Docket File

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

April 10, 1997

APPLICANT: Westinghouse Electric Corporation

PROJECT: AP600

SUBJECT: SUMMARY OF MEETING TO DISCUSS AP600 APPLICATION OF WCOBRA/TRAC FOR LONG TERM COOLING (LTC) ANALYSES

The subject meeting was held on March 12, 1997, in the Rockville, Maryland, offices of Westinghouse Electric Corporation between representatives of Westinghouse and its consultant and, the Nuclear Regulatory Commission (NRC) staff and its consultant. The purpose of the meeting was to discuss additional information Westinghouse had prepared to support is application of a "windows" approach to analysis of AP600 LTC using the WCOBRA/TRAC computer code. This information was sent to the NRC via separate correspondence. Westinghouse letter NSD-NRC-97-5016 dated March 10, 1997, provided a summary report on the AP600 LTC windows methodology (WCAP-14857). Westinghouse letter NSD-NRC-97-5014 dated March 10, 1997, provided some extended run time analyses of selected OSU tests to demonstrate that WCOBRA/TRAC does not diverge in-between calculational windows.

Highlights from the meeting include the following items:

- Westinghouse provided support for its assertion that the LTC is a quasi-steady process that is mostly driven by boundary conditions such as decay heat, sump level, and containment pressure. The window solution is insensitive to initial conditions or perturbations of a transient.
- Westinghouse has attempted to address the staff's concerns on possible solution divergence at extended calculational times by extending the lengths of several select windows from 1000 seconds to 3000 seconds. No change to a window solution was observed by extending the calculational length and no evidence of solution divergence was encountered.
- Westinghouse presented information that showed the total vessel inflows and outflows predicted by the code was within the OSU data uncertainty.
- Some AP600 LTC analyses will be performed assuming all non-flooded compartments eventually flood thereby minimizing the sump level for LTC recirculation.
- There has been no significant change to the LTC PIRT for over two years.
- Westinghouse provided additional information on how the WGOTHIC code is applied to support LTC analyses.

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The meeting was productive and contributed to the staff's understanding of the windows approach for both WCOBRA/TRAC code validation against OSU LTC tests and analyses of the AP600 LTC transients. The staff and its contractor made several observations during the meeting. Specifically;

- Extending the nodalization of the vessel channels into the hot and cold legs appeared to be a unique application that the staff's contractor had not seen used before.

- The ADS4 frictional pressure drop, as captured by the hot leg flow pattern transition and separation at ADS4 tee, appears to be more important than reflected in the current Westinghouse PIRT during sump injection.

- The conservative containment pressure calculation for a 2" break by Westinghouse was not substantially different that a best estimate pressure containment pressure estimate for a 1" break by the staff's contractor.

Westinghouse agreed to the following actions (which would be documented in the Open Item Tracking System) as a result of discussion during the meeting:

- Westinghouse will describe the calculation of the mass and energy releases out of ADS4 due to core boiloff during long term cooling, including the use of WGOTHIC and NOTRUMP to compute the draining of the IRWST.

- Westinghouse will determine if Regulatory Guide 1.1 on net positive suction head criteria may have applicability to AP600 SSAR Chapter 15 design basis accident LTC analyses. The staff is uncertain if Westinghouse can take credit for containment pressure greater than the saturation pressure of the sump water.

- Westinghouse appears to be relying on the drainage of non-flooded containment compartments into the normally flooded containment spaces for line breaks in the non-flooded compartments (i.e., various DVI line breaks). Westinghouse needs to address what credit is taken for the drainage and the operability of the compartment drain line check valves for the LTC analyses and whether these drain paths need to be safety related or covered under technical specifications?

Attachment 1 is the list of meeting attendees. Attachment 2 is a copy of the presentation handouts with material removed which Westinghouse claims is proprietary. Westinghouse committed to submit via separate correspondence an application for withholding, affidavit, and non-proprietary copy of the proprietary presentation material.

A draft of this meeting summary was provided to Westinghouse to allow them the opportunity to ensure that the representation of comments and discussion was accurate.

original signed by:

William C. Huffman, Project Manager
Standardization Project Directorate
Division of Reactor Program Management
Office Of Nuclear Reactor Regulation

Docket No. 52-003

Attachments: As stated

cc w/atts: See next page

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WESTINGHOUSE - NRC MEETING
ON APPLICATION OF WCOBRA/TRAC TO THE AP600
LONG TERM COOLING ANALYSES
MARCH 12, 1997
MEETING ATTENDEES

NAME	ORGANIZATION
Earl Novendstern	Westinghouse
Brian McIntyre	Westinghouse
Larry Hochreiter	Westinghouse
Dan Garner	Westinghouse
Bob Kemper	Westinghouse
Lambros Lois	NRC
Alan Levin	NRC
Norm Lauben	NRC
Bill Huffman	NRC
Cliff Davis	NRC Consultant (INEEL)
Jack Wheeler	DOE

Attachment 1

PRESENTATION HANDOUT MATERIAL

FROM MARCH 12, 1997, MEETING ON

APPLICATION OF WCOBRA/TRAC TO AP600

LONG TERM COOLING ANALYSES

Attachment 2

AP600 LONG TERM COOLING ANALYSIS

AGENDA

March 12, 1997
Wednesday, 12:00 pm
Westinghouse Rockville Office

LONG TERM COOLING
NRC/W MEETING

1. Introduction (Novendstern)

2. Analysis Approach (Hochreiter)

3. PIRT (Hochreiter)

4. Summary of Westinghouse Topical Report (Garner)

5. Recent Extended Time Calculation Results (Garner)

6. WC/T Plant Model (Kemper)

7. Summary (NRC/W)

8. ACRS Agenda (Hochreiter)

- INTRODUCTION
  - AP600 LONG TERM COOLING IS UNIQUE
    - QUASI-STEADY GRAVITY INJECTION FOR LONG PERIODS (INDEFINITY UNTIL THE PLANT IS RECOVERED)
    - TWO INJECTION PHASES:
      - INITIAL INJECTION IS FROM IRWST (HIGHER HEAD WITH HIGHER FLOWS, WHEN DECAY POWER IS HIGHER
      - RECIRCULATION INJECTION FROM SUMP WITH LOWER FLOWS WHEN DECAY POWER IS LOWER
    - REACTOR CAVITY BECOMES FLOODED, COVERS HOT AND COLD LEGS

