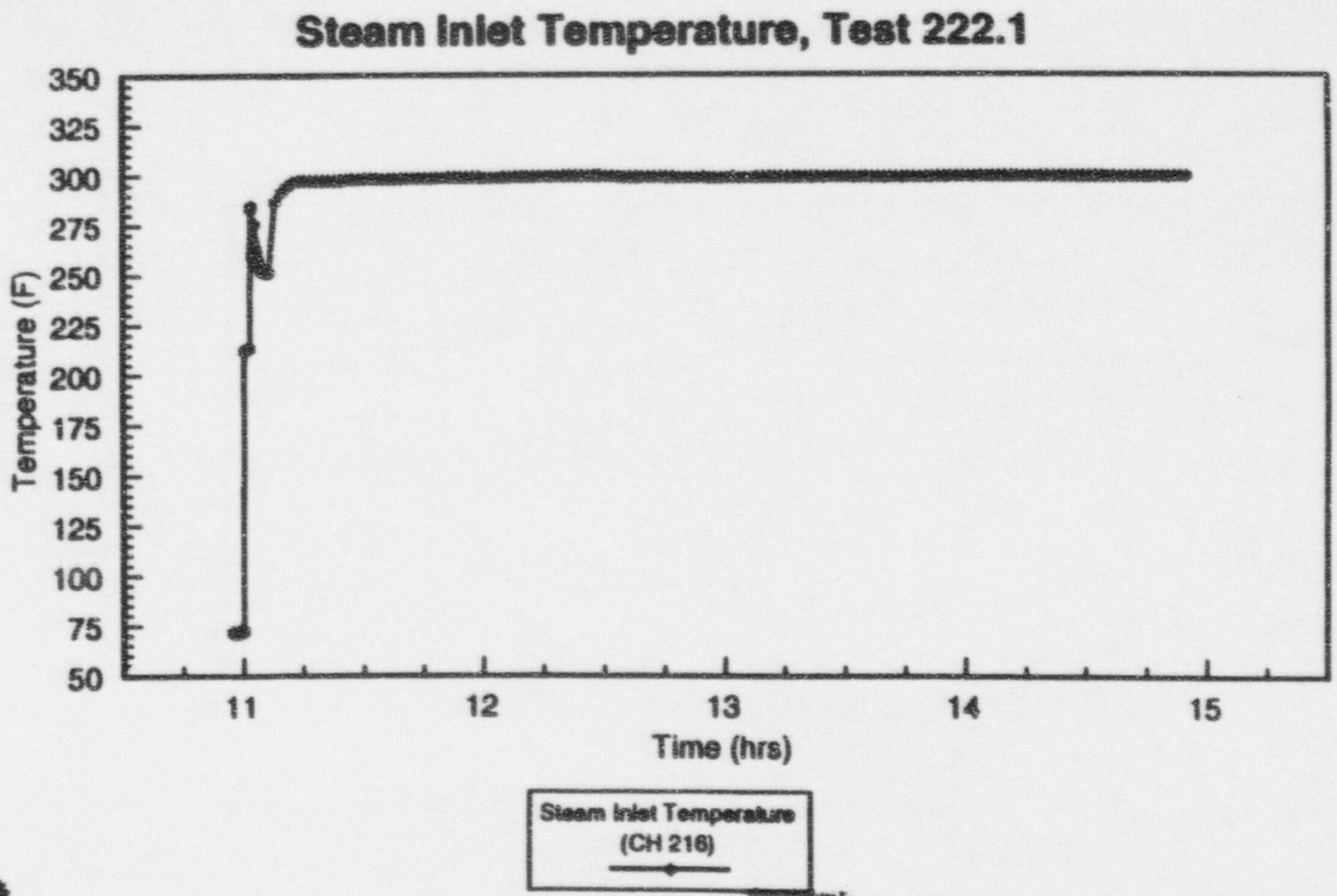
- Exterior water coverage for the first and second steady-state periods was 100% wet. For the third steady-state period, the water coverage was 95%.



