Westinghouse Electric Corporation
Energy Systems

Box 355
Pittsburgh Pennsylvania 15230-0355

AW-97-1100

April 23, 1997

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

ATTENTION: MR. T. R. QUAY

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

SUBJECT: PRESENTATION MATERIAL FROM MARCH 28, 1997 ACRS MEETING

Dear Mr. Quay:

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-97-1100 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-97-1100 and should be addressed to the undersigned.

Very truly yours,

Brian A. McIntyre

Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

jml

cc: Kevin Bohrer NRC OWFN - MS 12E20

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 and Licensing

Sworn to and subscribed
before me this 24th day
of April, 1997

Janet A. Schwab
Notary Public

Notarial Seal
Janet A. Schwab, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires May 22, 2000
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 NSD-NRC-97-5082, April 23, 1997 being transmitted by Westinghouse Electric Corporation (W) letter and Application for Withholding Proprietary Information from Public Disclosure, Brian A. McIntyre (W), to Mr. T. R. Quay, 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.

Enclosure 2 to Westinghouse

Letter NSD-NRC-97-5082

April 23, 1997

3169A

PRESENTATION
TO
UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

AP600 LONG TERM COOLING

DR. L. E. HOCHREITER
SYSTEMS ANALYSIS ENGINEERING

WESTINGHOUSE ELECTRIC CORPORATION

(412) 374-5158

ACRS MEETING
FRIDAY, MARCH 28, 1997
LONG TERM COOLING

1. Introduction
   a. Computer Code Selection
   b. Window Mode Approach Definition

2. PIRT

3. WC/T Validation
   a. OSU Model
   b. Sensitivity Calculations
   c. Comparisons with Data

4. AP600 Plant Model
   a. Plant Model
   b. Containment Boundary Conditions

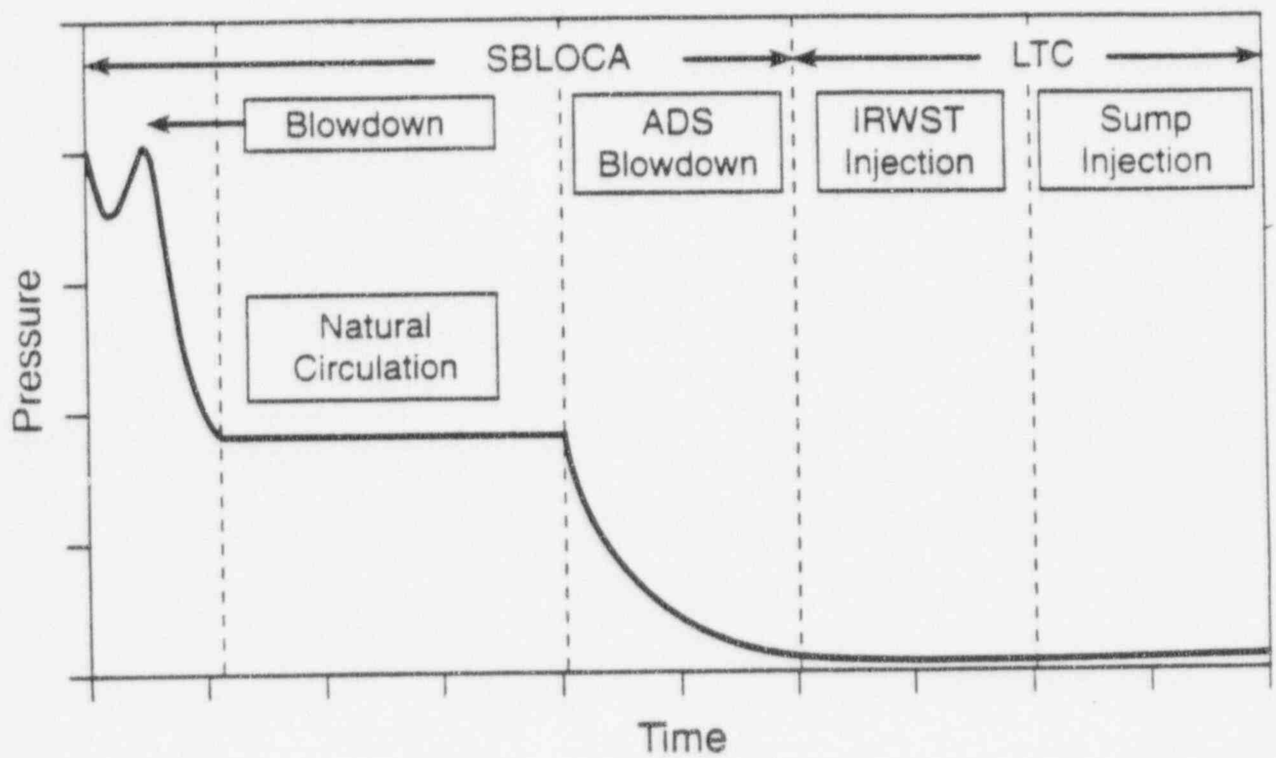
5. Conclusions

AP600 LONG TERM COOLING

- INTRODUCTION
  - AP6OO LONG TERM COOLING FEATURES:
    - QUASI-STEADY GRAVITY INJECTION FOR LONG PERIODS (INDEFINITELY UNTIL THE PLANT IS RECOVERED)
    - TWO INJECTION PHASES:
      - INITIAL INJECTION FROM IRWST WITH (HIGHER HEAD AND HIGHER FLOWS WHEN DECAY POWER IS HIGH
      - RECIRCULATION INJECTION FROM SUMP WITH LOWER FLOWS WHEN DECAY POWER HAS DECREASED
    - REACTOR CAVITY BECOMES FLOODED, COVERS HOT AND COLD LEGS