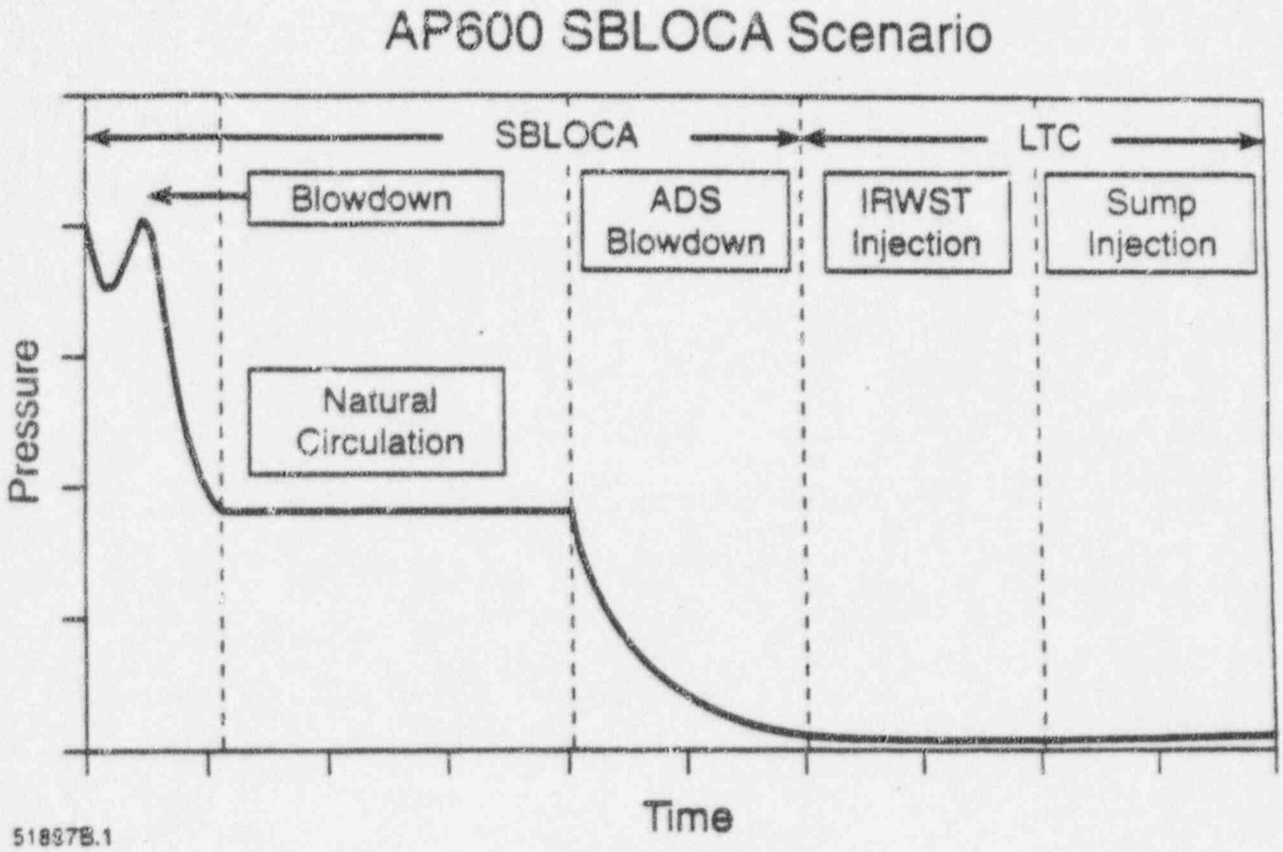
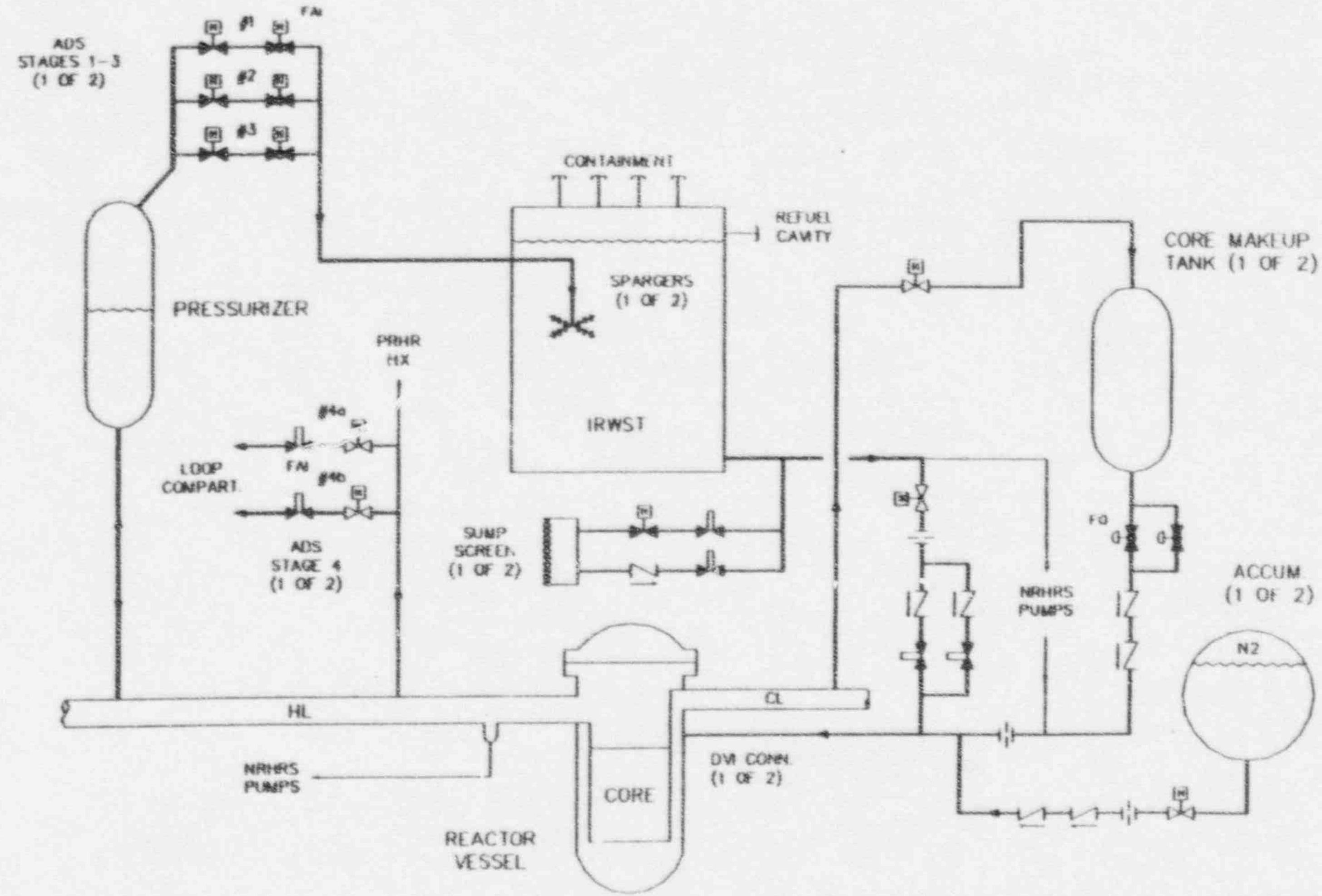
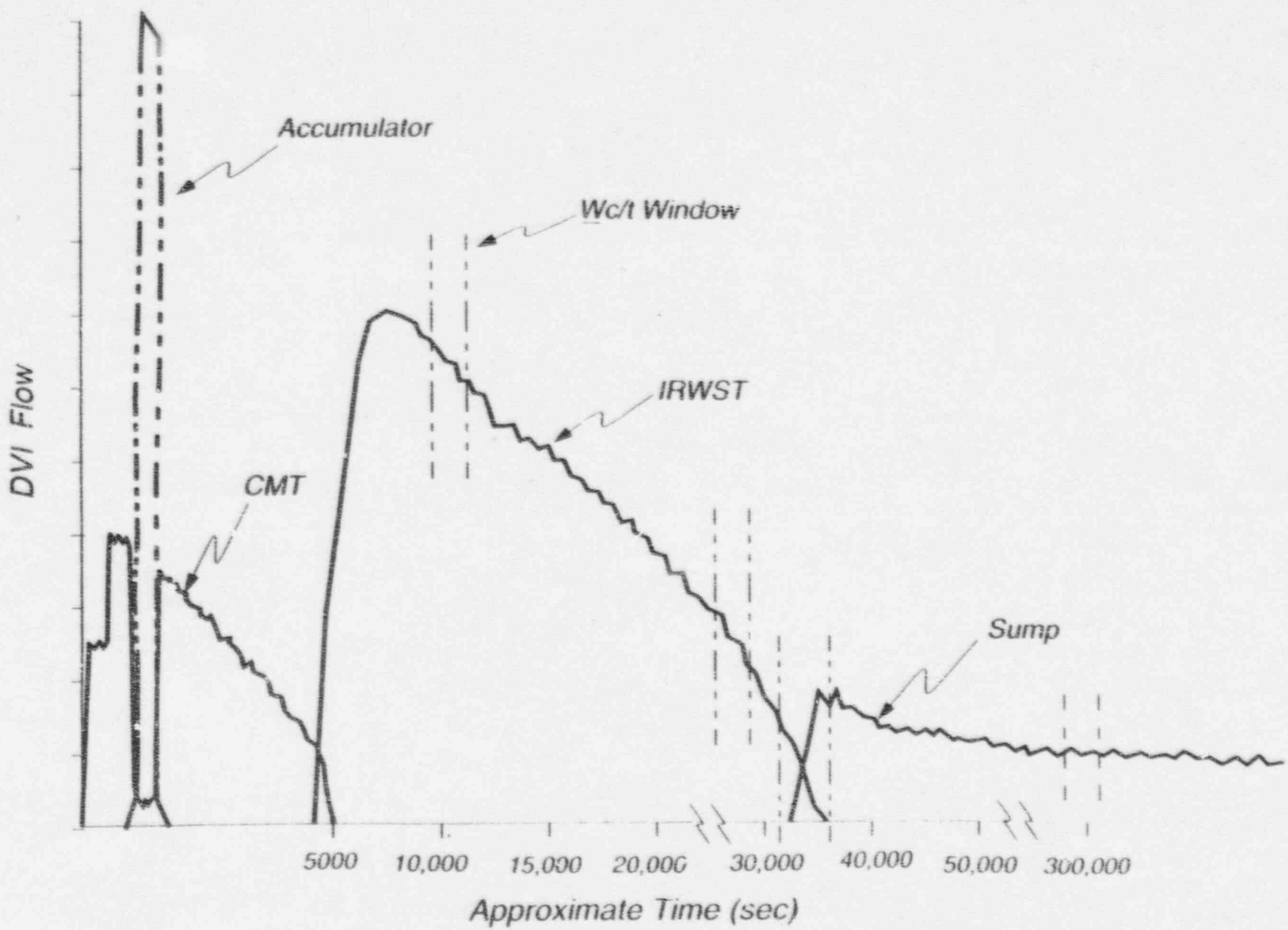