Initial Steam Flow Test 222.1, Run RC061

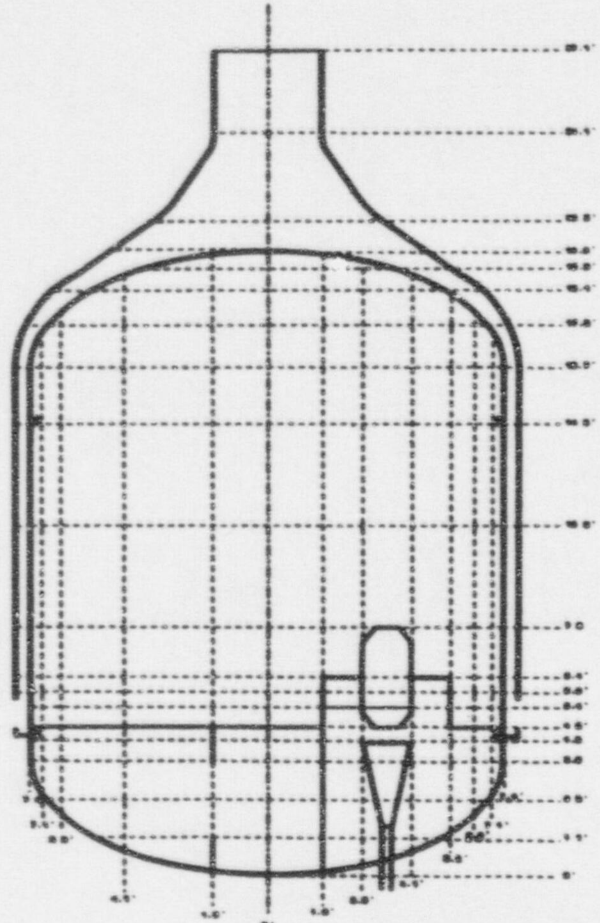
[redacted]

Test 222.1



stm61216.drw
rc061fl.wk3

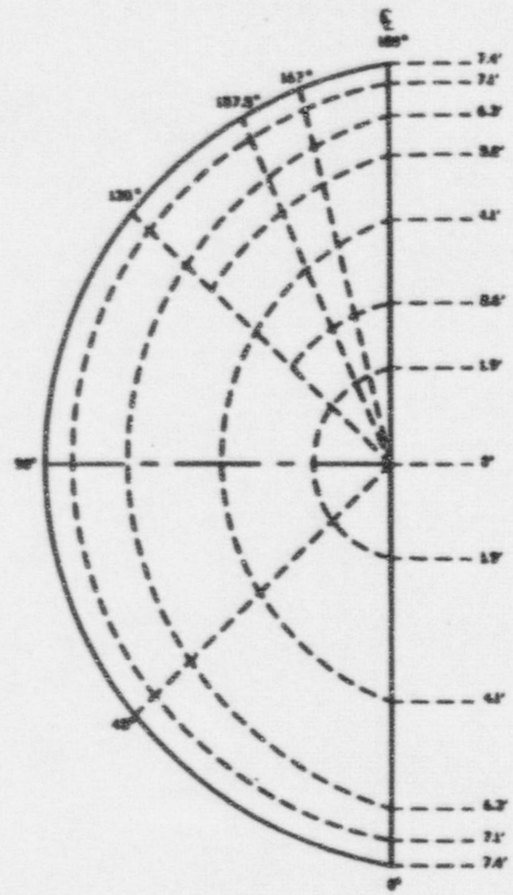
Subdivided WGOTHIC Model



Noding Diagram of Subdivided LST

[redacted]