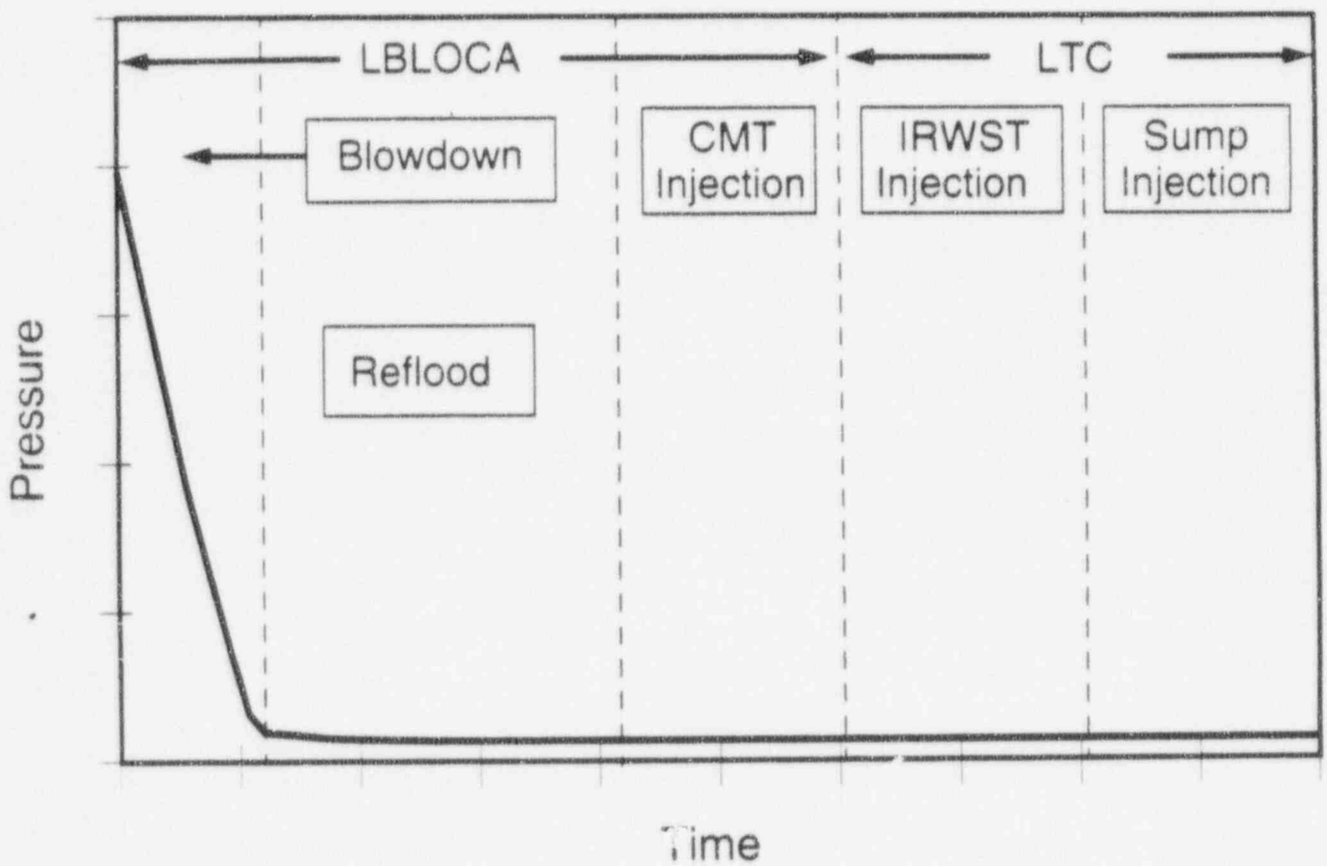
AP600 LONG TERM COOLING

AP600 Small Break LOCA
and LTC Scenario

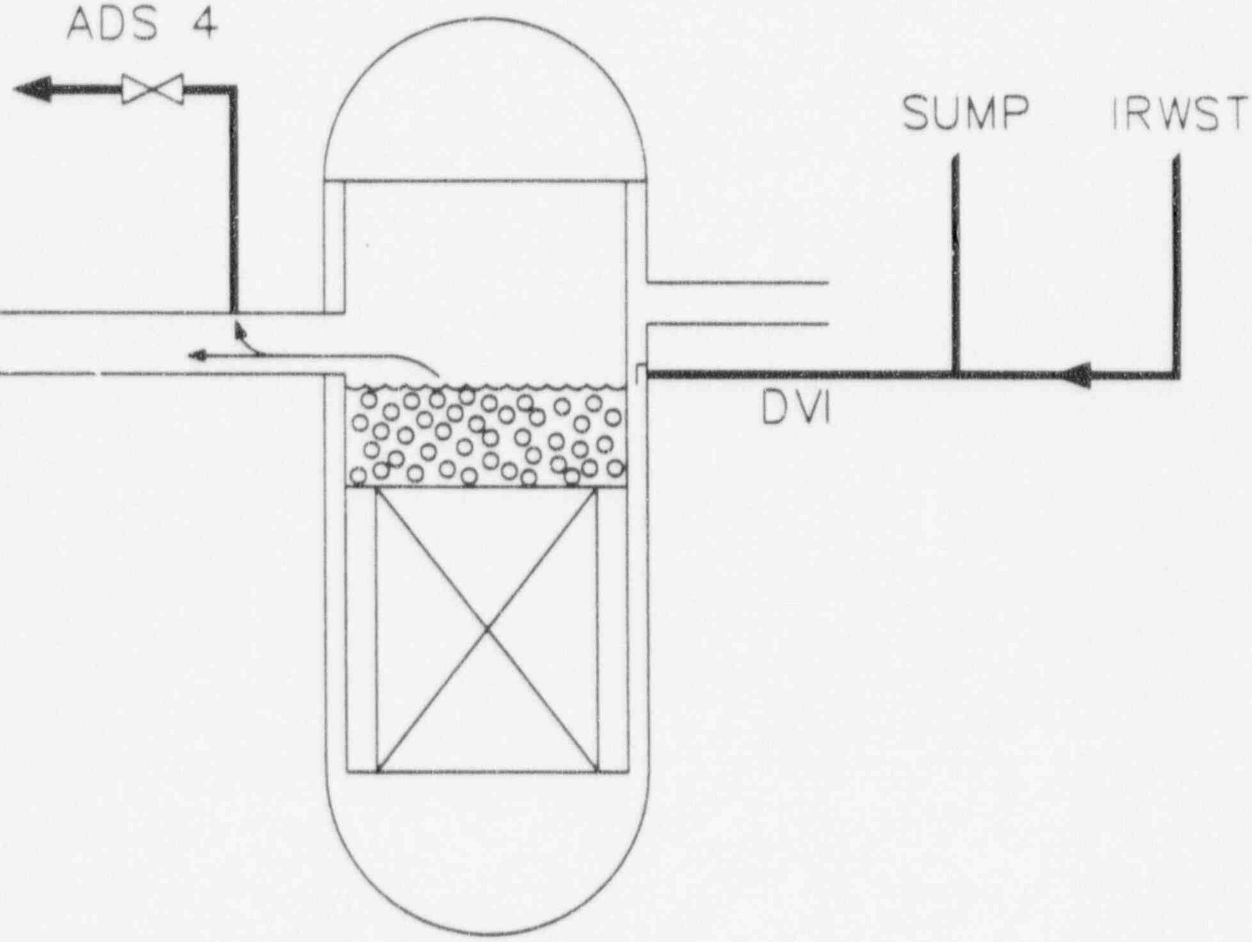


AP600 LONG TERM COOLING

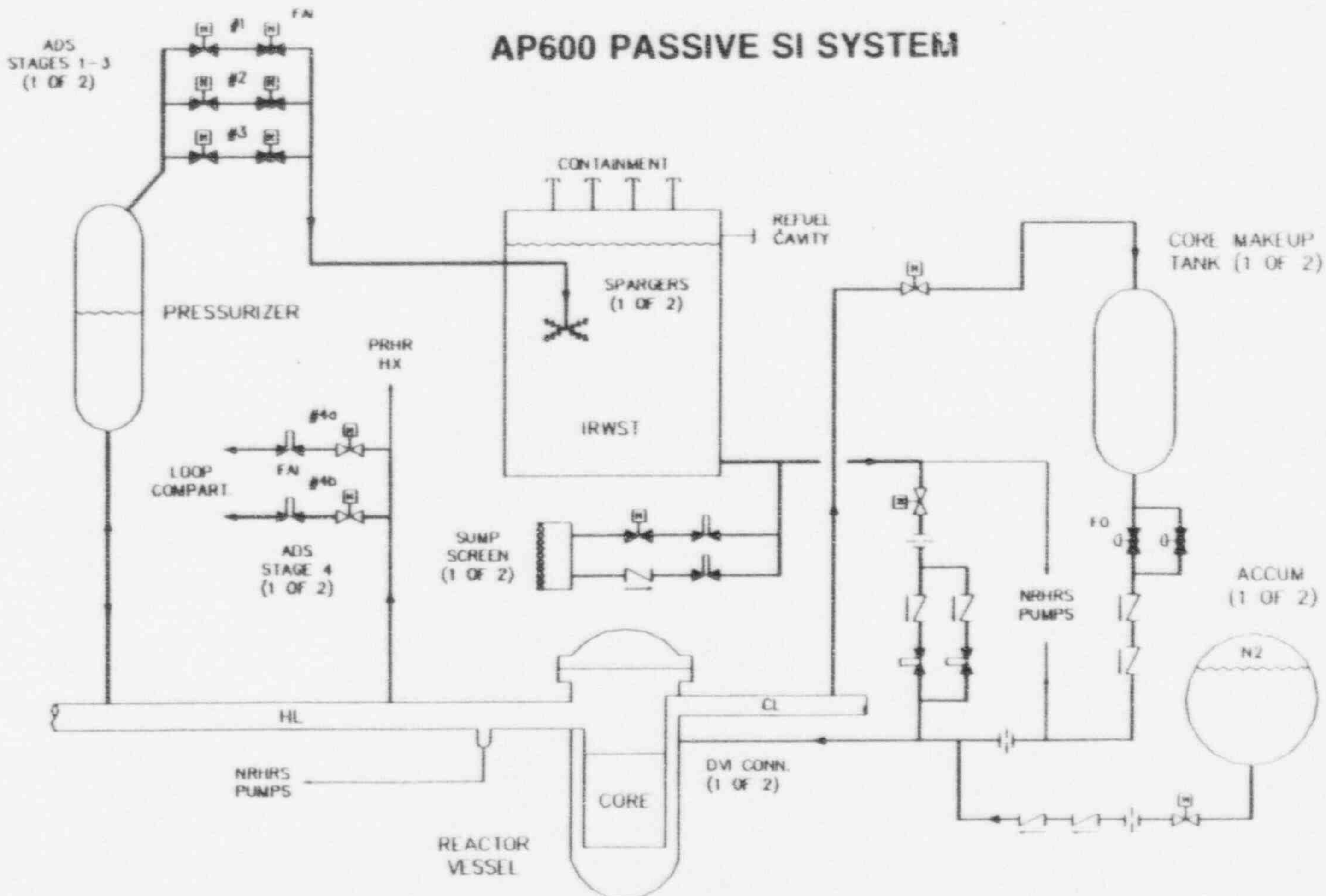
AP600 Large Break LOCA
and LTC Scenario



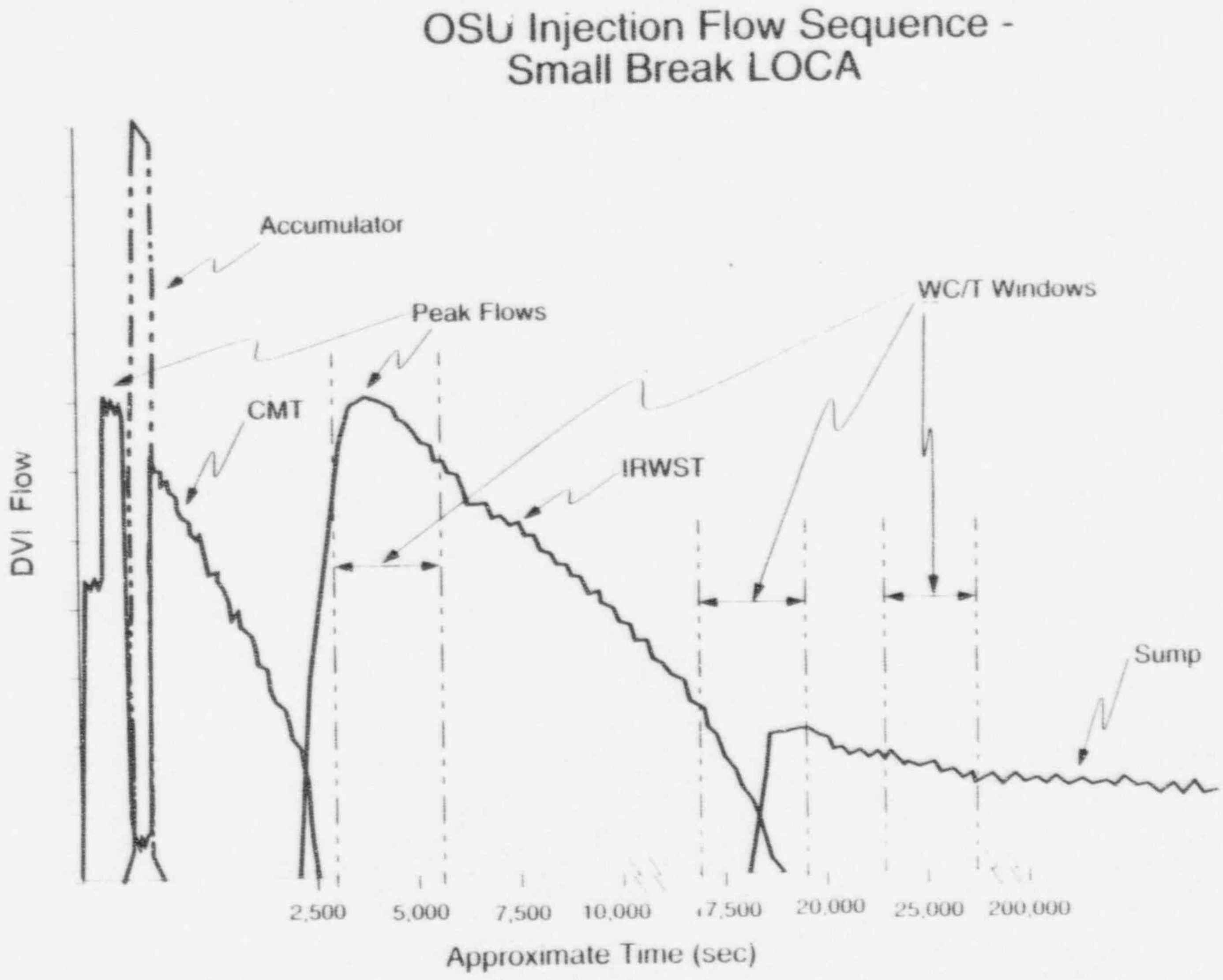
AP600 LONG TERM COOLING



AP600 LONG TERM COOLING



AP600 LONG TERM COOLING



AP600 LONG TERM COOLING

IRWST INJECTION PHASE

a,b,c

AP600 LONG TERM COOLING

a,c

AP600 LONG TERM COOLING

a,b,

AP600 LONG TERM COOLING

a,b

AP600 LONG TERM COOLING

- INTRODUCTION - CON'T

  - LONG TERM COOLING IS COMMON END POINT FOR ANY TRANSIENT WHICH ACTIVATES ADS 1-3, OR THE RCS IS DEPRESSURIZED (SBLOCA, LBLOCA).

  - OBJECTIVES OF THE AP600 PLANT ANALYSIS IS TO VERIFY THAT AP600 PASSIVE SAFETY SYSTEMS:

    - MAINTAIN CORE COOLABILITY INDEFINITELY

    - HAVE THE SAME PEDIGREE AS SIMILAR LONG TERM COOLING SYSTEMS ON CURRENT OPERATING PLANTS.

AP600 LONG TERM COOLING

- LONG TERM ANALYSIS METHOD

  - WCOBRA/TRAC WAS SELECTED FOR AP600 LONG TERM COOLING ANALYSIS

    - ACCURATE LOW PRESSURE CALCULATIONS ARE NEEDED
    - APPENDIX K TYPE CALCULATIONS WERE AGREED UPON WITH THE NRC
    - IT WAS DESIRABLE TO USE AN ANALYSIS METHOD WITH WHICH THE NRC WAS FAMILIAR

AP600 LONG TERM COOLING

- LONG TERM COOLING ANALYSIS METHOD - CON'T

- SINCE THE LONG TERM COOLING TRANSIENTS ARE LONG QUASI-STEADY FLOW SITUATIONS, A "WINDOW MODE" ANALYSIS METHOD HAS BEEN ADOPTED

    - THE "WINDOWS" REPRESENT SELECTED TIME PERIODS FROM THE FULL TRANSIENT WHICH EXAMINE THE MOST CHALLENGING LTC CONDITIONS

    - "WINDOW " CALCULATIONS ARE TYPICALLY 1000 - 2000 SECONDS IN LENGTH FOR THE PLANT

WESTINGHOUSE WCOBRA/TRAC DOCUMENTATION

WC/T OPERATING PLANTS

- BAJOREK, S. M., "WESTINGHOUSE CODE QUALIFICATION DOCUMENT FOR BEST ESTIMATE LOCA ANALYSIS", WCAP-12945-P, JUNE 1993.
- JONES, R.C., "ACCEPTANCE FOR REFERENCING OF THE TOPICAL REPORT WCAP-12945-P, WESTINGHOUSE CODE QUALIFICATION DOCUMENT FOR BEST ESTIMATE LOCA ANALYSIS", TAC NO. M83964, JUNE 1996.

WC/T LONG TERM COOLING

- GARNER, D. C., et.al. "WC/T OSU LONG-TERM COOLING VALIDATION REPORT", WCAP-14776, NOVEMBER 1996.
- GARNER, D. C., "WC/T VALIDATION OF AP600 LONG TERM COOLING", NDS/NRC-97-5014, MARCH, 1997.
- GARNER, D. C., et.al. "LONG-TERM CORE COOLING SUMMARY REPORT", WCAP-14857, MARCH, 1996.

WESTINGHOUSE WCOBRA/TRAC DOCUMENTATION

AP600

- SER REQUIREMENTS FOR APPROVED VERSION OF WCAP-12945-P:
  - ROADMAP UP FRONT
  - RE-WRITTEN TO REFLECT FINAL METHODOLOGY
  - WELL INDEXED, WITH RELEVANT RAIS REFERENCED WITHIN THE REPORT
- W HAS RE-SCHEDULED THE COMPLETION DATE TO 5/30/97 (NSD-NRC-97-5011)
- MAGNITUDE OF THE TASK:
  - ORIGINAL DOCUMENT HAD 28 SECTIONS, TOTALLING ~ 5,000 PAGES
  - RAI RESPONSES, METHODOLOGY REVISIONS, ETC. TOTALLED ANOTHER ~ 10,000 PAGES
- STATUS:
  - 20 OF 28 SECTIONS REWRITTEN
  - 7 TO 8 MAN-MONTHS INVESTED

AP600 LONG TERM COOLING

- DURING THE LTC TRANSIENT, THE PLANT PRIMARY SYSTEM IS IN A ONCE THROUGH COOLING MODE WITH INJECTION INTO THE DVI LINE AND VENTING OUT THE ADS STAGE 4 VALVES

  - THE REACTOR SYSTEM TRANSIT TIME IS APPROXIMATELY 300 - 700 SECONDS DEPENDING ON THE TIME PERIOD

  - SINCE THE WINDOW MODE CALCULATIONS ARE FOR LONGER TIME PERIODS, THE RESULTING QUASI-STEADY STATE FOR THE REACTOR SYSTEM IS DRIVEN BY THE IMPOSED BOUNDARY CONDITIONS, NOT THE INITIAL CONDITIONS

  - THE INITIAL CONDITIONS (SUCH AS VESSEL LEVELS OR MASS DISTRIBUTION) WILL BE SWEPT AWAY BY THE IMPOSED BOUNDARY CONDITIONS OF,

    - DVI LINE FLOW
    - CORE POWER
    - CONTAINMENT PRESSURE

AP600 LONG TERM COOLING

- AS A RESULT, A REASONABLE SET OF INITIAL CONDITIONS ARE ADEQUATE TO INITIALIZE A WINDOW MODE CALCULATION SINCE AT THE END OF 1000 - 2000 SECONDS. THE RESULTS REFLECT THE IMPOSED BOUNDARY CONDITIONS.

- IN THIS FASHION, THE LONG TIME PERIODS OF THE LTC TRANSIENT CAN BE DIVIDED INTO SHORTER TRANSIENTS WHICH CAPTURE THE MOST IMPORTANT TIME PERIODS TO SHOW ADEQUATE CORE COOLING

- SEVERAL DIFFERENT CALCULATIONS ARE PERFORMED TO EXAMINE DIFFERENT LTC SITUATIONS TO ASSURE ADEQUATE CORE COOLING

AP6OO LONG TERM COOLING PIRT

AP600 LONG TERM COOLING

- AP600 LONG TERM COOLING PIRT

  - LTC PIRT WAS DEVELOPED AND REVIEWED AT WESTINGHOUSE AND HAS BEEN SUBMITTED TO THE NRC AS PART OF THE LTC V&V REPORT (WCAP-14776)

  - SOME PHENOMENA WHICH WERE INITIALLY RANKED HIGHER ARE NOW RANKED LOWER BASED ON THE OSU TEST ANALYSIS AND OSU SIMULATIONS

  - COMMENTS HAVE BEEN RECEIVED FROM THE NRC AND ITS CONSULTANTS, AND HAVE BEEN INCLUDED IN THE FINAL LTC PIRT.

TABLE 1-1 PHENOMENA IDENTIFICATION RANKING TABLE FOR AP600 LOCA LTC TRANSIENT (Rev. 1)		
Component Phenomenon	**IRWST Injection[1]**	**Sump Injection[1]**
Break		
Critical flow	M	N/A
Subsonic flow	M	L
ADS Stages 1 to 3		
Critical flow	M	N/A
Subsonic flow	M	L
Two-phase pressure drop	L	L
Valve loss coefficients	M/L	L
Single-phase pressure drop	L	L
Vessel/Core		
Decay heat	H	H
Flow resistance	L	L
Flashing	N/A	N/A
Wall-stored energy	M	M
Natural circulation flow and heat transfer	M	M
Mixture level mass inventory	H	H
Pressurizer		
Pressurizer fluid level	L	N/A
Wall-stored heat	L	N/A
Pressurizer Surge Line		
Pressure drop/flow regime	L	L
Downcomer/Lower Plenum		
Pressure	H	H
Liquid level	H	H
Condensation	M	M
Upper Head		
Liquid level	N/A	N/A
Flow through downcomer top nozzles	M	M

AP600 LONG TERM COOLING

TABLE 1-1 (Cont)
PHENOMENA IDENTIFICATION RANKING TABLE
FOR AP600 LOCA LTC TRANSIENT (Rev. 1)

Component Phenomenon	IRWST Injection[1]	Sump Injection[1]
Upper Plenum		
Liquid level	H	H
Entrainment/deentrainment	M	M
Cold Legs		
Condensation	L	L
Separation at balance line tee	L	L
Steam Generator		
2Φ - natural circulation	N/A	N/A
Steam generator heat transfer	L/NA[2]	N/A
Secondary conditions	L/NA[2]	N/A
Hot Leg		
Flow pattern transition	H/M	H/M
Separation at ADS4 tee	H/M	H/M
ADS4		
Critical flow	H	N/A
Subsonic flow	H	H
CMT		
Recirculation injection	N/A	N/A
Gravity draining injection	L	L
Vapor condensation rate	L	L
CMT Balance Lines		
Pressure drop	N/A	N/A
Flow composition	L	L
Accumulators		
Noncondensible gas entrainment	N/A	N/A
IRWST		
Gravity draining injection	H	M
Vapor condensation rate	L	L
Temperature distribution	M	M

TABLE 1-1 (Cont) PHENOMENA IDENTIFICATION RANKING TABLE FOR AP600 LOCA LTC TRANSIENT (Rev. 1)		
Component Phenomenon	IRWST Injection(1)	Sump Injection(1)
DVI Line		
Pressure drop	H	H
PRHR		
Liquid natural circulation flow and heat transfer	N/A	N/A
Sump		
Gravity draining injection	N/A	H
Level	N/A	H
Temperature	N/A	H

Note:

1. H = High
   M = Medium
   L = Low
   N/A = Not Applicable

2. The rankings for steam generator heat transfer and secondary conditions are Low for IRWST injection after a large break and Not Applicable for IRWST injection after a small break.