Figure 1-1 AP600 Small-Break LOCA and LTC Scenario

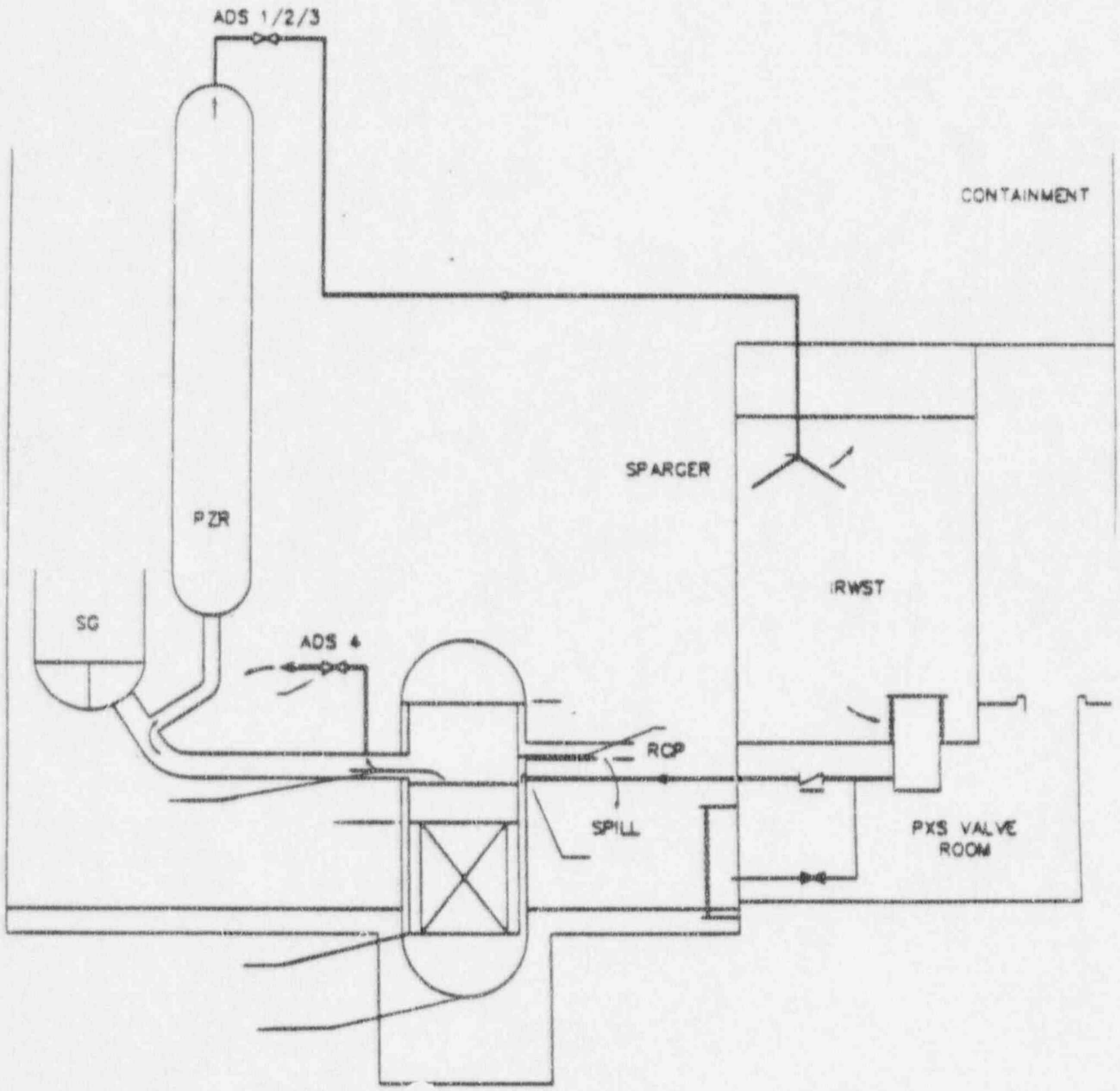
AP600 PASSIVE SI SYSTEM



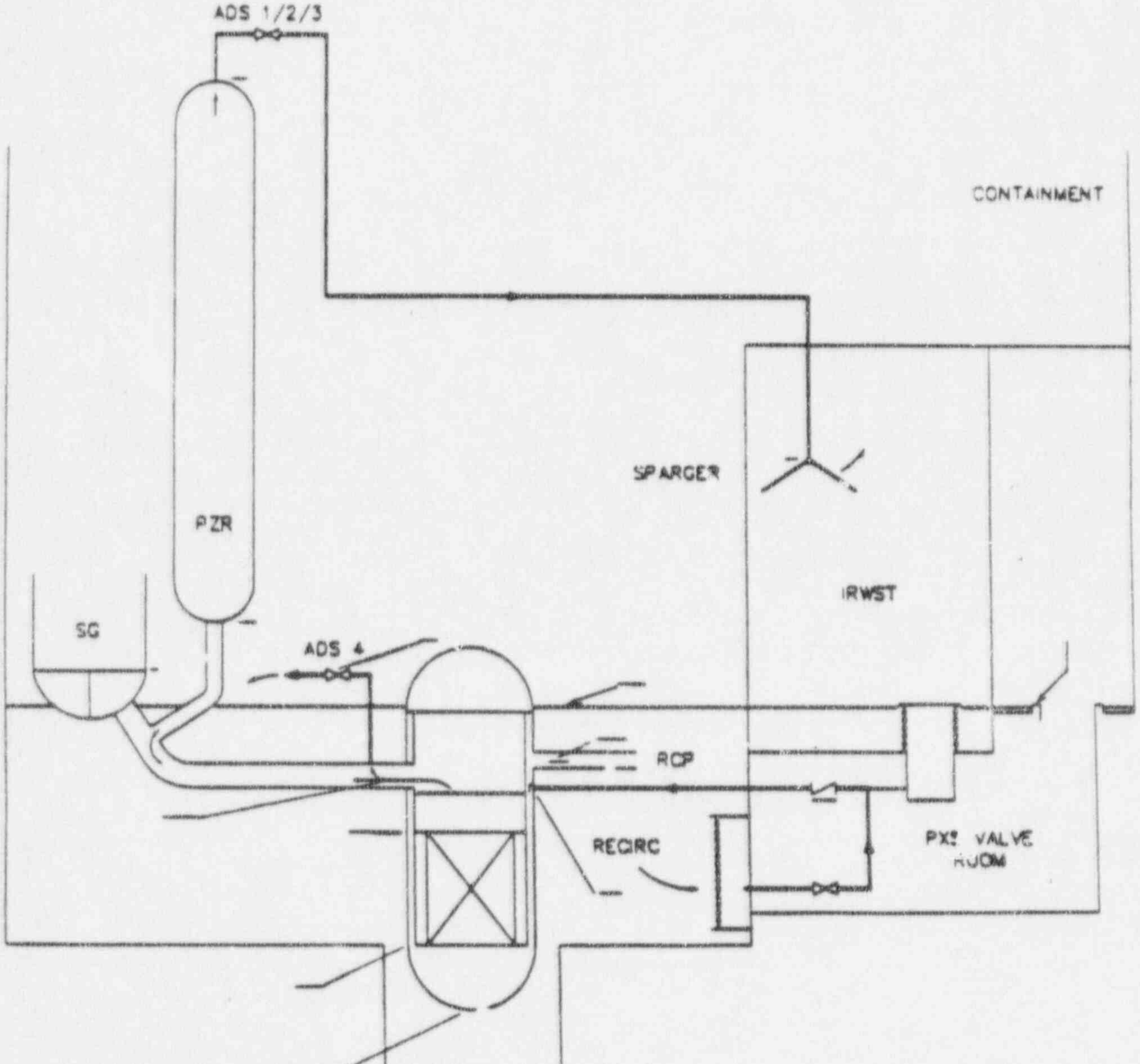
AP600 Injection Flow Sequence



AP600 LONG TERM COOLING
IRWST INJECTION

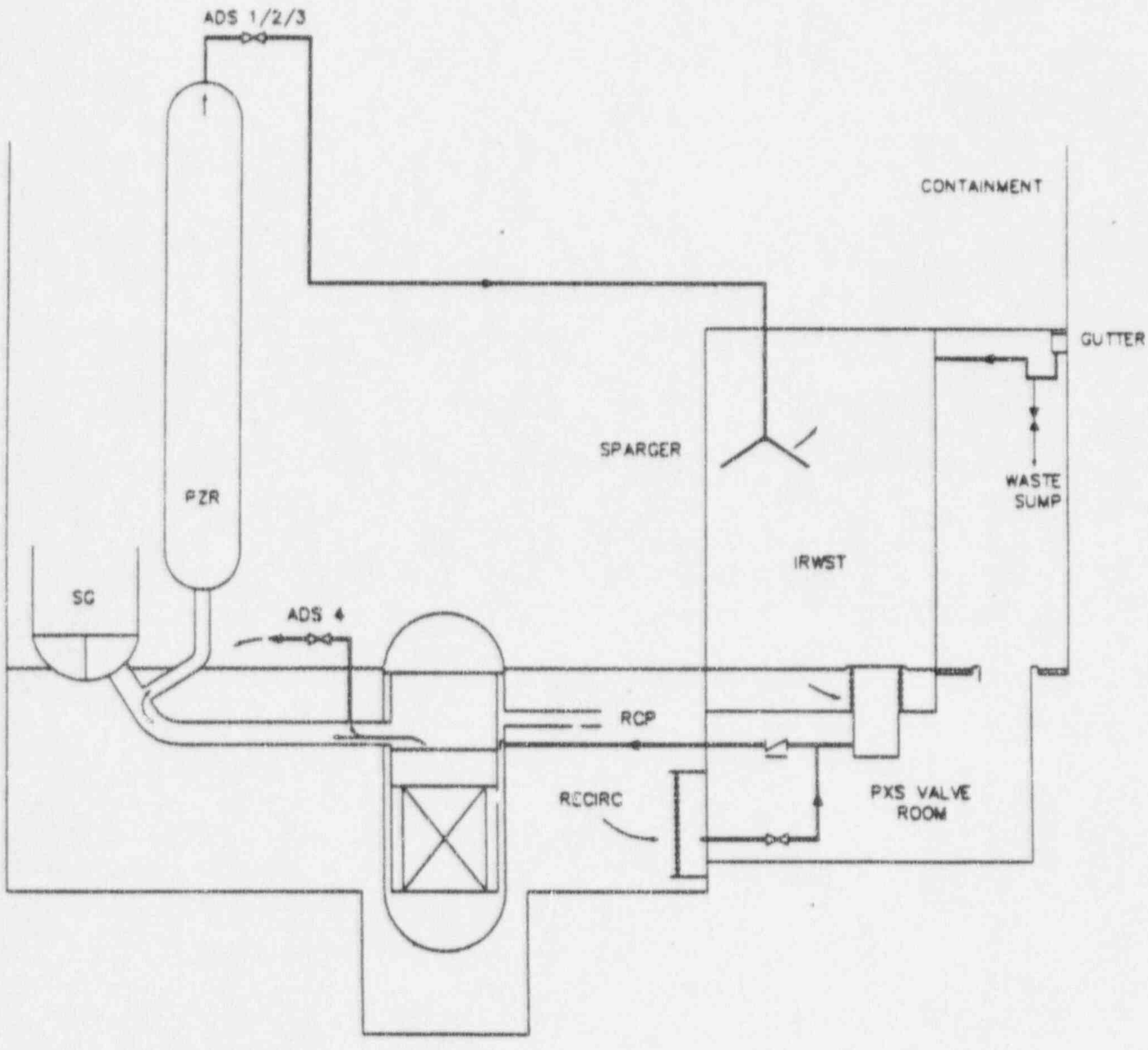


AP600 LONG TERM COOLING
RECIRCULATION



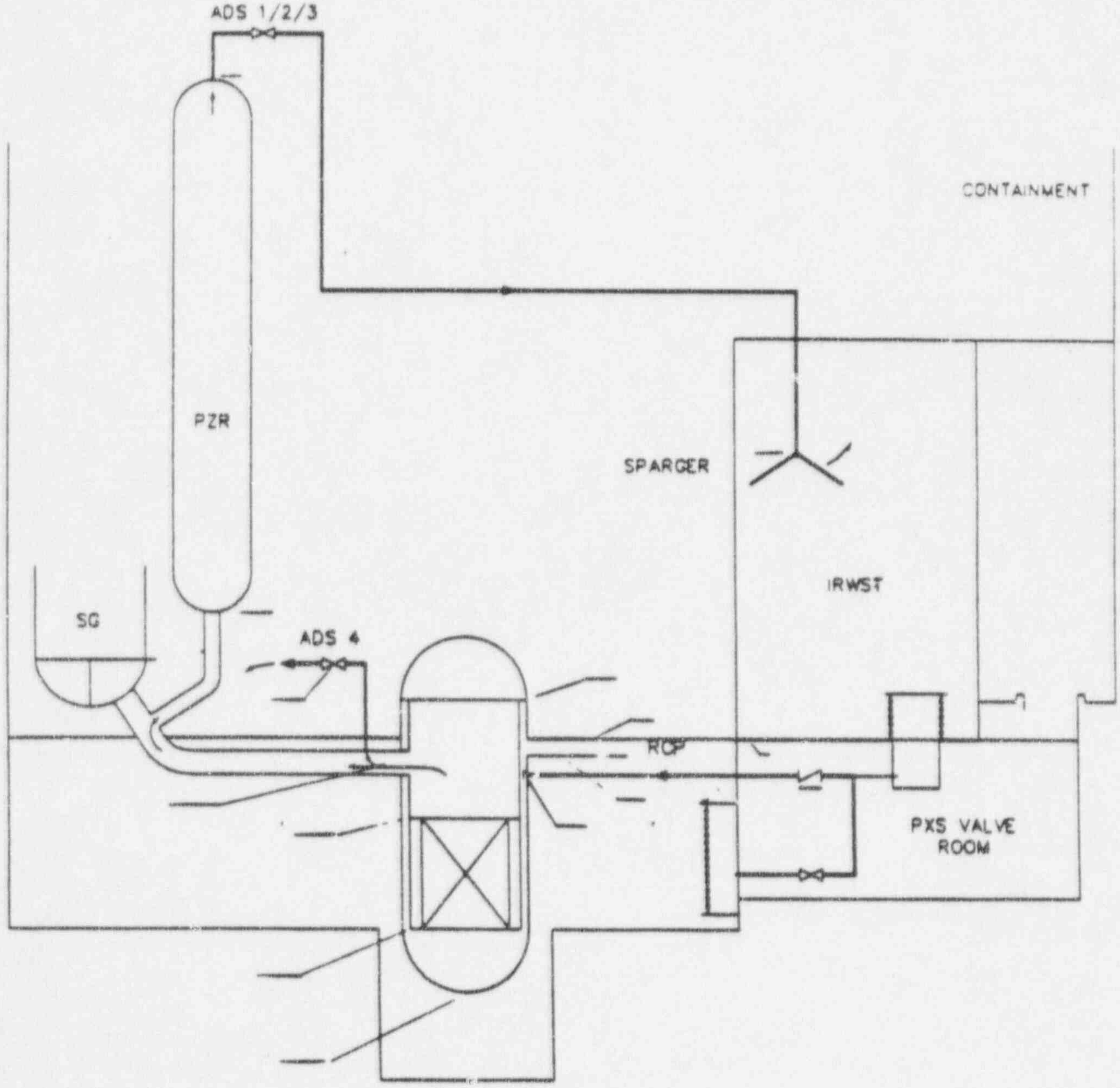
AP600 LONG TERM COOLING

RECIRCULATION



AP600 LONG TERM COOLING

WALL TO WALL



- INTRODUCTION - CON'T

  - LONG TERM COOLING IS COMMON END POINT FOR ANY TRANSIENT WHICH ACTIVITATES 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 INDEFINITY

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

- 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 WHICH THE NRC WAS FAMILIAR WITH

  - WCOBRA/TRAC HAS BEEN VALIDATED FOR LOW PRESSURE GRAVITY INJECTION SITUATIONS (CCTF AND SCTF TESTS) AND IS MOST SUITABLE FOR AP600 LTC

- 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 OF THE FULL TRANSIENT TO EXAMINE TIME PERIODS WHICH ARE MOST CHALLENGING FOR LTC

    - "WINDOW " CALCULATIONS ARE TYPICALLY 1000 - 1500 SECONDS IN LENGTH FOR THE PLANT

- 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

    - SYSTEM PRESSURE

- AS A RESULT, A REASONABLE SET OF INITIAL CONDITIONS WILL BE ADEQUATE TO INITIALIZE A WINDOW MODE CALCULATION SINCE AT THE END OF 1000 - 1500 SECONDS THE RESULTS WILL 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 PIRT

  - LTC PIRT WAS DEVELOPED AND REVIEWED AT WESTINGHOUSE AND HAS BEEN SUBMITTED TO THE NRC AS PART OF THE LTC WCAP

  - COMMENTS HAVE BEEN RECEIVED FROM THE NRC AND ITS CONSULTANTS AND HAVE BEEN INCLUDED IN THE FINAL LTC PIRT (MARCH 1996 MEETING)

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

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

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.