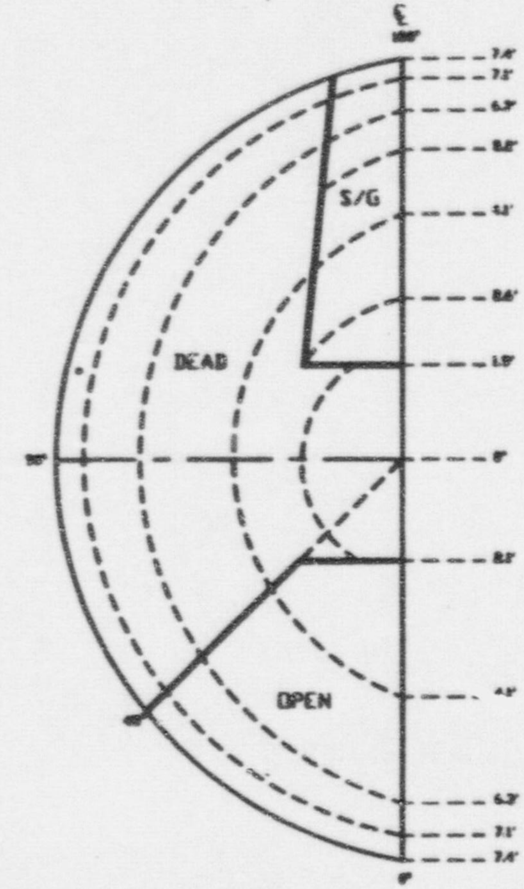
Subdivided WGOTHIC Model



Subdivided Noding Above Operating Deck

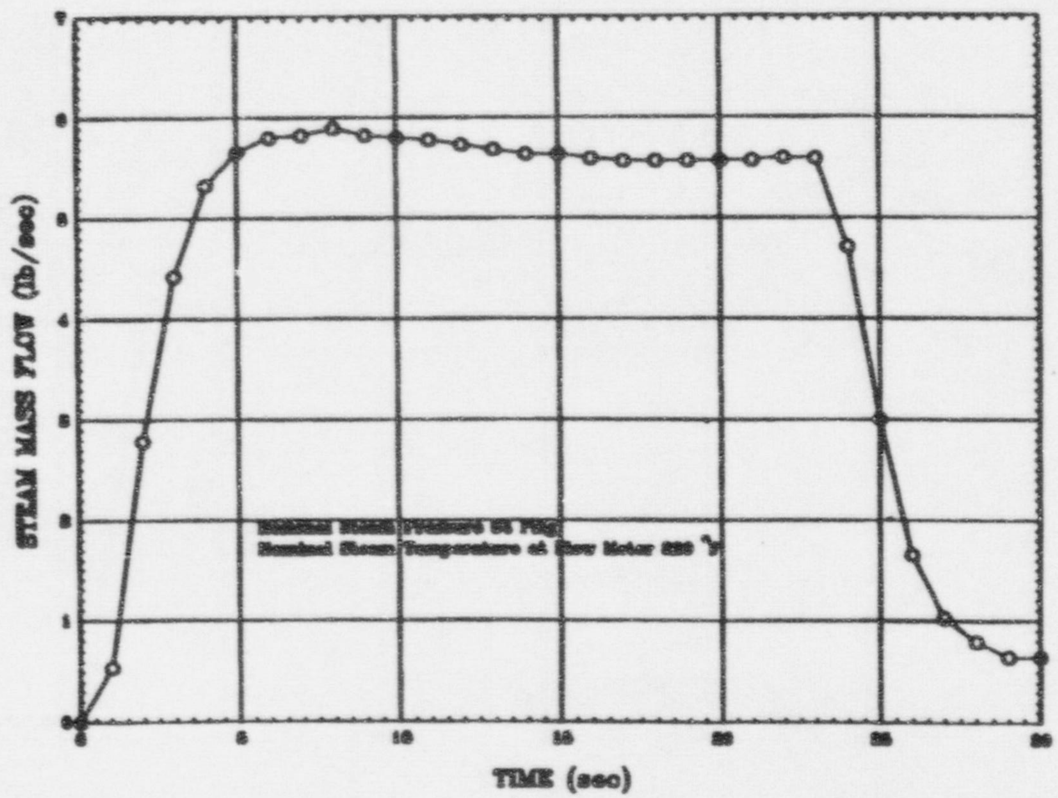
[redacted]