PRESENTATION
TO
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NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

AP600 LONG TERM COOLING

D. C. GARNER
SYSTEMS ANALYSIS ENGINEERING

WESTINGHOUSE ELECTRIC CORPORATION

(412) 374-5352

WC/T Code Validation for AP600 Long-Term Cooling

- Overview of OSU Test Data
  - Test to Test Similarities
  - Significant Flow Rates
  - Vessel Pressure Variations
- Summary of Westinghouse Topical Report (WCAP-14776)
- Recent Extended Time Calculational Results (NSD/NRC-97-5014)

The Following Figures are in the Proprietary Version of this Presentation

Figure 1

Figure 2

Figure 3

OSU Measured Flow Rates at End of IRWST Draindown

	Test / Time			
	SB01 / 14,500 sec	SB10 / 14,000 sec	SB12 / 9,000 sec	SB23 / 14,500 sec
<u>Vessel inflows</u>				
DVI-1 (lb/sec)	0.530	0.520	1.140*	0.540
DVI-2 (lb/sec)	0.520	0.540	0.300	0.560
Total Vessel Inflow (lb/sec) **	1.050	1.060	1.440	1.100
<u>Vessel Outflows</u>				
Break Flow (lb/sec)	-0.030	0.070	-	-0.025
ADS1,2,3 Flow (lb/sec)	0.006	0.003	0.011	0.014
ADS4-1 Flow (lb/sec)	0.530	0.960	0.710	0.450
ADS4-2 Flow (lb/sec)	0.550		0.580	0.550
Total Vessel Outflow (lb/sec) **	1.056	1.033	1.301	0.989

* Broken DVI line has low hydraulic resistance

** Inflow and outflow measurements match within the 2σ flow measurement uncertainty of $\pm$ 0.14 lb/sec

The Following Figures are in the Proprietary Version of this Presentation

Figure 1

Figure 1

OSU Test Data Summary

- In the latter half of IRWST injection and during sump injection, reactor vessel conditions are largely independent of break size and location. *

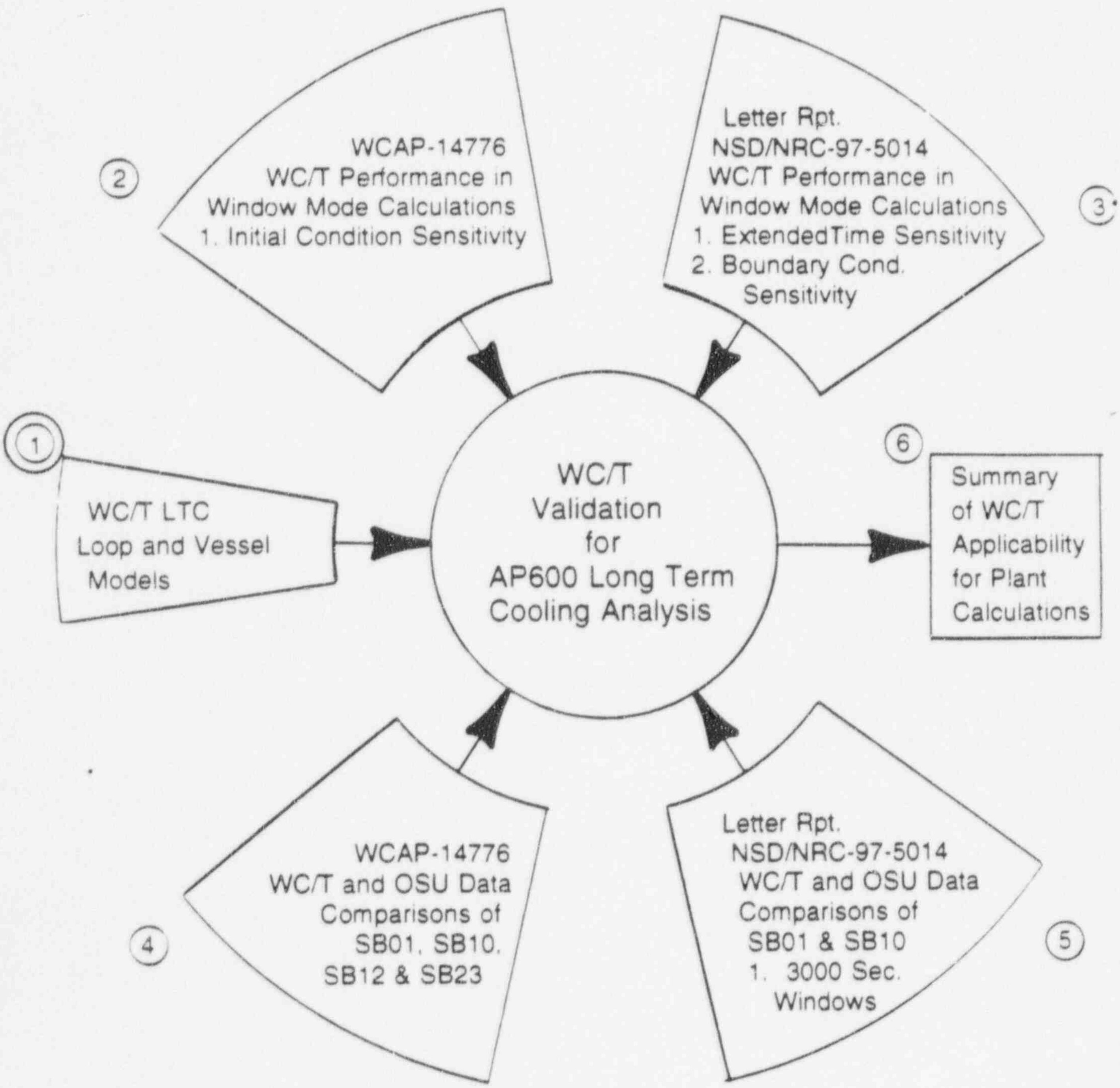
    - Reactor vessel liquid levels
    - DVI and ADS 4 flow rates
    - Reactor vessel pressure

- In the same time period, pressures in the downcomer, upper plenum, and upper head are essentially equal.

- As a consequence of the above, collapsed liquid levels in the downcomer and core/upper plenum are essentially equal.

* Only partially true of DVI line breaks due to substantially reduced resistance to vessel inlet flow.

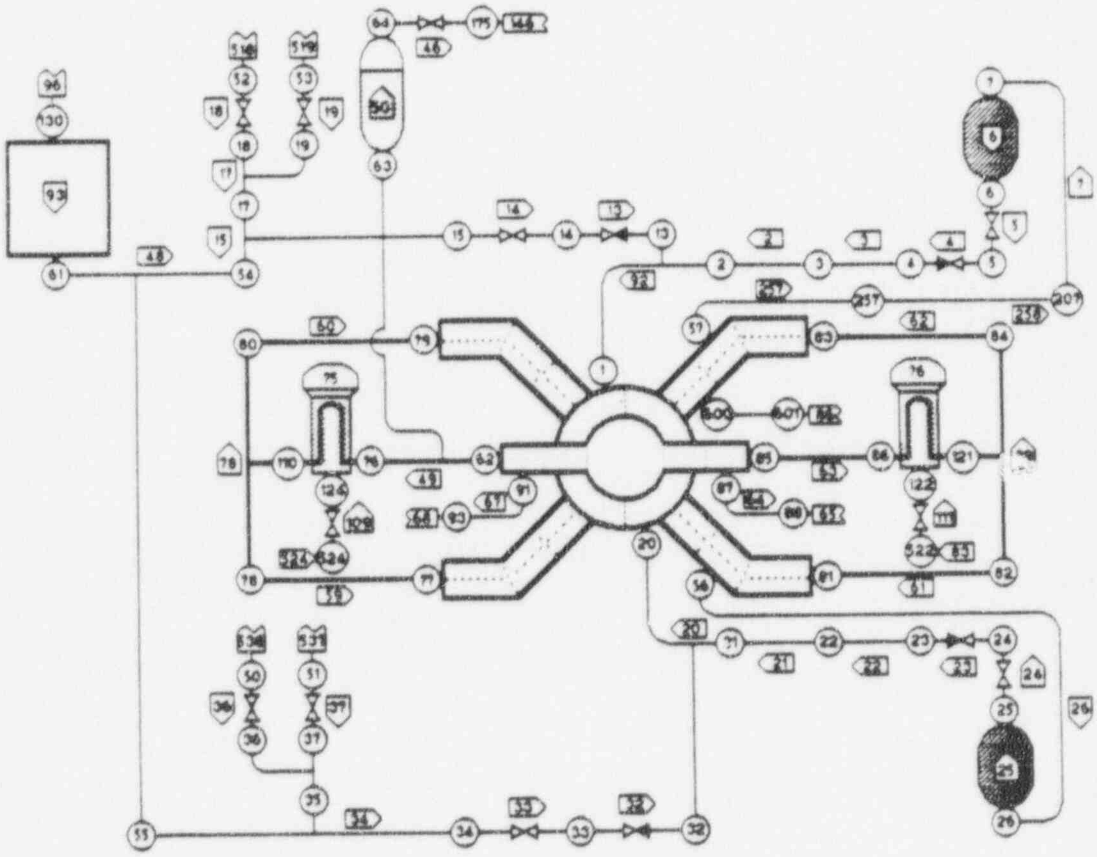
WC/T Code Validation for AP600 Long Term Cooling Analysis



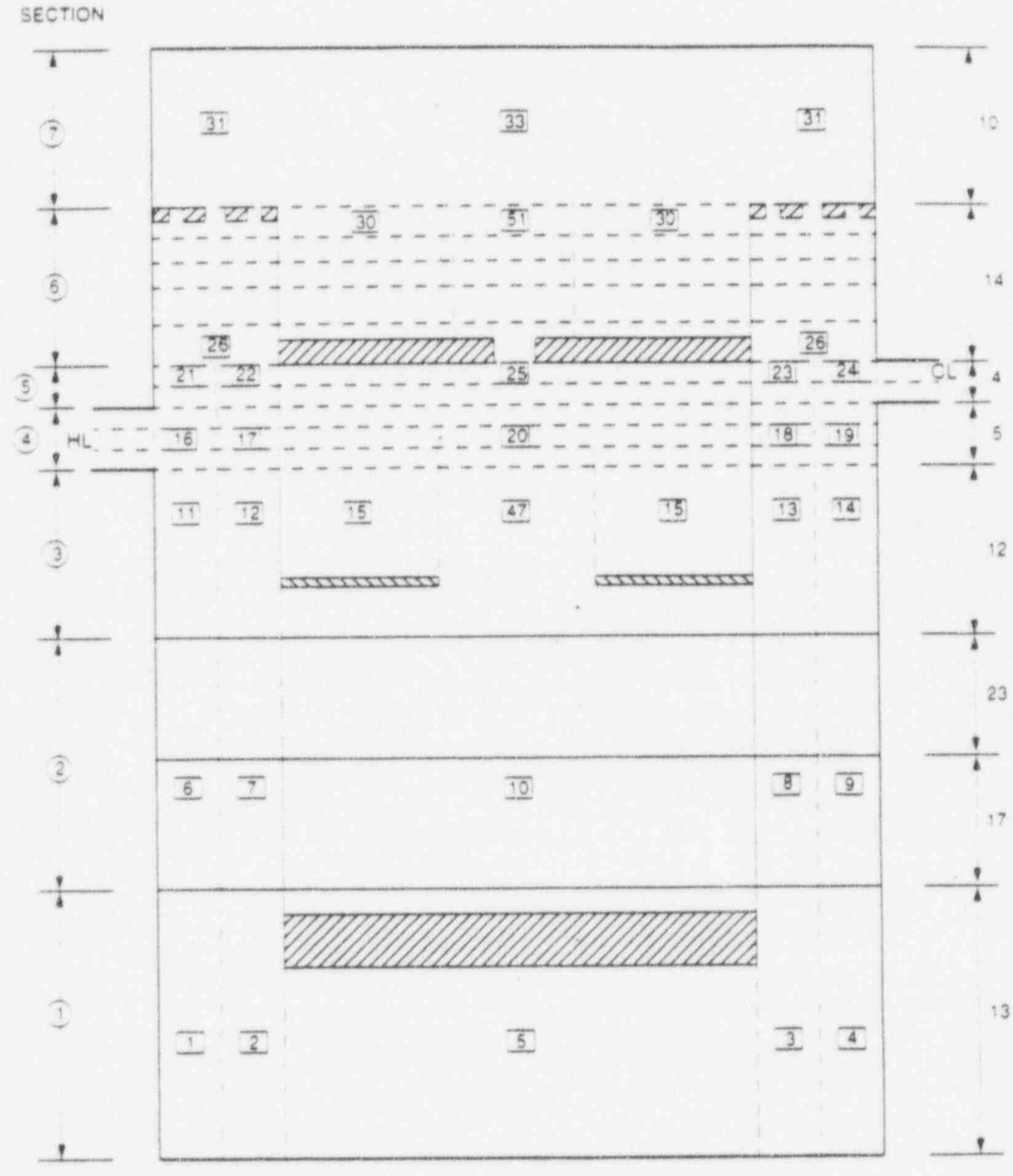
OSU - WC/T Modeling

- Loop Model
- Vessel Model
- Boundary Condition Inputs
- Initial Condition Inputs

OSU WC/T Schematic Loop Diagram



WCOBRA/TRAC Model of OSU Vessel



OSU - WC/T Long-Term Cooling Boundary Conditions

No.	Condition / Calc Initiation Time (sec)	sb01 14,000	sb10 13,500	sb12 8500	sb23 14,000	Source of data
1.	IRWST Level (Rel. to drain) (in)	19.5	20.5	19.5	27.5	CLDP-701
2.	IRWST Temperature (°F)	95	94	90	130	TF-713
3.	Sump Level (Rel. to drain) (in)	59	57	64	58	CLDP-901
4.	Sump Temperature (°F)	165	177	87	172	TF-904, 909
5.	Break Separator Level (in)	105	102.5	103	110	CLDP-905
6.	Break Separator Temp (°F)	150	152	187	182	TF-908
7.	Core Makeup Tank 1 Flow (lb/sec)	0	0	0	0	CLDP-507
8.	Core Makeup Tank 1 Temp (°F)	132	69	200	148	TF-501
9.	Core Makeup Tank 2 Flow (lb/sec)	0.3/0.1	0	0	0	CLDP-502
10.	Core Makeup Tank 2 Temp (°F)	114	162	190	153	TF-504
11.	SG Secondary Side Temp (°F)	290	295	322	290	TF-305, 307, 306, 308
12.	SG Secondary Side Press (psia)	58	62	92	58	TF-305, 307, 306, 308
13.	Core Power Factor	0.243	0.244	0.283	0.243	KW-102,103

OSU - WC/T Long-Term Cooling
Initial Conditions

No.	Condition / Time of Start of IRWST (sec)	sb01 1262	sb10 810	sb12 360	sb23 2980	Source of data
1.	Upper Plenum Level (in) *	56	56	56	56	CLDP-116, 140
2.	Downcomer Level (in) *	56	56	56	56	CLDP-116, 140
3.	Downcomer Fluid Temp. (°F)	190	150	190	200	TF-155, 156, 130, 131
4.	Vessel Wall Metal Temp. (°F)	200	150	190	200	TF-155, 156, 130, 131
5.	Core Liquid Temp. (°F)	212	212	212	212	WCAP-14252
6.	Initial Fuel Rod Temp. (°F)	212	212	212	212	TH-307, 309, 102, 103
7.	Hot Leg Level (in)	Empty	Empty	Empty	Empty	CLDP-207, 208
8.	SG Channel Head Level (in)	Empty	Empty	Empty	Empty	CLDP-209, 214
9.	Cold Leg Level (in)	Empty	Empty	Empty	Empty	CLDP-116, 140
10.	Pressurizer Level (in)	Empty	Empty	Empty	Empty	CLDP-601
11.	Surge Line Level (in)	Empty	Empty	Empty	Empty	CLDP-602

* Relative to the bottom of the vessel

WC/T Validation Calculations for Long-Term Cooling Analysis

1. WC/T Initial Condition Sensitivity - WCAP-14776

   - Fixed boundary conditions
   - Varied individually vessel initial conditions
     - Vessel liquid level
     - Downcomer temperature
   - Tests SB01 and SB10

2. WC/T Extended Time Calculation - **NSD/NRC-97-5014**

   - Reference calc., SB01, 1260 sec. to 4600 sec.
   - Comparison calc., SB01, 3600 sec. to 4600 sec.
   - Identical vessel initial conditions
   - Appropriate, time dependent boundary conditions