WC/T Code Validation for

AP600 Long-Term Cooling

- Overview of OSU Test Data
- Summary of Westinghouse Topical Report
- Recent Extended Time Calculational Results

March 12, 1997

Overview of OSU Test Data

- Test to Test Similarities
- Significant Flow Rates
- Vessel Pressure Variations

The Following Figures are in the Proprietary Version of this Report

Figure 1

Figure 2

Figure 3

OSU Measured Flow Rates at End of IRWST Draindown

(a,b,c)

	Test / Time			
	SB01 / 14.500 sec	SB10 / 14.0500 sec	SB12 / 9.000 sec	SB23 / 14.500 sec
DVI-1 (lb/sec)				
DVI-2 (lb/sec)				
Total Vessel Inflow (lb/sec)				
Break Flow (lb/sec)				
ADS1.2.3 Flow (lb/sec)				
ADS4-1 Flow (lb/sec)				
ADS4-2 Flow (lb/sec)				
Total Vessel Outflow (lb/sec)				

REACTOR VESSEL PRESSURES DURING IRWST DRAINING

OSU Test sb01, sb12, sb18, & sb23

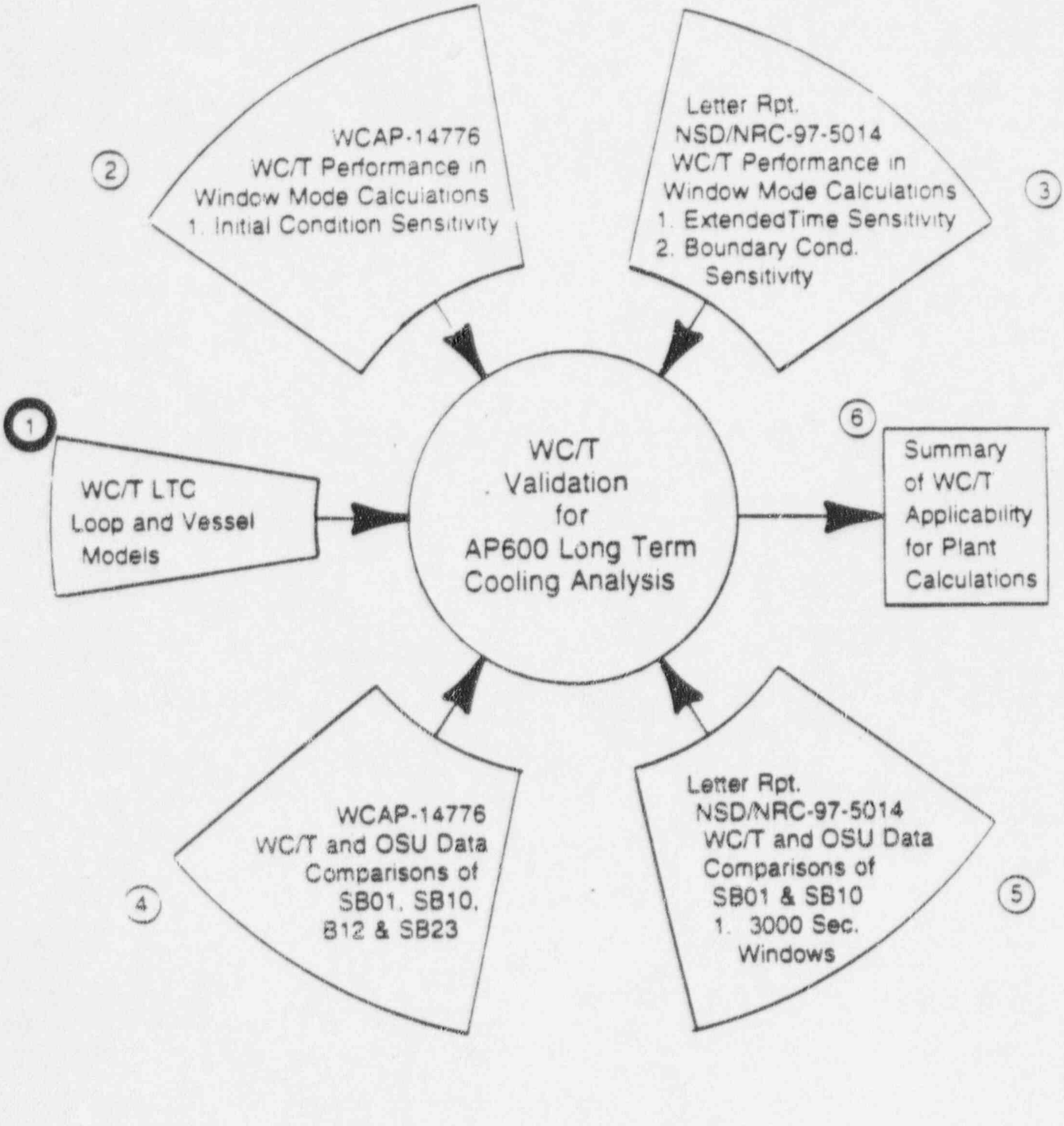
(a,b,c)

REACTOR VESSEL PRESSURES DURING IRWST DRAINING

OSU Test sb18, 2" Cold Leg Break

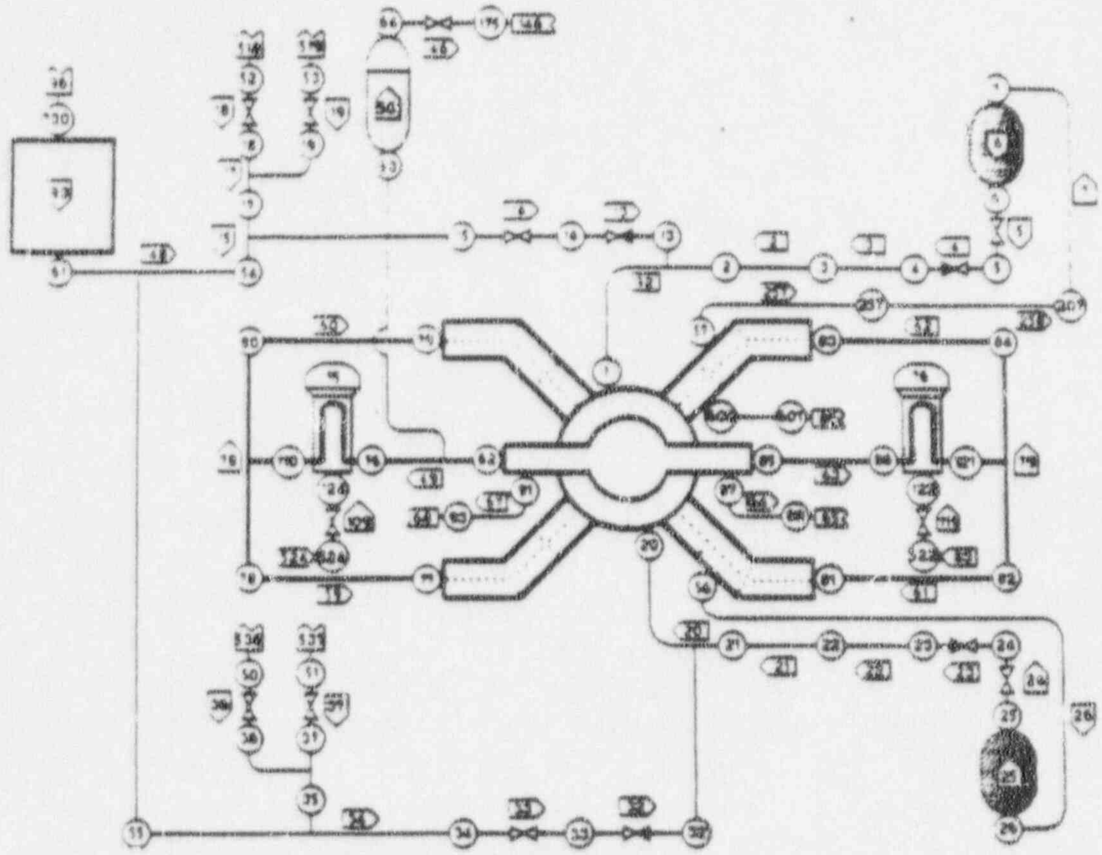
(a.b.c)