Subdivided WGOTHIC Model

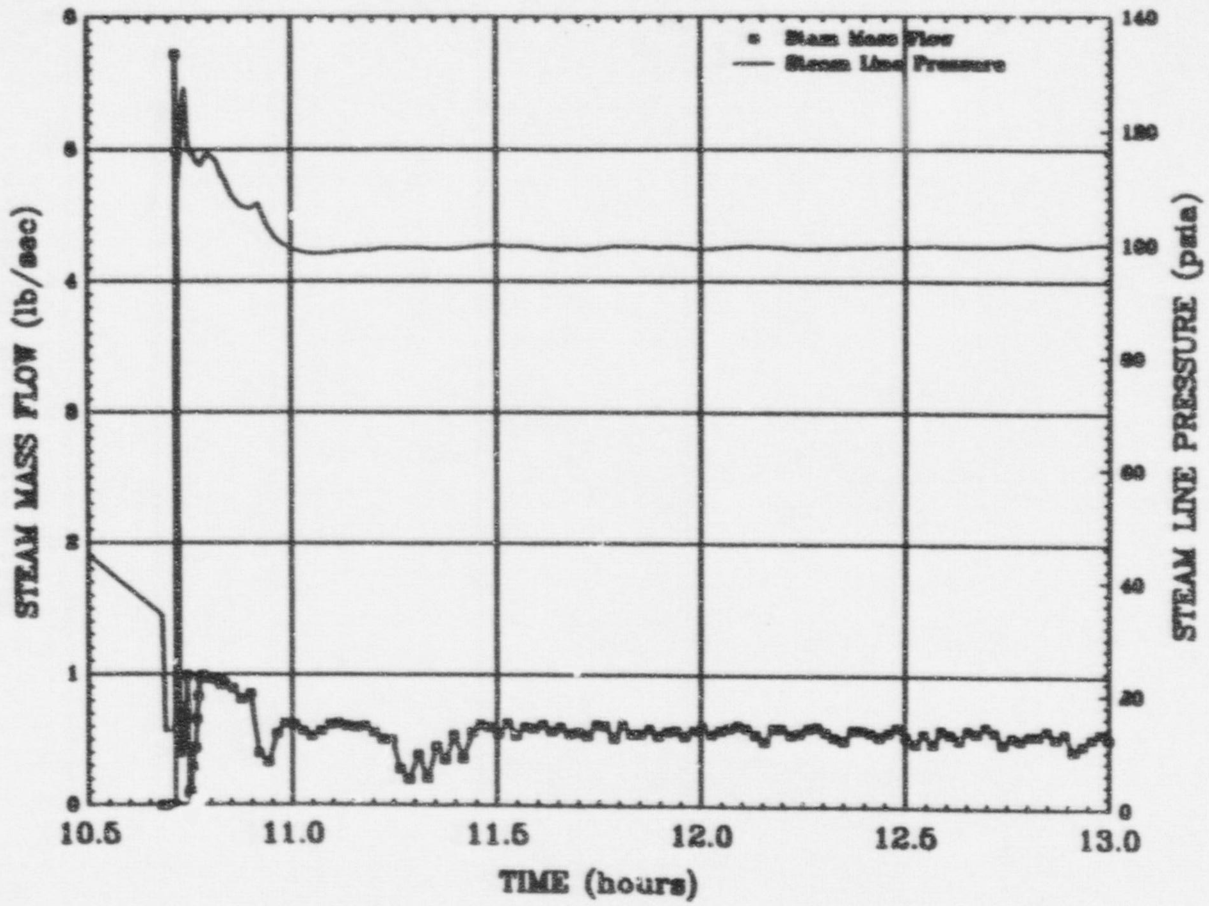


Subdivided Noding Below Operating Deck

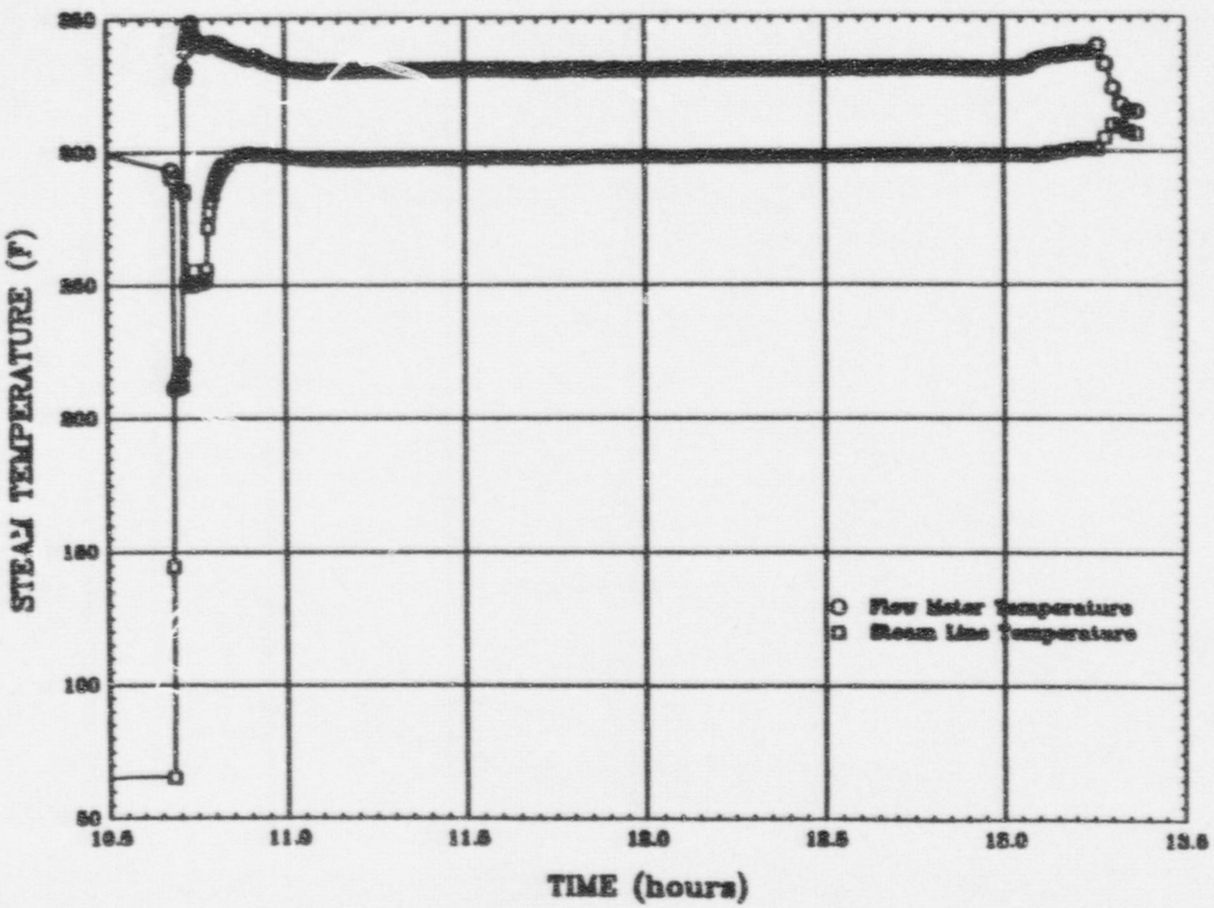
[redacted]