3. WC/T Boundary Condition Sensitivity - **NSD/NRC-97-5014**

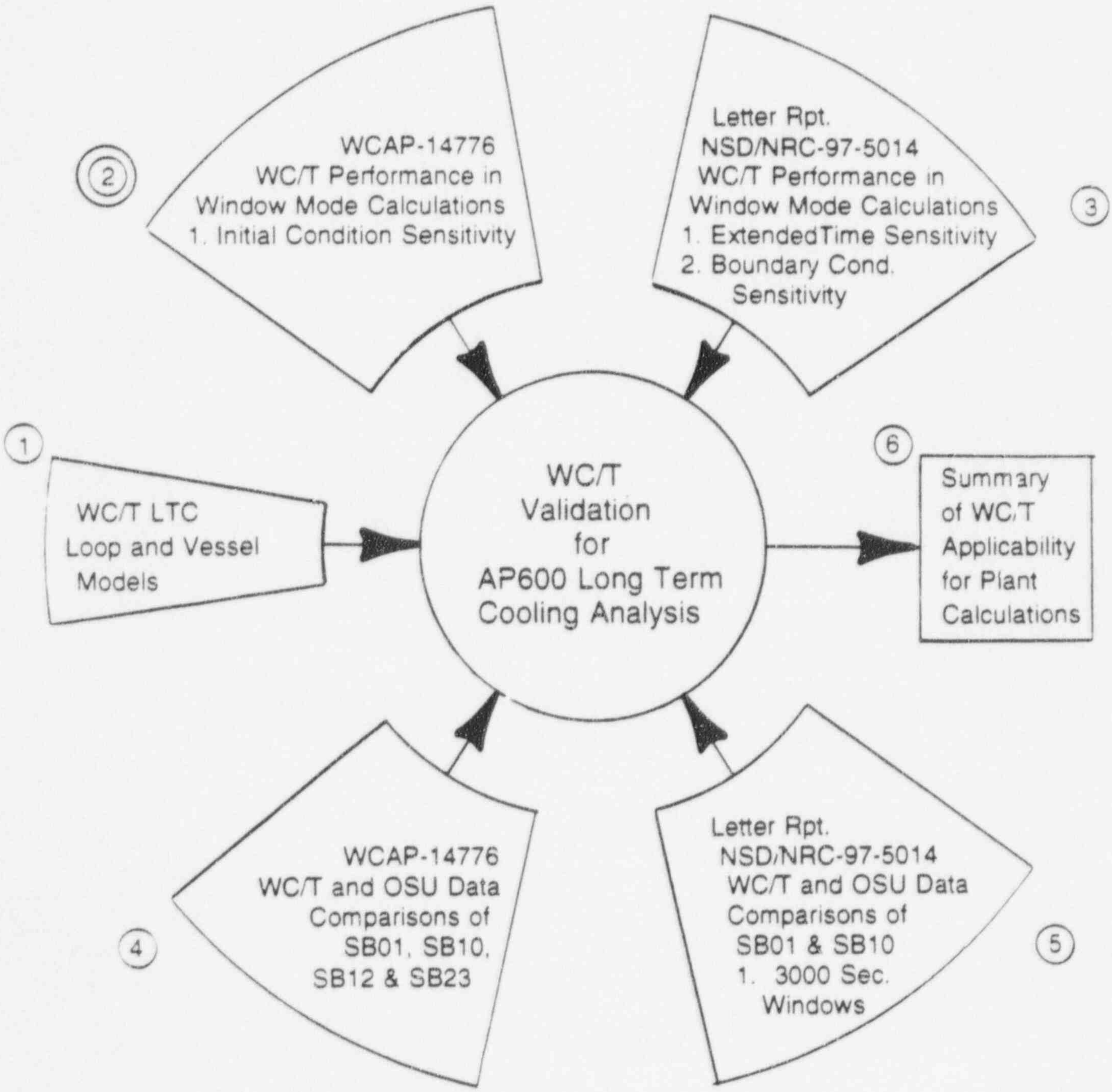
   - Reference calc., SB01, 8000 sec. to 9000 sec.
   - Comparison calc., SB01, 8000 sec. to 9000 sec.
     - IRWST level raised 2.5 ft for 200 sec. (3600 sec level)
     - Core Power raised 30% for 200 sec. (3600 sec value)
     - S.G. Temp. raised 45°F for 200 sec. (3600 sec value)
   - Identical vessel initial conditions (8000 sec. value)

4. WC/T Comparison with OSU Test Data

   - WCAP-14776
     - SB01, 2' CL Break, 14,000 sec. to 15,000 sec.
     - SB10, CMT Balance Line Brk., 13,500 sec. to 14,500 sec.
     - SB12, DEG DVI Line Brk., 8,500 sec. to 9,500 sec.
     - SB23, 1/2' CL Break, 14,000 sec. to 15,000 sec.

   - **NSD/NRC-97-5014**
     - SB01, 2' CL Break, 1,260 sec. to 4,600 sec.
     - SB01, 2' CL Break, 8,000 sec. to 9,000 sec.
     - SB10, CMT Balance Line Brk., 13,500 sec. to 16,500 sec.

WC/T Code Validation for AP600 Long Term Cooling Analysis



Sensitivity to Initial Conditions - SB10

Initial Vessel Liquid Level Sensitivity

- Upper Plenum Collapsed Liquid Level
- Downcomer Collapsed Liquid Level
- DVI-1 Injection Flow
- ADS4-1 Flow

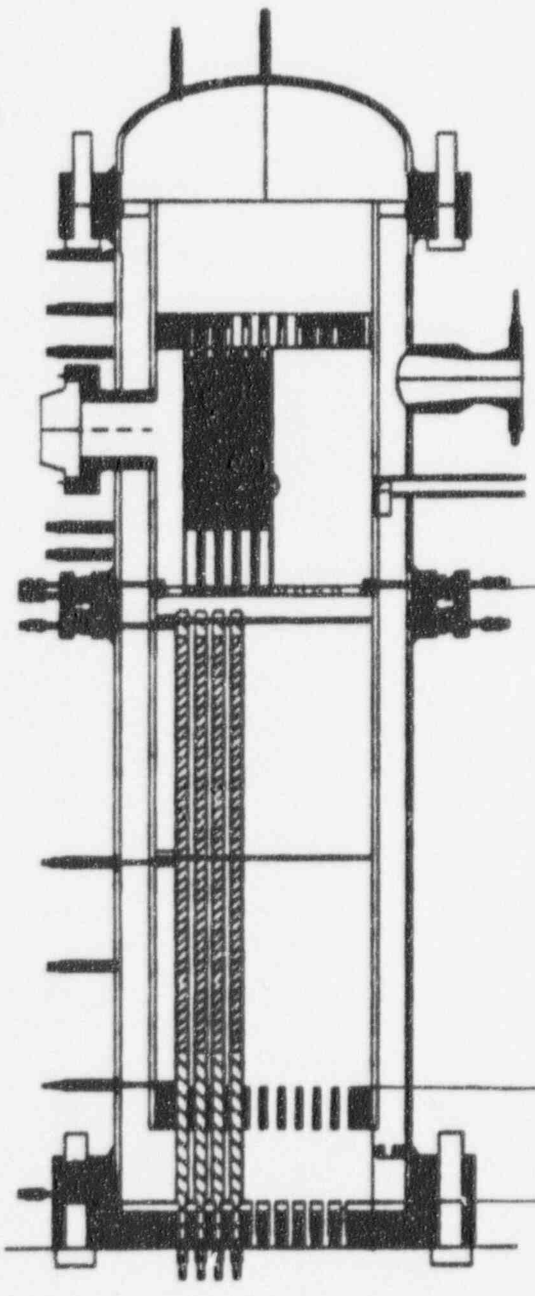
Initial Downcomer Liquid Temperature Sensitivity

- Upper Plenum Collapsed Liquid Level
- Downcomer Collapsed Liquid Level
- DVI-1 Injection Flow
- ADS4-1 Flow

OSU Collapsed Liquid Level Reference Elevations

Elevations

Hot Leg Centerline - 67.1" (14.4" wrt UCP)
Cold Leg Centerline - 71.5"
DVI Line Centerline - 62.1"
Top of Downcomer - 87.1"
Top of Core - 13.1" + 39.6" = 52.7"
Top of Upper Plenum - 52.7" + 20.6" = 73.3"



- Upper Plenum Reference Level - 52.7 inches
- Core Reference Level - 13.1 inches
- Downcomer Reference Level - 0.0 inches

The Following Figures are in the Proprietary Version of this Presentation

Figure 3-22

Figure 3-20

Figure 3-25

Figure 3-31

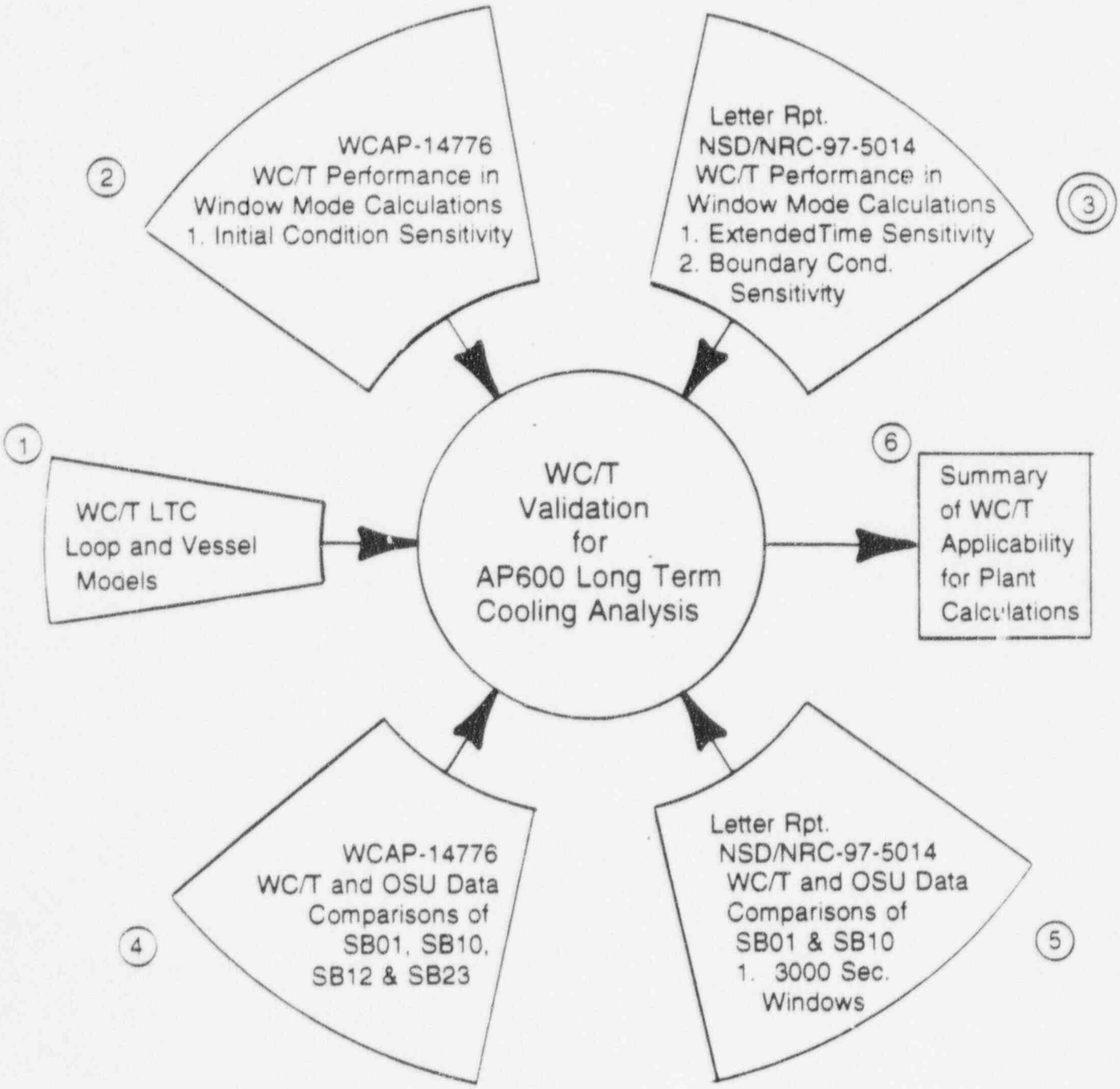
Figure 3-38

Figure 3-36

Figure 3-41

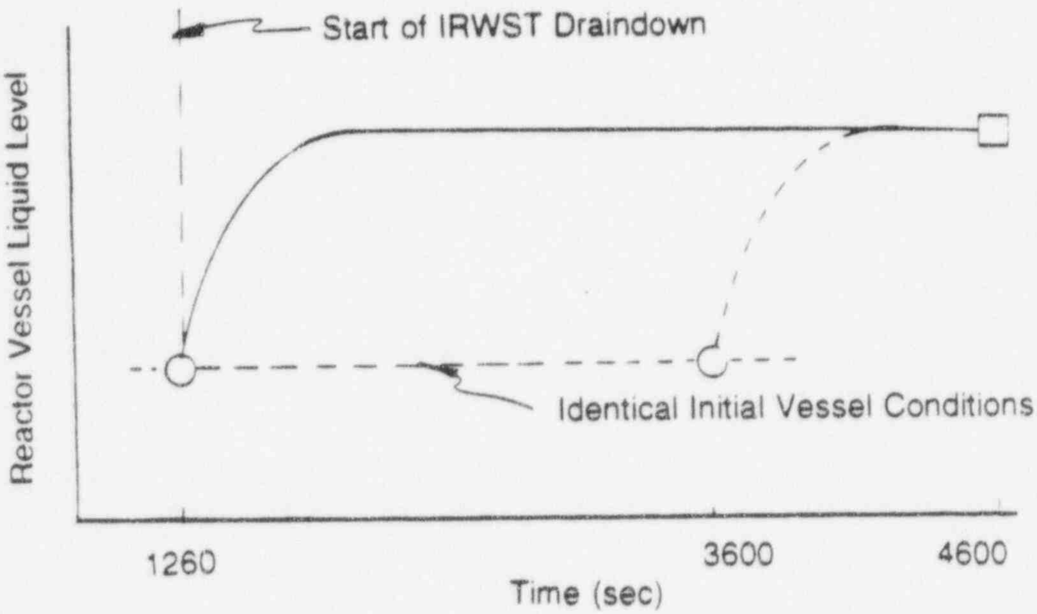
Figure 3-47

WC/T Code Validation for AP600 Long Term Cooling Analysis



WC/T Extended Time Sensitivity - SB01

Schematic Description of Calculations



WC/T Extended Time Sensitivity - SB01

- Upper Plenum Collapsed Liquid Level
- Downcomer Collapsed Liquid Level
- Core Collapsed Liquid Level
- DVI-1 Injection Flow
- Integrated DVI-1 Flow
- ADS4-1 Flow
- Integrated ADS4-1 Flow