WC/T Code Validation for AP600
Long Term Cooling Analysis

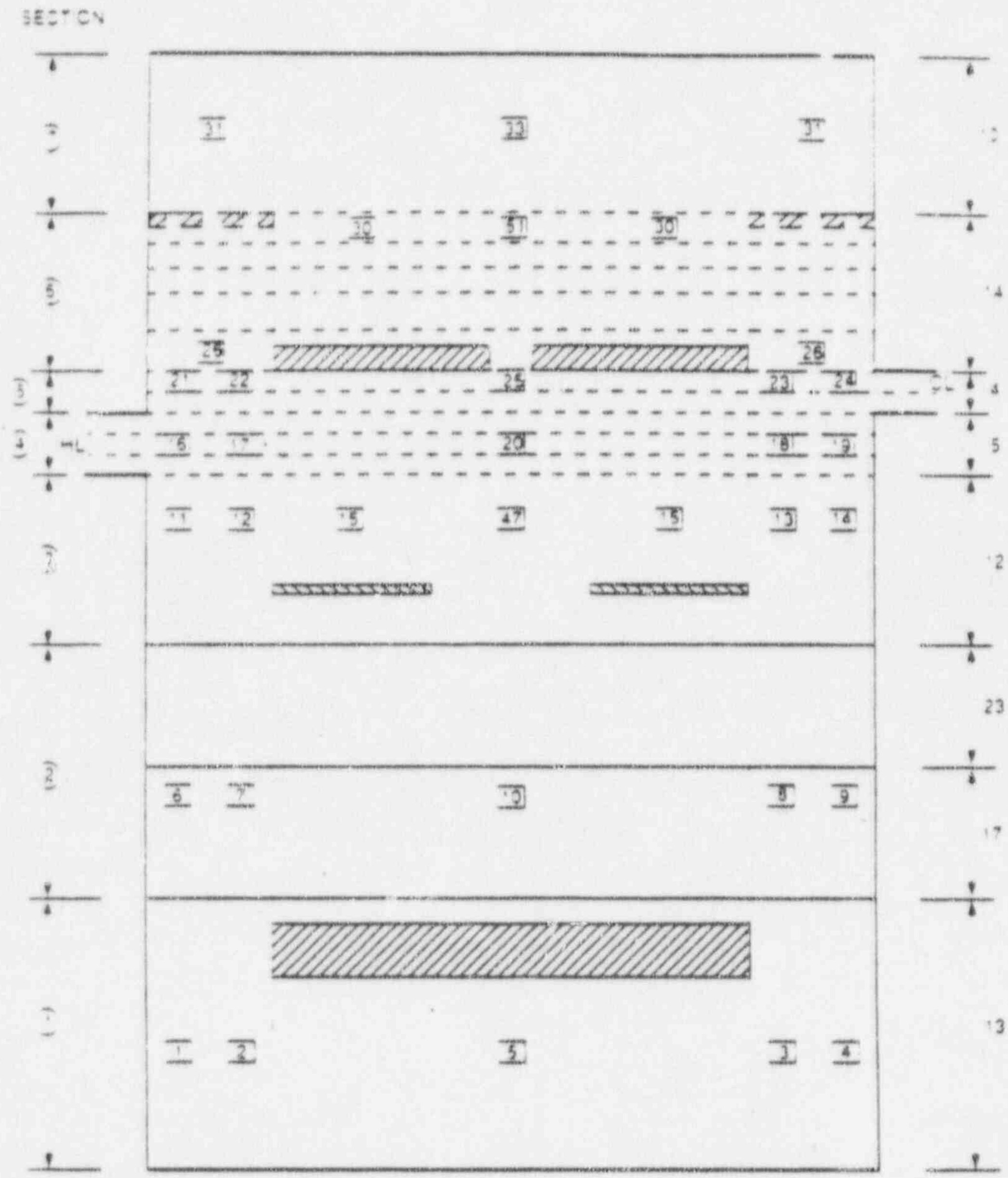


OSU - WC/T Modeling

- 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	sb01	sb10	sb12	sb23	Source of data
1.	Calc Initiation Time (sec)					
2.	IRWST Level (Rel. to drain) (in)					
3.	IRWST Temperature (°F)					
4.	Sump Level (Rel. to drain) (in)					
5.	Sump Temperature (°F)					
6.	Break Separator Level (in)					
7.	Break Separator Temp (°F)					
8.	Core Makeup Tank 1 Flow (lb/sec)					
9.	Core Makeup Tank 1 Temp (°F)					
10.	Core Makeup Tank 2 Flow (lb/sec)					
11.	Core Makeup Tank 2 Temp (°F)					
12.	SG Secondary Side Temp (°F)					
13.	SG Secondary Side Press (psia)					
14.	Core Power Factor					

(a,b,c)

OSU - WC/T LONG-TERM COOLING

INITIAL CONDITIONS

No.	Condition	sb01	sb10	sb12	sb23	Source of data
1.	Time of Start of IRWST (sec)					
2.	Upper Plenum Level (in)					
3.	Downcomer Level (in)					
4.	Downcomer Fluid Temp. (°F)					
5.	Vessel Wall Metal Temp. (°F)					
6.	Core Liquid Temp. (°F)					
7.	Initial Fuel Rod Temp. (°F)					
8.	1-D Hot Leg Level (in)					
9.	SG Channel Head Level (in)					
10.	Cold Leg Level (in)					
11.	Pressurizer Level (in)					
12.	Surge Line Level (in)					

(a,b,c)

WC/T VALIDATION CALCULATIONS FOR LONG-TERM COOLING ANALYSIS

1. WC/T Initial Condition Convergence - 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 Convergence - 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 Convergence - NSD/NRC-97-5014

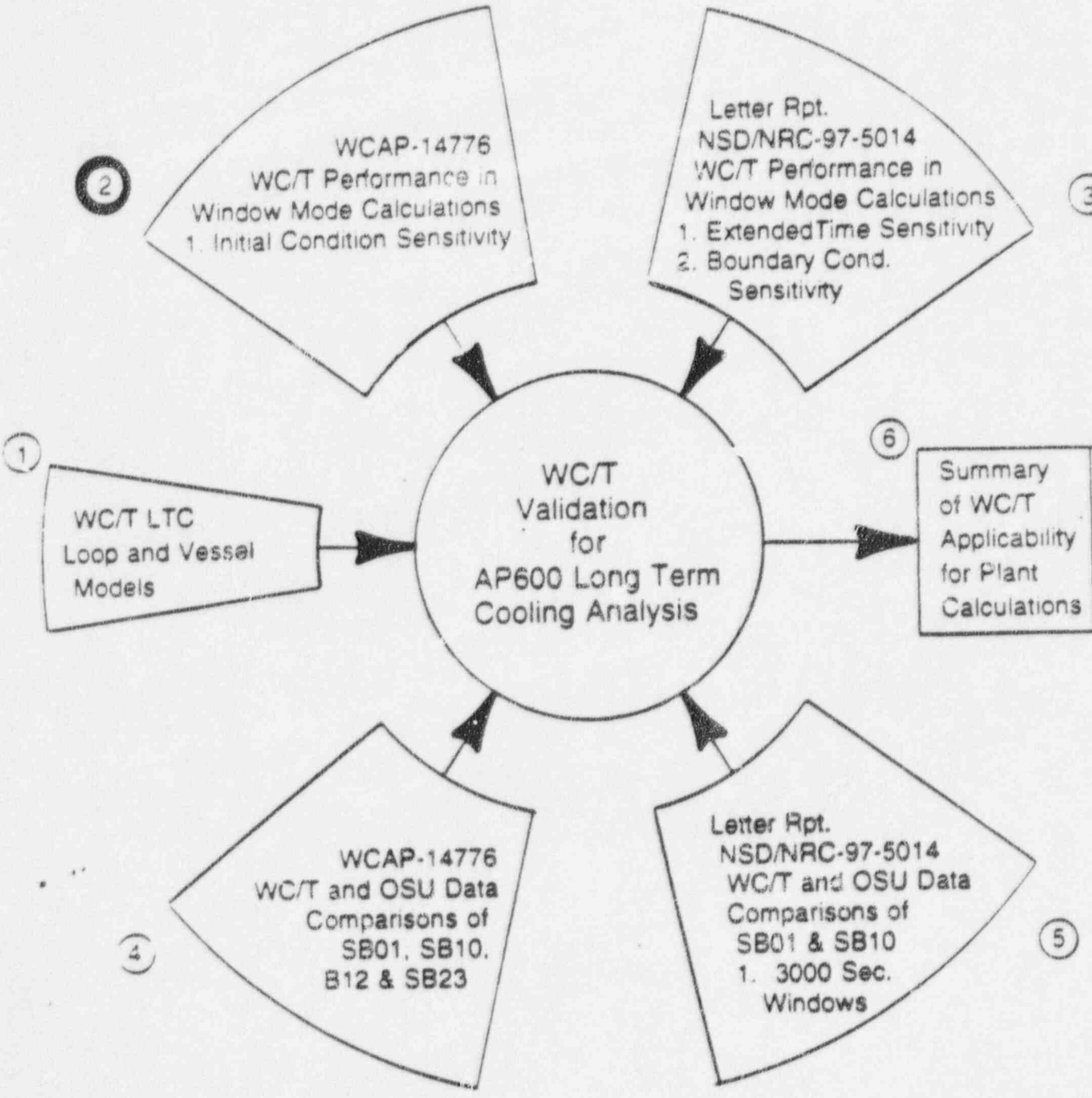
   - Reference calc., SB01, 8000 sec. to 9000 sec.
   - Comparison calc., SB01, 8000 sec. to 9000 sec.
     - IRWST level raised 2.5 ft for 200 sec. (3600 sec level)
     - Core Power raised 30% for 200 sec. (3600 sec value)
     - S.G. Temp. raised 45°F for 200 sec. (3600 sec value)
   - Identical vessel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