Initial Steam Flow Test 220.1, Run RC062



Steam Inlet Test 220.1, Run RC062



Steam Inlet Temperaturns Test 220.1, Run RC062

[redacted]

TEST 220.1 PRE-TEST SUMMARY DATA RUN RC062					
	WALL TEMPERATURES		TEMPERATURES		
	INSIDE (°F)	OUTSIDE (°F)	INTERNAL FLUID (°F)	WALL ΔT (°F)	INSIDE BAFFLE (°F)
RC062	INSIDE	OUTSIDE	FLUID	DELTA	INSIDE BAFFLE
DOME	62.98	62.91	63.88	0.116	59.14
DOME 21	62.99	62.88	63.80	0.012	
DOME 42	62.87	62.57	63.85	0.582	
DOME 63	63.02	63.11	63.75	0.041	
DOME 84	63.08	62.94	64.19	-0.178	
A	61.85	61.83	63.52	0.018	59.18
B	61.68	61.75	63.04	0.087	58.64
C	61.30	61.20	63.19	-0.060	58.82
D	60.76	60.64	62.79	-0.084	58.15
E	60.04	60.00	52.53	-0.038	57.90
F	61.89	61.97		0.102	
BAROMETRIC PRESSURE			28.80 IN. HG		
RELATIVE HUMIDITY			90%		
VESSEL START TEMP			62 F		
FAN SPEED			533 RPM		

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DCP/NRC1415
NSD-NRC-98-5759
Docket No.: 52-003

August 17, 1998

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 2055

ATTENTIC :: T. R. Quay

SUBJECT: RESPONSE TO NRC LETTERS CONCERNING REQUEST FOR WITHHOLDING INFORMATION

Reference:
1. Letter, Donohew to Liparulo, "Request for withholding information from public disclosure for Westinghouse AP600 design letters of November 21, 1994," dated August 1, 1995.
2. Letter, McIntyre to Quay, "Status review of AP600 proprietary submittals," dated September 18, 1995.
3. Letter, Jackson to Liparulo, "Request for withholding information from public disclosure for Westinghouse AP600 design letters of June 20, 19954," dated November 16, 1995.
4. Letter, McIntyre to Quay, "WCAP-14845, 'Scaling analysis for AP600 containment pressure during design basis accidents', Rev 3 errata," DCP/NRC1379, dated June 9, 1998.
5. Letter, McIntyre to Quay, "Errata to WCAP-14407, Rev 3, 'WGOTHIC application to AP600'," DCP/NRC1395, dated July 14, 1998.
6. Letter, McIntyre to Quay, "Response to NRC letter of August 23, 1995, 'Request for withholding information in the design certification application for the AP600'," DCP/NRC1400, dated July 22, 1998.