The Following Figures are in the Proprietary Version of this Presentation

Figure 2.1-4

Figure 2.1-2

Figure 2.1-3

Figure 2.1-7

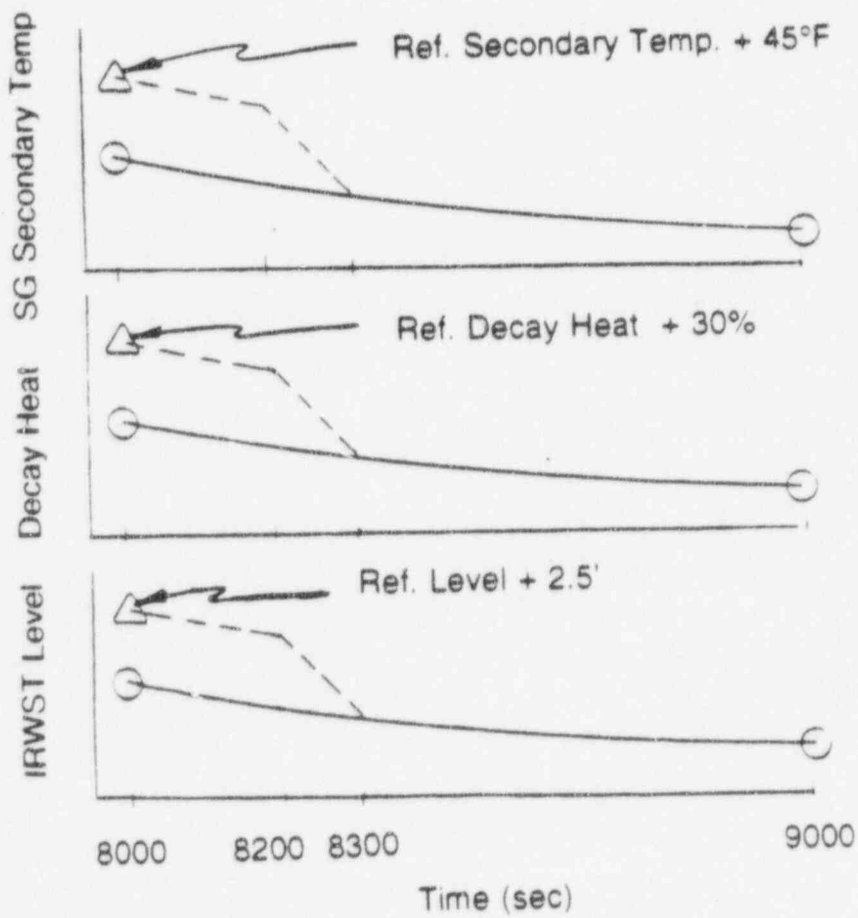
Figure 2.1-8

Figure 2.1-13

Figure 2.1-14

WC/T Boundary Condition Sensitivity - SB01

Schematic Description of Calculations



WC/T Boundary Condition Sensitivity - SB01

- Upper Plenum Collapsed Liquid Level
- Downcomer Collapsed Liquid Level
- Core Collapsed Liquid Level
- DVI-1 Injection Flow
- Integrated DVI-1 Flow
- ADS4-1 Flow
- Integrated ADS4-1 Flow

The Following Figures are in the Proprietary Version of this Presentation

Figure 2.2-4

Figure 2.2-2

Figure 2.2-3

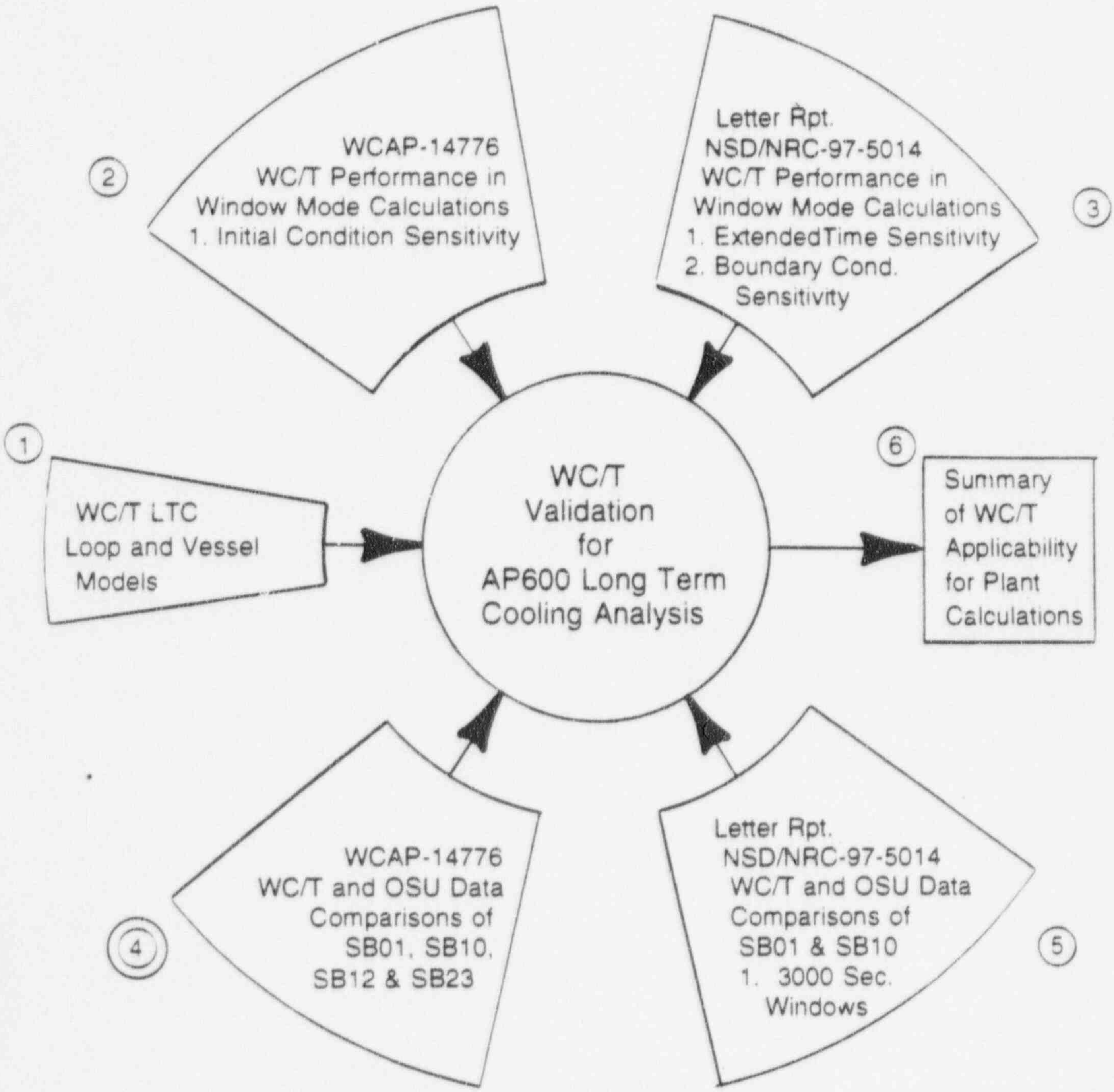
Figure 2.2-7

Figure 2.2-8

Figure 2.2-13

Figure 2.2-14

WC/T Code Validation for AP600 Long Term Cooling Analysis



Test Data Comparisons - SB01

- Upper Plenum Collapsed Liquid Level

- Downcomer Collapsed Liquid Level

- Total DVI-1 Injection Flow

- ADS 4-1 Flow

The Following Figures are in the Proprietary Version of this Presentation

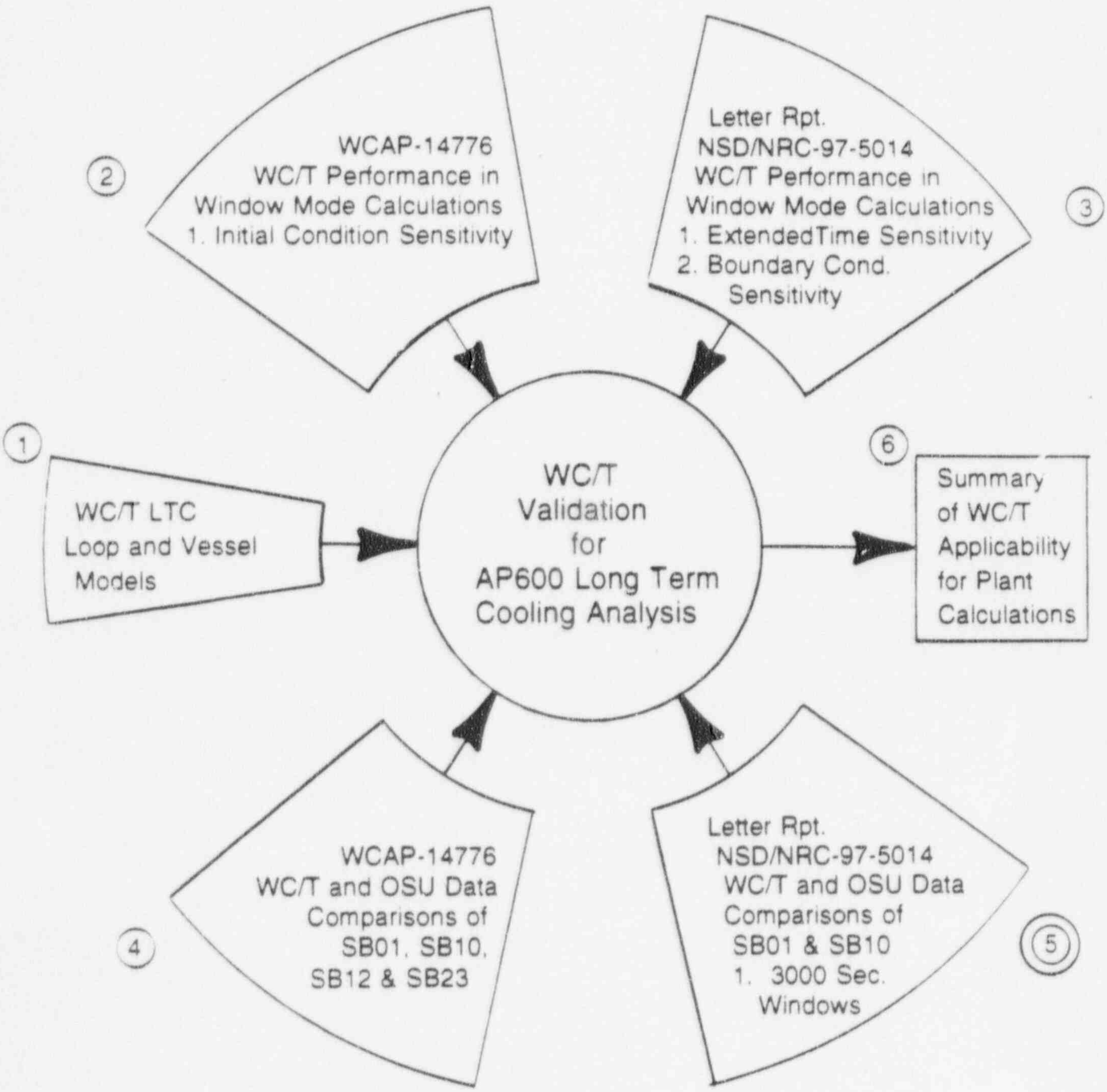
Figure 5.1-23

Figure 5.1-24

Figure 5.1-7

Figure 5.1-17

WC/T Code Validation for AP600 Long Term Cooling Analysis



WC/T Extended Time Calculation - SB01 from 1260 sec. to 4600 sec.

- Upper Plenum Collapsed Liquid Level
- Downcomer Collapsed Liquid Level
- Core Collapsed Liquid Level
- DVI-1 Injection Flow
- Integrated DVI-1 Flow
- ADS 4-1 Flow
- Integrated ADS 4-1 Flow

The Following Figures are in the Proprietary Version of this Presentation

Figure 2.3-23

Figure 2.3-24

Figure 2.3-22

Figure 2.3-7

Figure 2.3-8

Figure 2.3-17

Figure 2.3-18

WC/T Extended Time Calculation - SB01 from 8000 sec. to 11000 sec.

- Upper Plenum Collapsed Liquid Level
- Downcomer Collapsed Liquid Level
- Core Collapsed Liquid Level
- DVI-1 Injection Flow
- Integrated DVI-1 Flow
- ADS 4-1 Flow
- Integrated ADS 4-1 Flow

The Following Figures are in the Proprietary Version of this Presentation

Figure 2.4-23

Figure 2.4-24

Figure 2.4-22

Figure 2.4-3

Figure 2.4-8

Figure 2.4-17

Figure 2.4-18

WC/T Extended Time Calculation - SB10 from 13,500 sec. to 16,500 sec.

- Upper Plenum Collapsed Liquid Level
- Downcomer Collapsed Liquid Level
- Core Collapsed Liquid Level
- DVI-1 Vessel Inlet Temperature
- IRWST DVI-2 Injection Flow
- Sump Injection 2 Flow
- Total DVI-2 Injection Flow
- Total Integrated DVI-2 Flow
- Total ADS 4 Flow
- Total Integrated ADS 4 Flow