The Following Figures are in the Proprietary Version of this Report

Figure 3-22

Figure 3-36

Figure 3-41

Figure 3-47

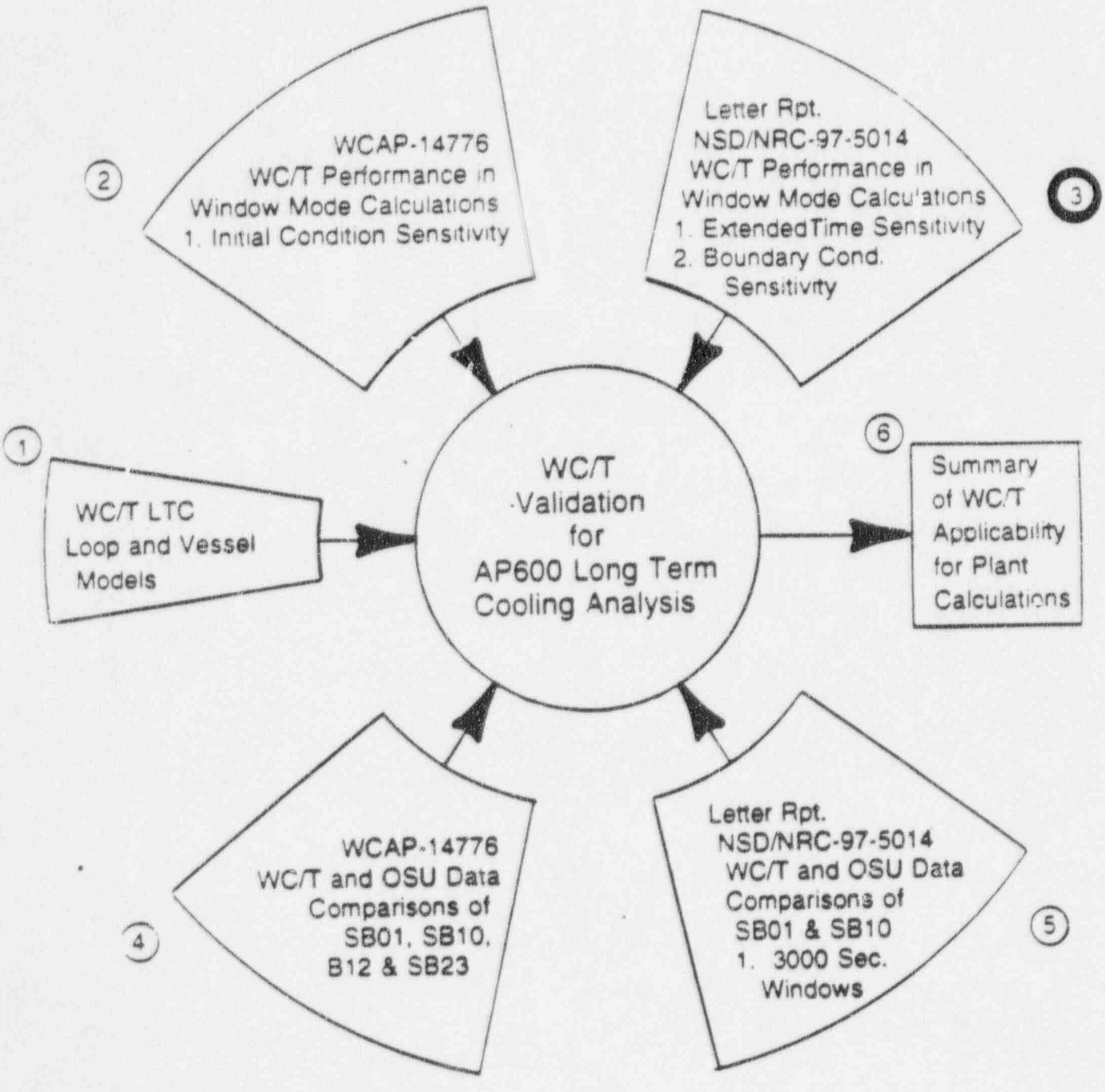
Figure 3-54

Figure 3-52

Figure 3-57

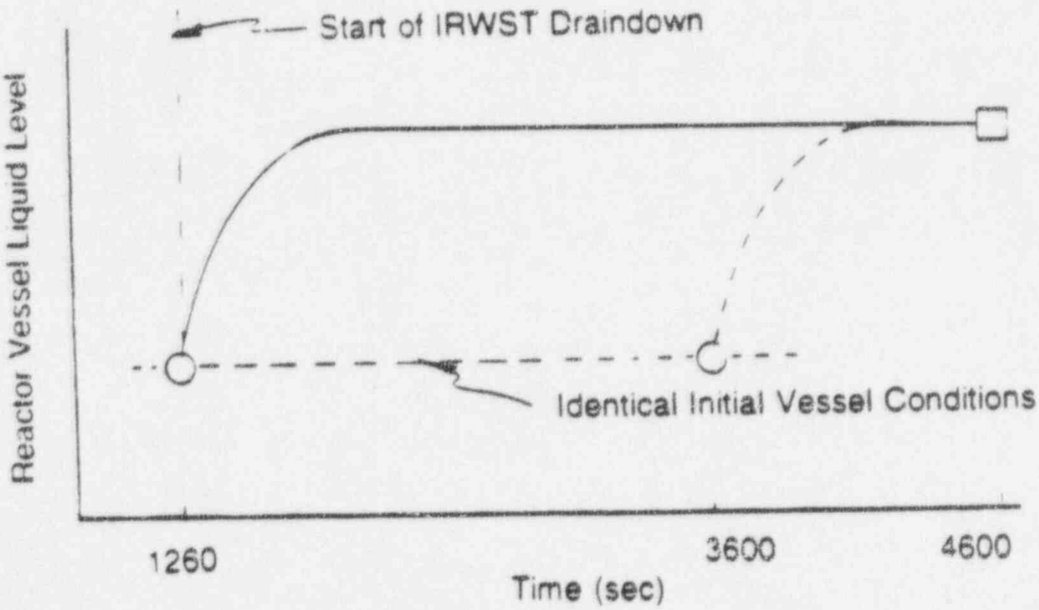
Figure 3-63

WC/T Code Validation for AP600 Long Term Cooling Analysis



WC/T Extended Time Convergence - 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 Report

Figure 2.1-4

Figure 2.1-2

Figure 2.1-3

Figure 2.1-7

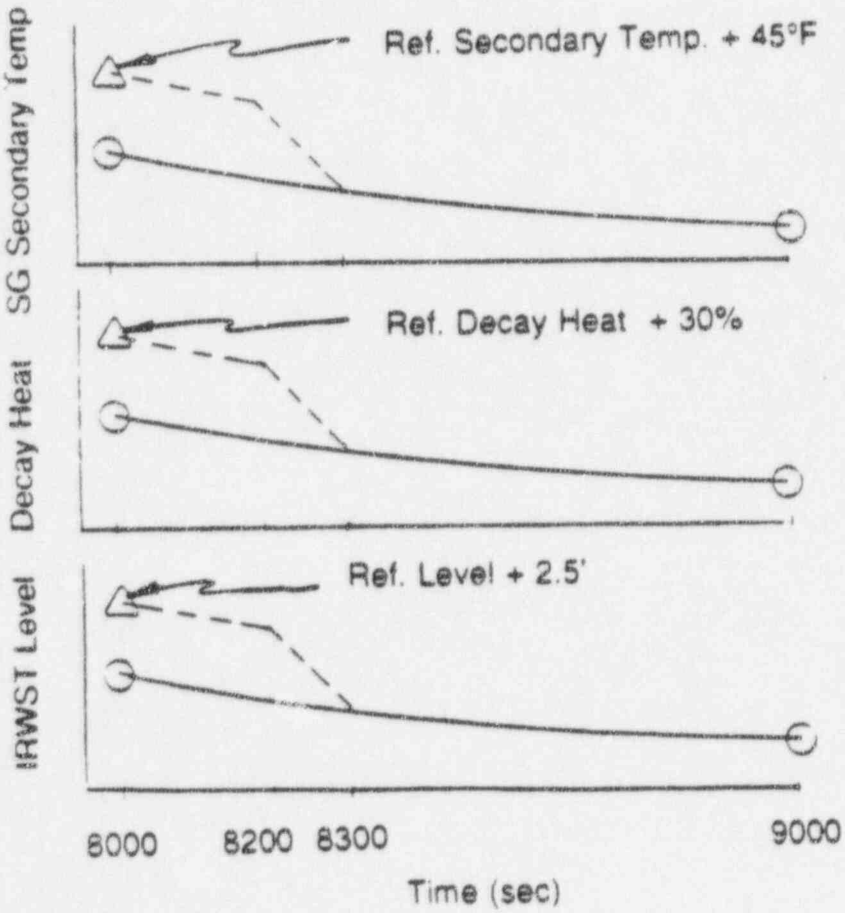
Figure 2.1-8

Figure 2.1-13

Figure 2.1-14

WC/T Boundary Condition Convergence - 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 Report