Dear Mr. Quay:

Reference 1 provided the NRC assessment of the Westinghouse claim that proprietary information was provided in a letter dated November 21, 1994, that contained presentation materials from the November 15 through 17, 1994, meeting where the AP600 passive containment cooling system was discussed. The NRC assessment was that some, but not all, of the material was sufficiently specific to

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ENCLOSURE 2

the AP600 and the AP600 passive containment cooling testing to reveal distinguishing aspects of the passive containment cooling system and improve a competitors advantage. Our 1995 request, Reference 2, indicated that the material provided in the Westinghouse letter of November 21, 1994, was presentation material that was intended for clarification only, not part of the formal review material and requested that the material be returned to Westinghouse. At the time this subject was being discussed with the NRC technical staff, the information was considered to be proprietary by Westinghouse since it contained information that had commercial value to Westinghouse. If this presentation material was indeed used by the staff in development of the AP600 final safety evaluation report, then at this time, almost four years later, this information will no longer considered to be proprietary by Westinghouse.

Reference 3 provided the NRC assessment of the Westinghouse claim that proprietary information was provided in a letter dated June 20, 1995, which provided a copy of WCAP-14382, "WGOTHIC Code Description and Validation." The NRC assessment was that all of the material identified as proprietary, with the exception of Figure 8-19, "Large scale PCS Instrumentation Elevations" would be accepted as proprietary by the NRC. The Reference 3 pointed out that this same figure was nonproprietary on page 3-12 of WCAP-14382. Figure 8-19, therefore, will no longer considered to be proprietary by Westinghouse.

Westinghouse has been verbally informed by the NRC that the Westinghouse letter of June 9, 1998, (reference 4), appeared to contain proprietary information that was not clearly identified other than being marked "Westinghouse Proprietary Class 2" on the page and also that there was no affidavit included with the letter. The June 9, 1998, letter contained errata for WCAP-14845, Revision 3, which is a proprietary report and for WCAP-14846, Revision 3, which is the nonproprietary version of WCAP-14845. In accordance with Westinghouse company policy, each page of a proprietary report has "Westinghouse Proprietary Class 2" on the page header. Specific information that is proprietary is then indicated with brackets. It is possible that there will be no information on a page that is marked as being proprietary. In the case of the June 9, 1998, letter, none of the errata pages for WCAP-14845 contained Westinghouse proprietary information, thus no affidavit was necessary and the letter can be placed in the NRC public document room.

Westinghouse has been verbally informed by the NRC that the Westinghouse letter of July 14, 1998, (reference 5), appeared to contain proprietary information that was not clearly identified other than being marked "Westinghouse Proprietary Class 2" on the page and also that there was no affidavit included with the letter. The July 14, 1998, letter contained errata for WCAP-14407, Revision 3, which is a proprietary report. In accordance with Westinghouse company policy, each page of a proprietary report has "Westinghouse Proprietary Class 2" on the page header. Specific information that is proprietary is then indicated with brackets. It is possible that there will be no information on a page that is marked as being proprietary. In the case of the July 14, 1998, letter, none of the errata pages for WCAP-14407 contained Westinghouse proprietary information, thus no affidavit was necessary and the letter can be placed in the NRC public document room.

On August 14, 1998, Westinghouse was verbally informed by the NRC that the information contained in Chapter 18 of Revision 0 of the AP600 Standard Safety Analysis Report (SSAR) that was submitted to the NRC on June 26, 1992, and was requested to be withdrawn by Reference 6, forms the basis of the Chapter 18 of the AP600 Final Safety Evaluation report that will soon be issued by the NRC and therefore cannot be withdrawn without seriously affecting the FSER issuance date. To maintain this information as proprietary, Westinghouse would have to provide a marked proprietary version and a corresponding nonproprietary version of this material. Reference 6 pointed out that Chapter 18 has been entirely reformatted since the SSAR was submitted originally as a result of Westinghouse significantly changing the approach being taken to human factors as a part of design certification. As a result, the information in Revision 0 through 8 of the SSAR is essentially no longer applicable to the AP600 design certification process, except for the information contained in Subsection 18.9.8.1 - Development of emergency operating procedures and Tables 18.9.8-1 through 18.9.8-37 - Emergency response guidelines, which was declared to be nonproprietary in Reference 6. Given the desire to complete the AP600 FSER and Final Design Approval in a timely manner, Westinghouse will no longer consider the material in Chapter 18 of Revisions 0 through 8 of the SSAR to be proprietary.

This response addresses the proprietary issues delineated in the references.

Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

jml

cc: J. W. Roe - NRC/NRR/DRPM
J. M. Sebrosky - NRC/NRR/DRPM
W. C. Huffman - NRC/NRR/DRPM
H. A. Sepp - Westinghouse