The Following Figures are in the Proprietary Version of this Presentation

Figure 2.5-23

Figure 2.5-24

Figure 2.5-22

Figure 2.5-11

Figure 2.5-4

Figure 2.5-6

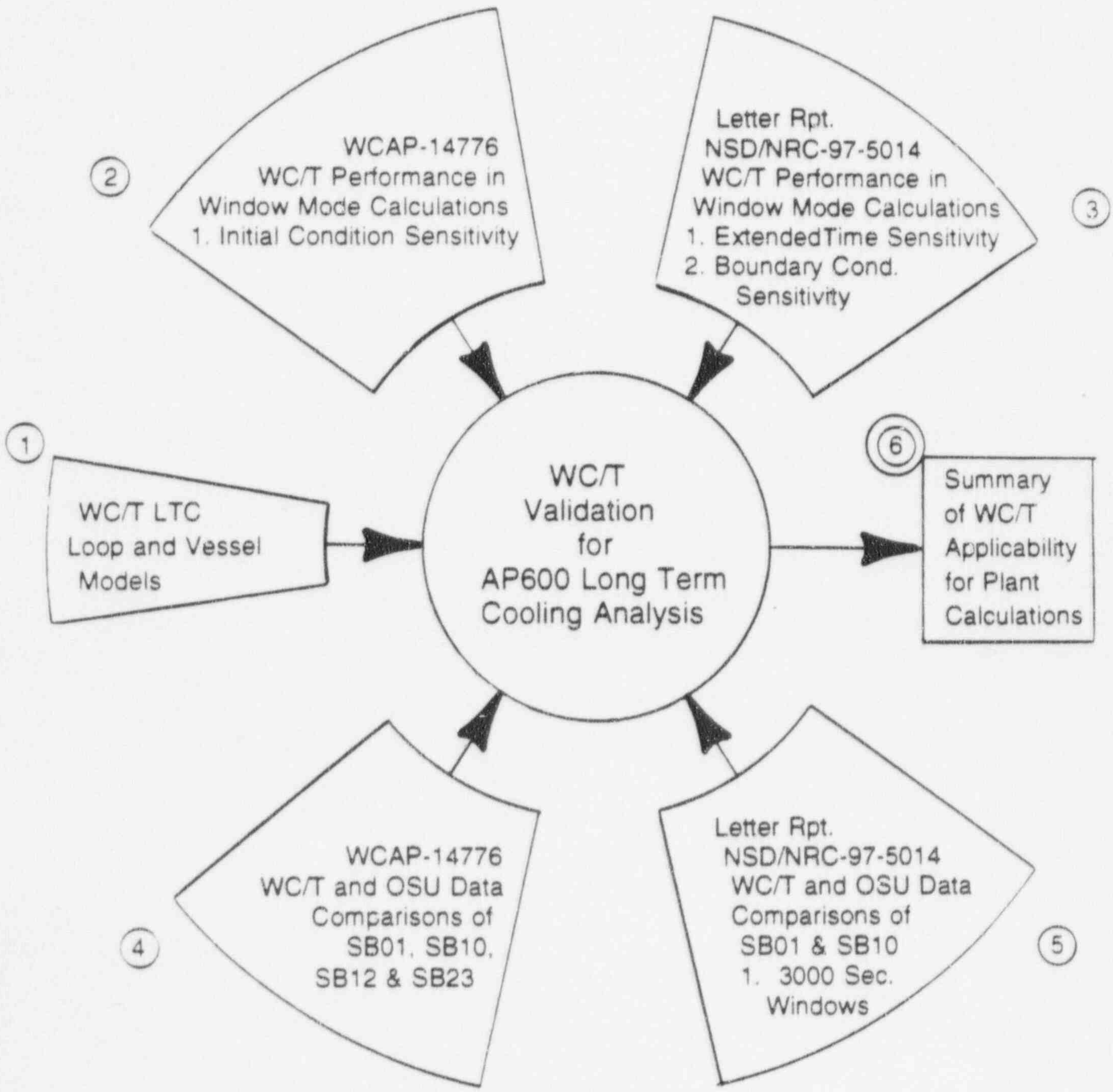
Figure 2.5-9

Figure 2.5-10

Figure 2.5-19

Figure 2.5-20

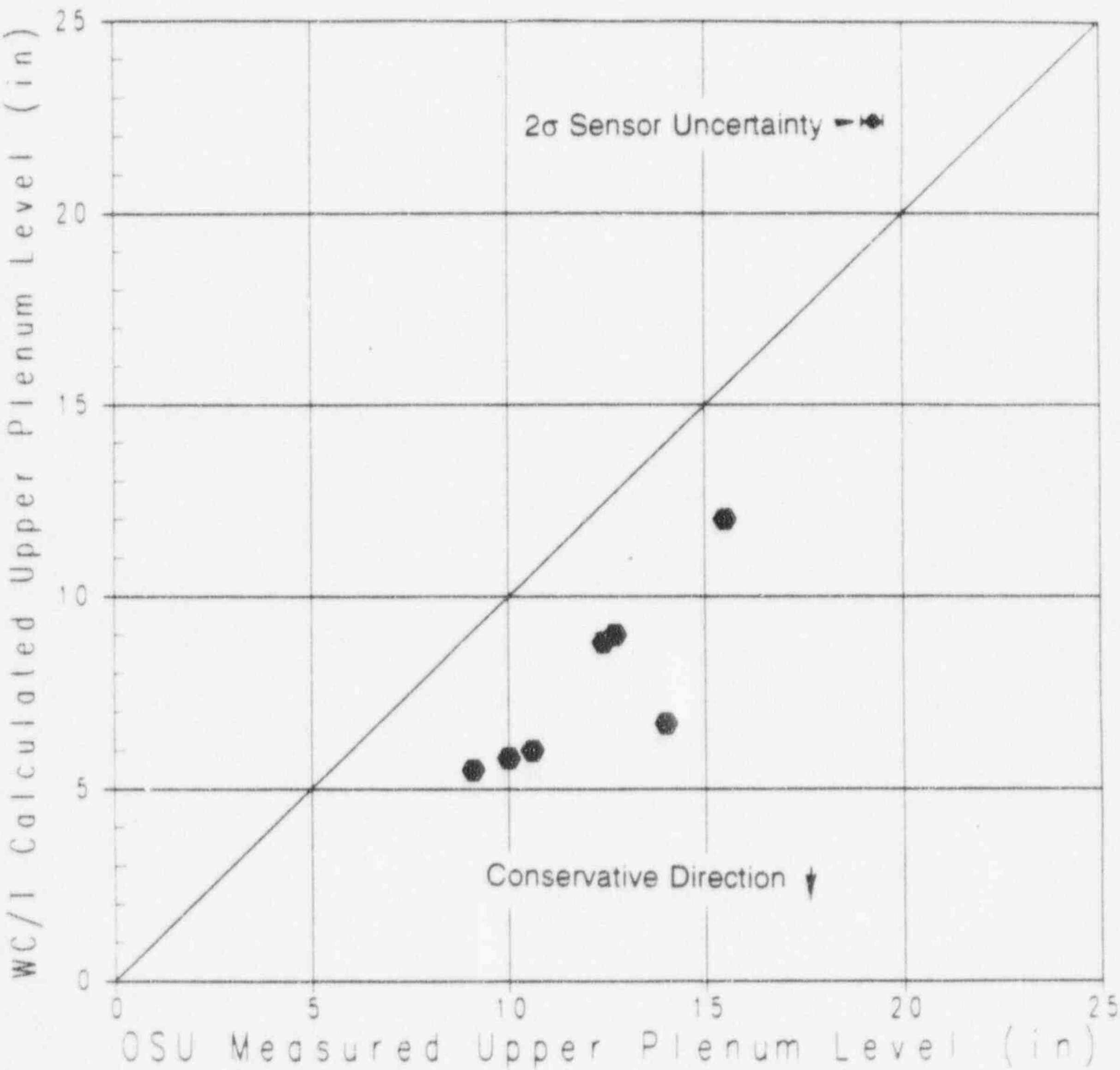
WC/T Code Validation for AP600 Long Term Cooling Analysis



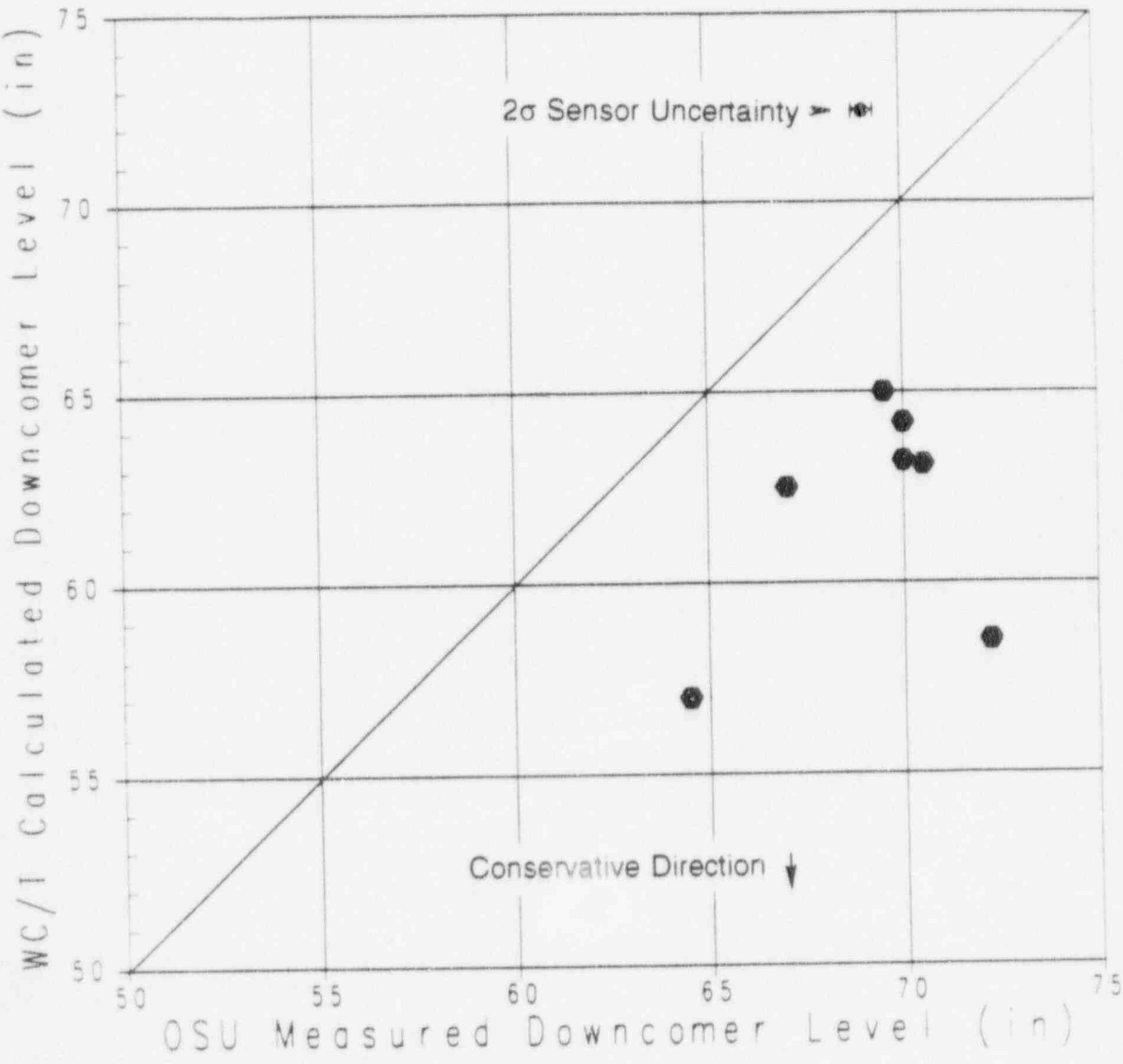
Summary of WC/T vs. OSU Data

- Upper Plenum Level Comparison
- Downcomer Level Comparison
- Total Vessel Inflow (DVI) Comparison
- Total Vessel Outflow Comparison
- WC/T Total Inflow / Outflow Comparison
- Vessel Pressure Comparison

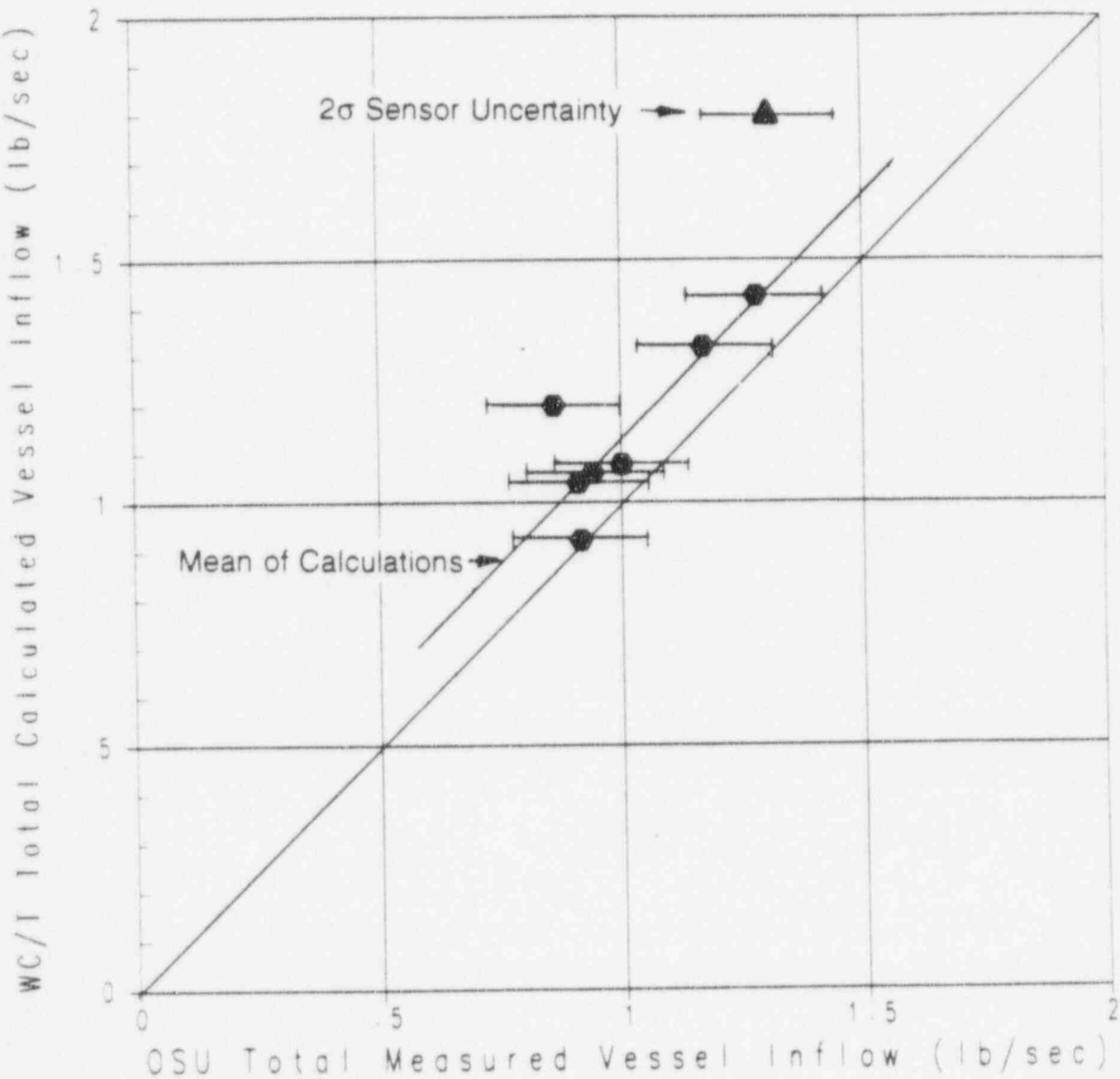
Upper Plenum Liquid Level Comparison



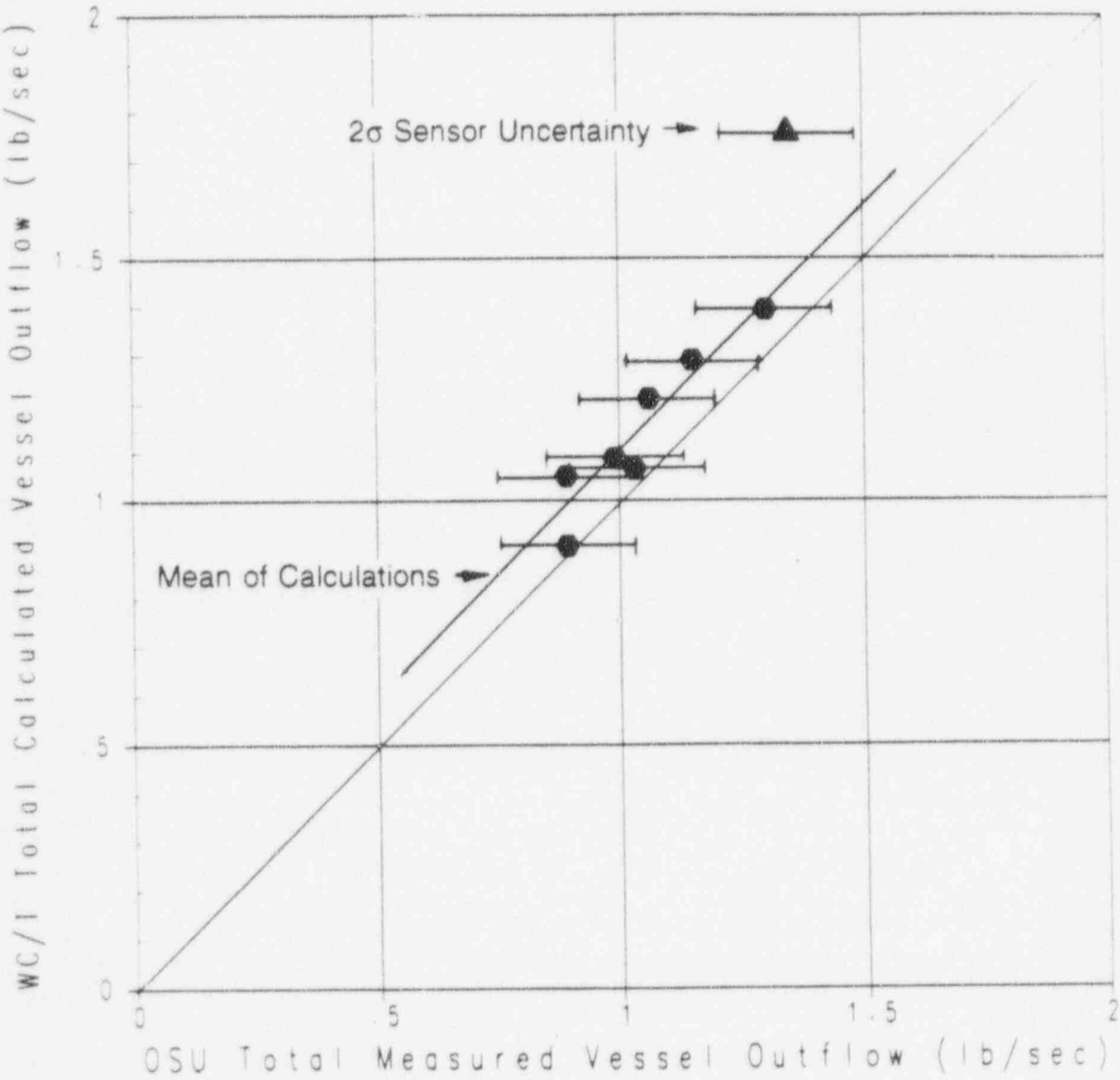
Downcomer Liquid Level Comparison



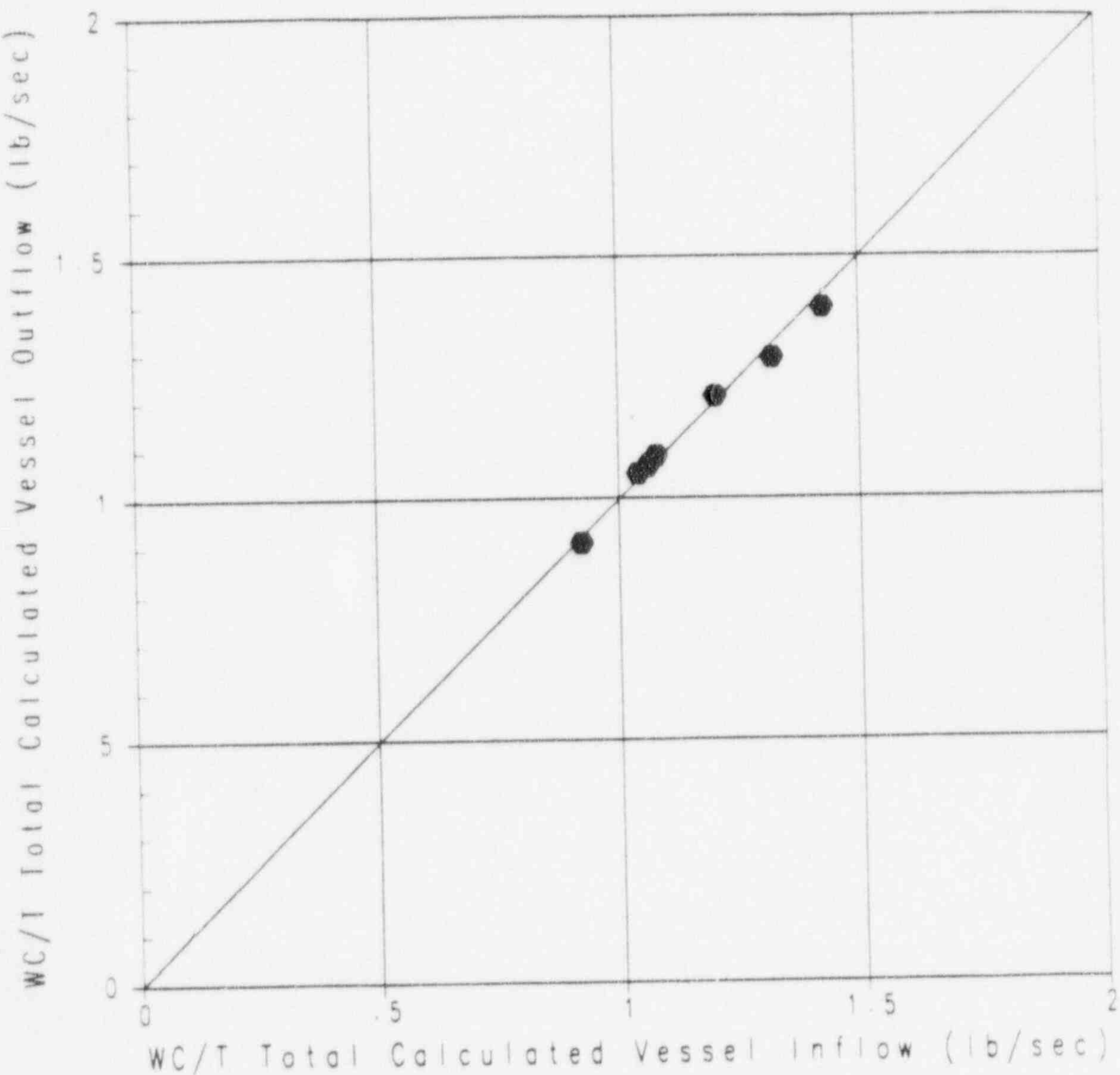
Reactor Vessel Total Inflow Comparison



Reactor Vessel Total Outflow Comparison



WC/T Total Inflow / Total Outflow Comparison



The Following Figures are in the Proprietary Version of this Presentation

Figure 1

Vessel Pressure Data Comparison

- Measured vessel (upper head) pressure range is 15.5 psia to 16.0 psia with a pressure sensor uncertainity of $\pm$ 2.44 psia at the 2σ uncertainty level.

- Calculate pressure of all tests were in the range of 15.3 psia to 15.9 psia during IRWST draindown and sump operation.

- Calculated vessel pressures show a favorable comparison with the measured values, i.e. well within the uncertainty bands.

Conclusions from WC/T Code Validation for AP600 Application

1. WC/T calculations show no solution divergence at 1000 seconds and no solution divergence for extended time calculations of 3000 seconds or approximately 5 to 10 times the period required to reach a quasi-equlibrium solution.

    - Extended Time Sensitivity Solution
    - Boundary Condition Sensitivity Solution
    - 3 Data Comparison Solutions

2. WC/T underpredicts reactor vessel collapsed liquid levels slightly in OSU tests which provides a degree of conservatism.

3. WC/T predicts total vessel inflows and outflows in the OSU tests within the 2σ uncertainty of the flow sensors.

4. WC/T predicts the reactor vessel pressures in the OSU tests within the 2σ uncertainty of the pressure sensors.

PRESENTATION
TO
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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

AP600 LONG TERM COOLING

R. M. KEMPER

SYSTEMS ANALYSIS ENGINEERING

WESTINGHOUSE ELECTRIC CORPORATION

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AP600 LONG TERM COOLING SSAR CALCULATIONS WITH WCOBRA/TRAC

- AP600 LONG TERM COOLING FEATURES
  - PASSIVE SAFETY-RELATED SYSTEMS
  - QUASI-STEADY-STATE CONDITIONS

- OSU V&V ESTABLISHED THE WCOBRA/TRAC LTC NODALIZATION

- CALCULATE AP600 PERFORMANCE AT LIMITING, DISCRETE TIMES USING WINDOW MODES

METHODOLOGY TO PERFORM A WINDOW MODE ECCS PERFORMANCE ANALYSIS

AP600

1. IDENTIFY LIMITING PORTIONS OF THE LTC PHASE, THE MOST DEMANDING ON THE SAFETY SYSTEMS.

2. ESTABLISH BOUNDARY CONDITIONS FOR WCOBRA/TRAC.

3. SELECT REPRESENTATIVE INITIAL CONDITIONS FOR CALCULATION.

4. EXECUTE WCOBRA/TRAC UNTIL QUASI-STEADY STATE ACHIEVED.

SSAR LONG TERM COOLING ANALYSIS STRATEGY

AP600

- USE WCOBRA/TRAC, SHOWN CAPABLE OF REALISTIC/CONSERVATIVE LTC ANALYSES BY V&V

- USE APPENDIX K REQUIRED FEATURES (102% INITIAL POWER; 1971 ANS DECAY HEAT + 20%)

- APPLY ADDITIONAL CONSERVATISMS IN DEFINING PLANT CONDITIONS.

  FOR INSTANCE, FOR WINDOWS AT START OF SUMP RECIRCULATION, APPLY A HIGH IRWST DRAIN RATE DURING IRWST INJECTION:
  - TO MAXIMIZE DECAY HEAT AT SUMP INITIATION
  - TO MAXIMIZE ENERGY CONTENT OF LIQUID EXITING ADS-4 DURING IRWST INJECTION TO MAXIMIZE SUMP TEMPERATURE RELATIVE TO CONTAINMENT PRESSURE

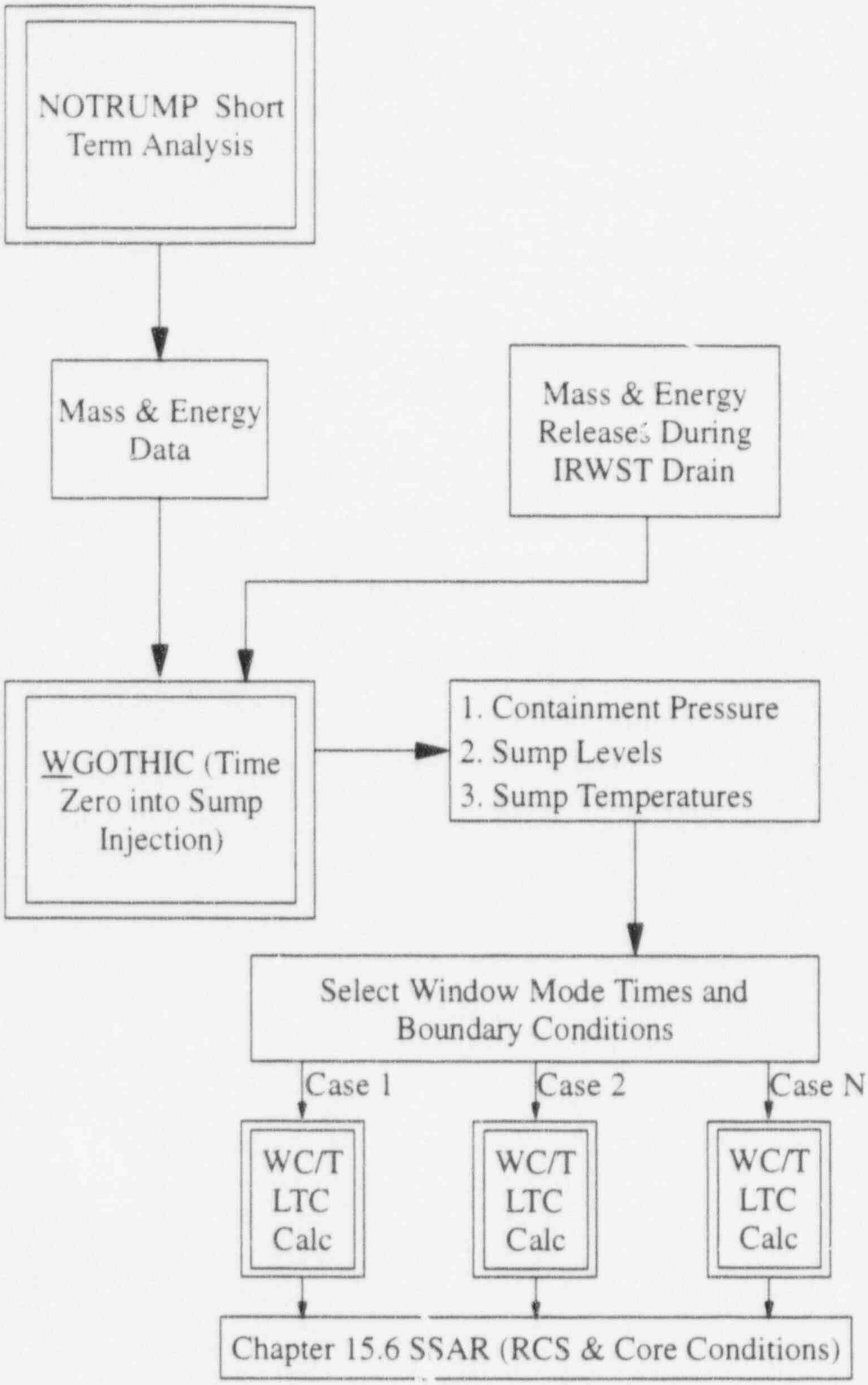
- ADDRESS A SPECTRUM OF LOCA BREAK SIZES
  - SMALL RCS LOOP BREAK
  - DEDVI BREAK
  - DECLG BREAK

WGOTHIC COMPUTES CONTAINMENT CONDITIONS THROUGHOUT THE TRANSIENT

AP600

- NO GUTTER RETURN OF CONDENSATE TO IRWST
- CONSERVATIVE ASSUMPTIONS APPLIED
  - MASS/ENERGY RELEASES
  - MAXIMUM PCS WATER FLOW EXTERNAL TO CONTAINMENT
  - MINIMUM PCS WATER TEMPERATURE
  - 1.05* BEST ESTIMATE FREE VOLUME
  - NO MODELING PENALTIES THAT MINIMIZE HEAT TRANSFER
  - MINIMIZE INITIAL AIR MASS PRESENT
- THESE RESULT IN A LOW CONTAINMENT PRESSURE AND A HIGH SUMP TEMPERATURE

Small Break LOCA Window Mode LTC Calculation



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INITIAL CONDITIONS FOR WINDOW CALCULATION

- INITIAL CONDITIONS ARE ESTIMATED AND DO <u>NOT</u> DETERMINE THE QUASI-STEADY STATE OBTAINED

  - PRIMARY CIRCUIT LIQUID LEVELS AND TEMPERATURE

  - STRUCTURE TEMPERATURES

- WINDOW APPROACH HAS SHOWN THAT AN EQUIVALENT QUASI-STEADY STATE WILL BE REACHED FROM ANY REASONABLE VALUES FOR THESE INITIAL CONDITIONS, AS VALIDATED BY OSU SIMULATIONS

- ANALYZE AP600 CASES USING INITIAL CONDITIONS ESTIMATED FROM EARLIER CALCULATIONS

BOUNDARY CONDITIONS FOR WINDOW CALCULATION

AP600

- BOUNDARY CONDITIONS WHICH DETERMINE THE QUASI-STEADY STATE
  - CORE POWER (APPENDIX K DECAY HEAT)
  - IRWST LIQUID LEVEL AND TEMPERATURE
  - CONTAINMENT PRESSURE
  - SUMP LIQUID LEVEL AND TEMPERATURE

CRITERIA FOR ACHIEVING A QUASI-STEADY STATE

AP600

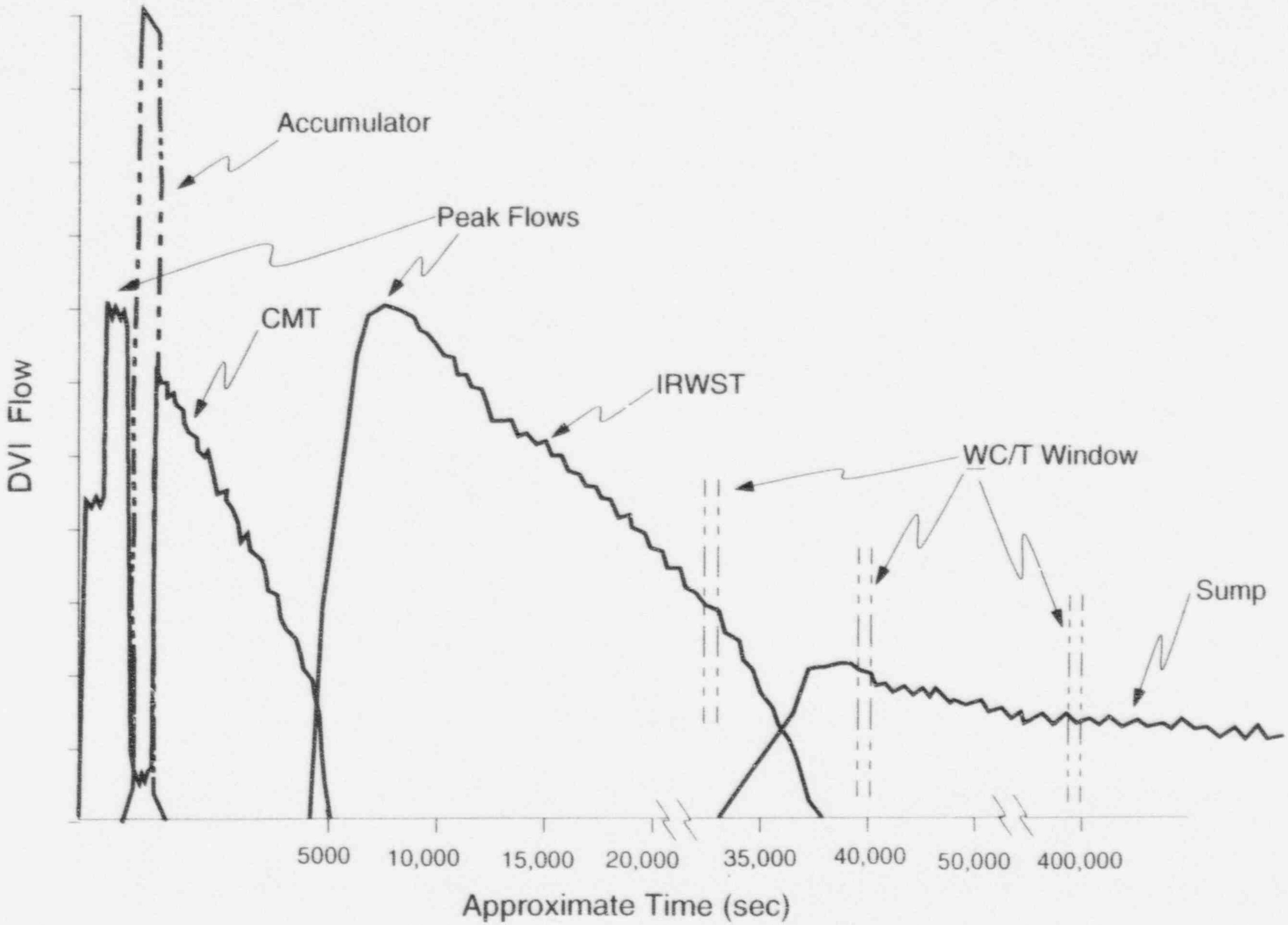
- KEY VARIABLES REMAIN STEADY OVER AN EXTENDED PERIOD
  - CORE LIQUID LEVEL
  - DOWNCOMER LIQUID LEVEL
  - UPPER PLENUM LIQUID LEVEL
  - UPPER PLENUM PRESSURE
  - DVI INJECTION RATE
  - ADS STAGE 4 FLOW

AP600 LONG-TERM COOLING CASES FOR FINAL SSAR

AP600

- CONSERVATIVE ANALYSIS BASES UTILIZED
  - CONTAINMENT CONDITIONS
  - SINGLE FAILURE OF ONE PASSIVE SAFETY SYSTEM COMPONENT
  - APPENDIX K DECAY HEAT
  - MAXIMUM DESIGN FLOW RESISTANCES FOR INJECTION PATHS AND ADS PATHS
- MODELING PER THE W C/T OSU FINAL VALIDATION REPORT
- CASES TO SHOW ADEQUATE CORE COOLING IN THE LONG TERM

AP600 Injection Flow Sequence - Small Break LOCA



AP600 SSAR LONG-TERM COOLING WINDOW MODE ANALYSES

CASE 1 - DOUBLE-ENDED DVI LINE BREAKS

SET I - DESIGN BASIS: ONLY PASSIVE SYSTEMS OPERATE

- WINDOWS INCLUDE THE LATE IRWST INJECTION PHASE AND THE INITIATION OF STABLE SUMP INJECTION
- REPRESENTS EARLIEST SWITCHOVER TO SUMP RECIRCULATION AND, THEREFORE, THE HIGHEST DECAY POWER FOR SUMP INJECTION

SET II - SYSTEMS INTERACTION: RNS OPERATION INITIALLY

- AFTER IRWST HAS BEEN DISCHARGED RAPIDLY BY PUMPS, RNS FAILURE ASSUMED AT THE TIME OF SUMP SWITCHOVER
- SUMP INJECTION BEGINS EARLIER THAN IT DOES IN SET I: SAME WINDOWS AS IN CASE 1, SET I

SET III - WALL-TO-WALL FLOOD UP IN THE VERY LONG-TERM

- WINDOW MODELS THE LEVEL REACHED WHEN ALL COMPARTMENTS BELOW LIQUID SURFACE HAVE FILLED DUE TO PASSIVE LEAKAGE
- MINIMUM SUMP LEVEL FOR DESIGN BASIS EVENTS

CASE 2 - SMALL COLD LEG BREAKS

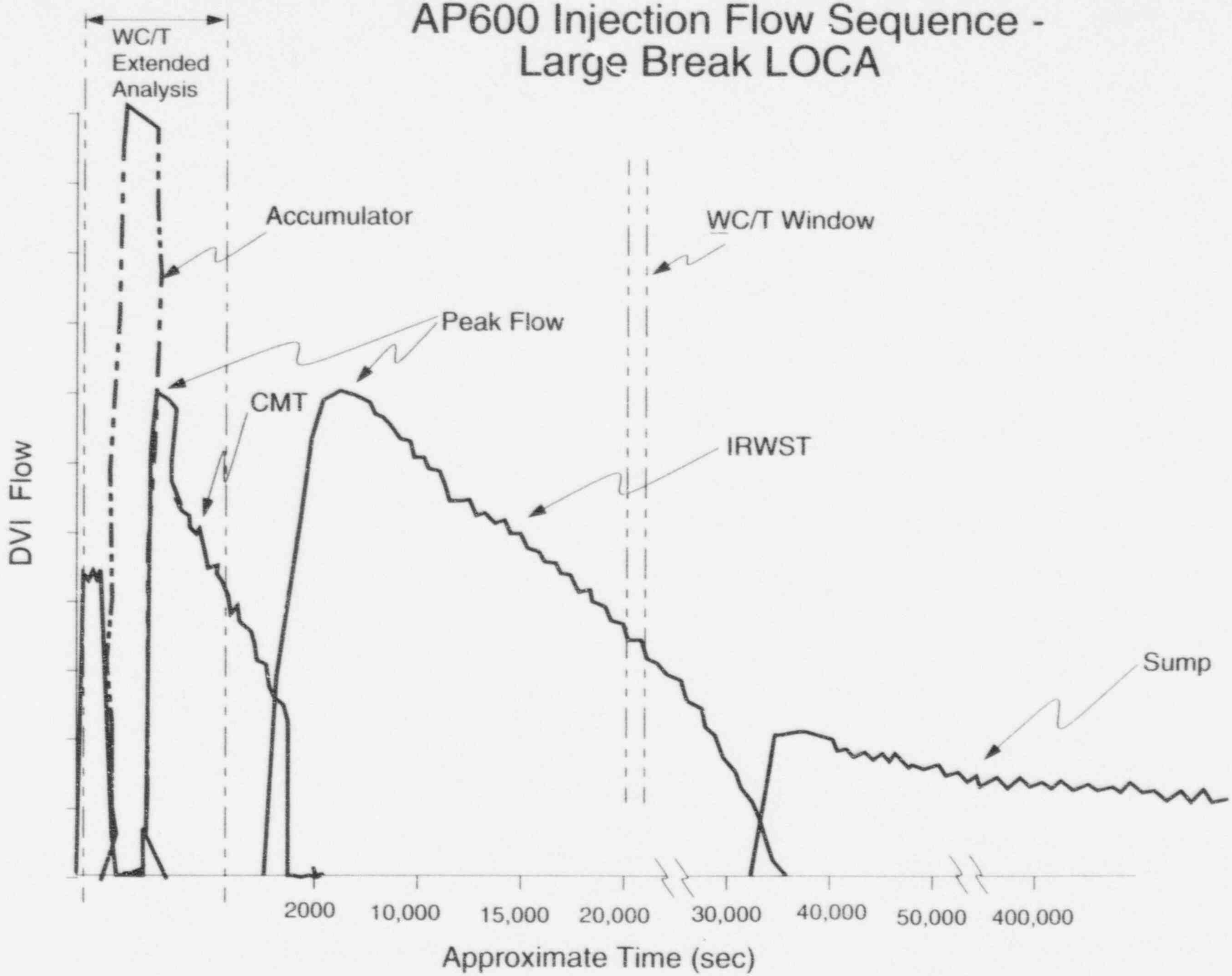
SET I - TWO-INCH COLD LEG BREAK WITH ONE ADS-4-PATH FAILED

- WINDOWS INCLUDE THE LATE IRWST INJECTION PHASE AND THE INITIATION OF STABLE SUMP INJECTION
- REPRESENTATIVE OF SMALL BREAK LOCA SWITCHOVER TO INJECT FROM A NEAR-SATURATED SUMP

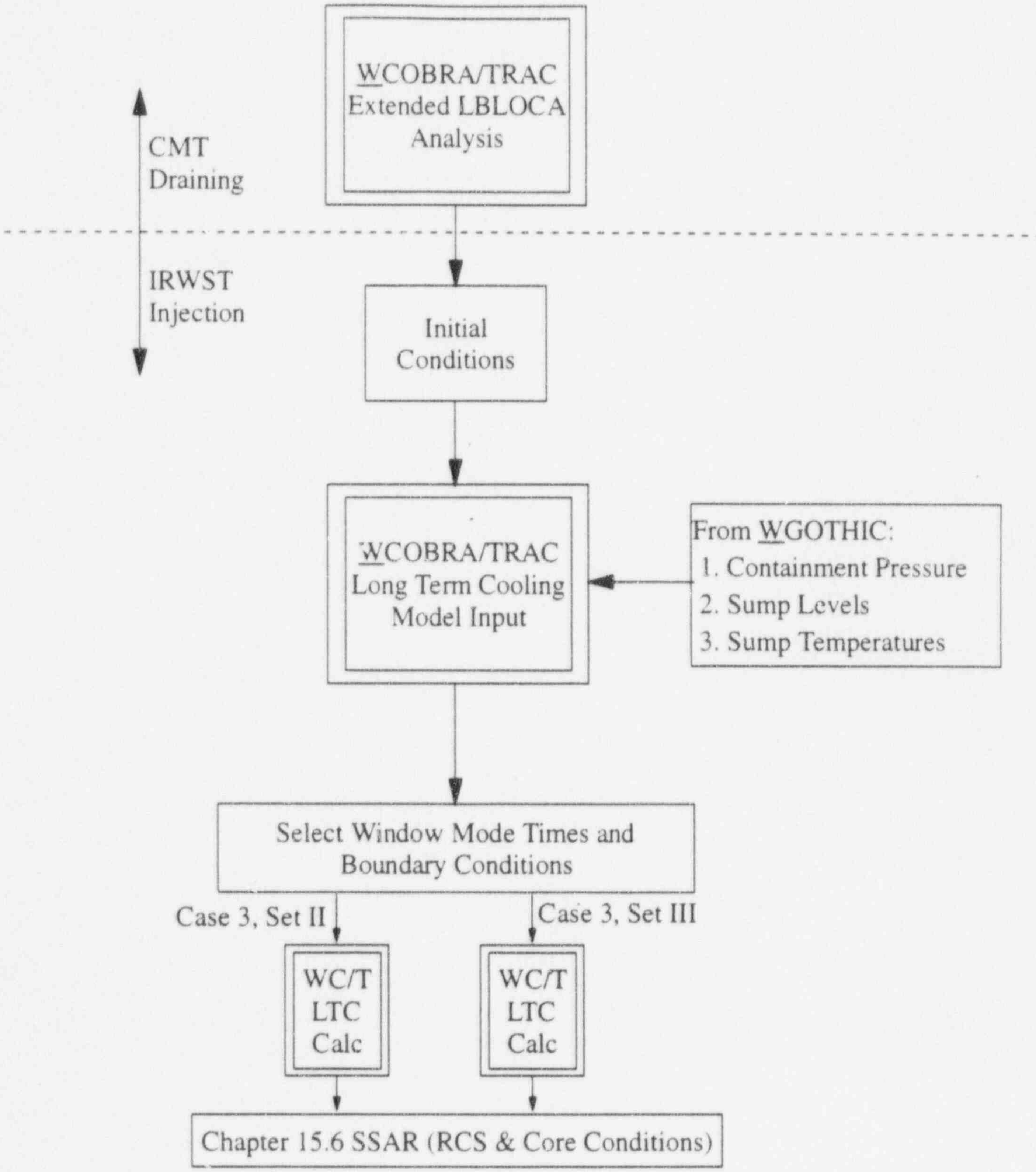
SET II - TWO-INCH COLD LEG BREAK WITH ONE DVI PATH FAILED

- SAME WINDOWS AS IN CASE 2, SET I
- SINGLE FAILURE SENSITIVITY CASE

AP600 Injection Flow Sequence - Large Break LOCA



Large Break LOCA LTC Calculation



AP600 SSAR LONG-TERM COOLING WINDOW MODEL ANALYSES

CASE 3 - LARGE COLD LEG (DECLG) BREAK

SET I - CONTINUE SHORT-TERM TRANSIENT WITH CMT INJECTION TO BEYOND ADS 1-3 INJECTION LEVEL

- SHOWS CONTINUED COOLING BY CMT INJECTION AFTER ACCUMULATORS ARE EMPTY
- LESS AVAILABLE HEAD PRESENT THAN EXISTS ONCE THE IRWST BECOMES AVAILABLE

SET II - WINDOW CONSIDERS IRWST INJECTION AT A TIME WHEN THE SUMP HAS FILLED TO A LEVEL TO WITHIN THE PERIMETER OF THE BROKEN COLD LEG

- FAIL ONE ADS-4 FLOW PATH

SET III - WINDOW CONSIDERS INJECTION FROM AN IRWST REFILLED WITH CONDENSATE RETURN FROM THE CONTAINMENT GUTTERS

- SENSITIVITY TO GUTTER OPERATION (RAI 440.155 RESPONSE)

CONCLUSIONS

AP600

- THE WCOBRA/TRAC WINDOW MODE ANALYSIS METHODOLOGY IS A VALID TECHNIQUE TO CALCULATE ECCS PERFORMANCE OF AP600 DURING LONG-TERM COOLING

- INPUT IS PRESCRIBED SO AS TO OBTAIN A CONSERVATIVE ANALYSIS RESULT

  - LOW CONTAINMENT PRESSURE
  - HIGH SUMP TEMPERATURE
  - MAXIMUM FLOW RESISTANCES IN PXS COMPONENTS
  - APPENDIX K DECAY HEAT

- WINDOWS SELECTED FOR THE SSAR LOCA ANALYSIS INVESTIGATE BOUNDING SCENARIOS

PRESENTATION

TO

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NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

AP600 LONG TERM COOLING

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CONCLUSIONS

AP600

- AP600 LONG TERM COOLING IS A QUASI-STEADY PROCESS
- "WINDOW MODE" APPROACH IS AN APPROPRIATE METHOD FOR LONG TERM COOLING ANALYSIS
- WC/T ANALYSIS OF THE LONG TERM COOLING TESTS USING THE WINDOW MODE APPROACH INDICATES:
  - VESSEL COLLAPSED LEVEL IS CONSERVATIVELY PREDICTED
  - TOTAL VESSEL INFLOWS, OUTFLOWS, AND PRESSURES ARE PREDICTED WITHIN THE DATA UNCERTAINTY
- APPENDIX K METHODOLOGY USED FOR THE AP600 PLANT CALCULATIONS PROVIDES ADDED CONSERVATISM
- A CONSERVATIVE RESPONSE OF THE AP600 PASSIVE SAFETY SYSTEM PERFORMANCE IS OBTAINED FOR THE LONG TERM COOLING TRANSIENT

Enclosure 1 to Westinghouse

Letter NSD-NRC-97-5082

April 23, 1997