Figure 2.2-4

Figure 2.2-2

Figure 2.2-3

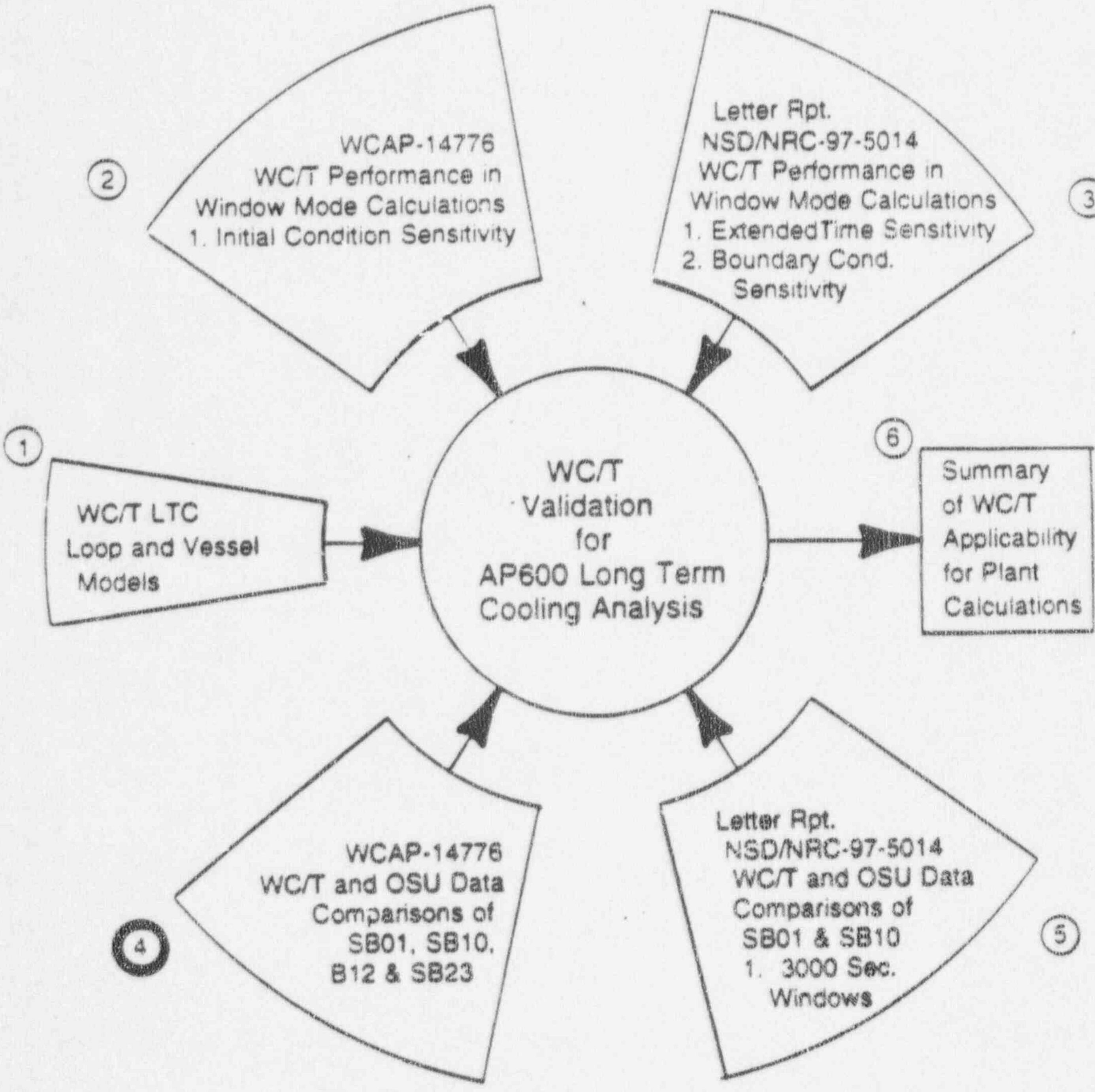
Figure 2.2-7

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 Report

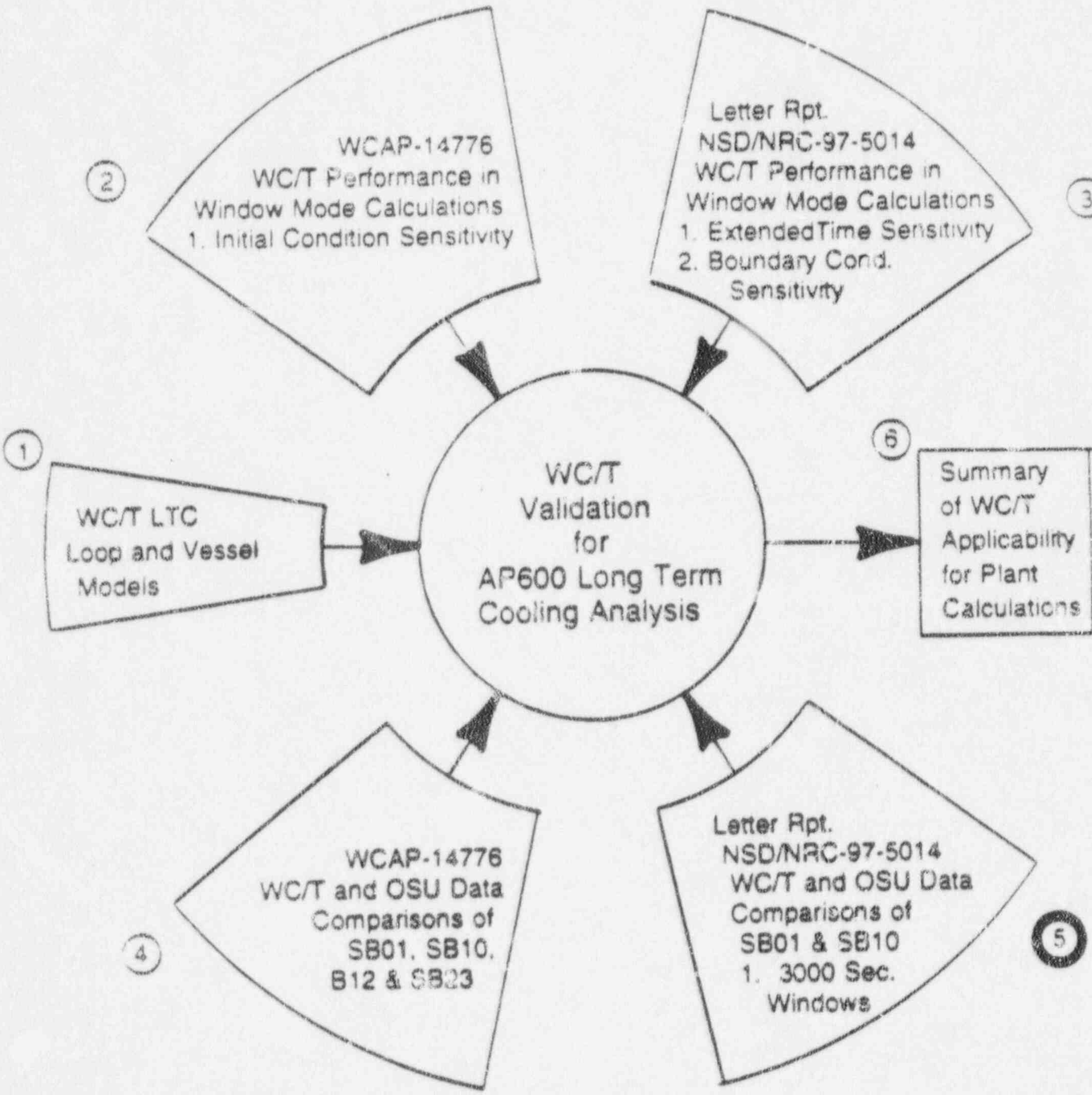
Figure 5.1-23

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 Report

Figure 2.3-23

Figure 2.3-24

Figure 2.3-22

Figure 2.3-3

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 Report

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
- DVI-2 Vessel Inlet Temperature
- IRWST DVI-1 Injection Flow
- IRWST DVI-2 Injection Flow
- Sump Injection 1 Flow
- Sump Injection 2 Flow
- Total DVI-1 Injection Flow
- Total Integrated DVI-1 Flow
- Total ADS 4-1 Flow
- Total Integrated ADS 4-1 Flow

The Following Figures are in the Proprietary Version of this Report

Figure 2.5-23

Figure 2.5-24

Figure 2.5-22

Figure 2.5-11

Figure 2.5-12

Figure 2.5-3

Figure 2.5-4

Figure 2.5-5

Figure 2.5-6

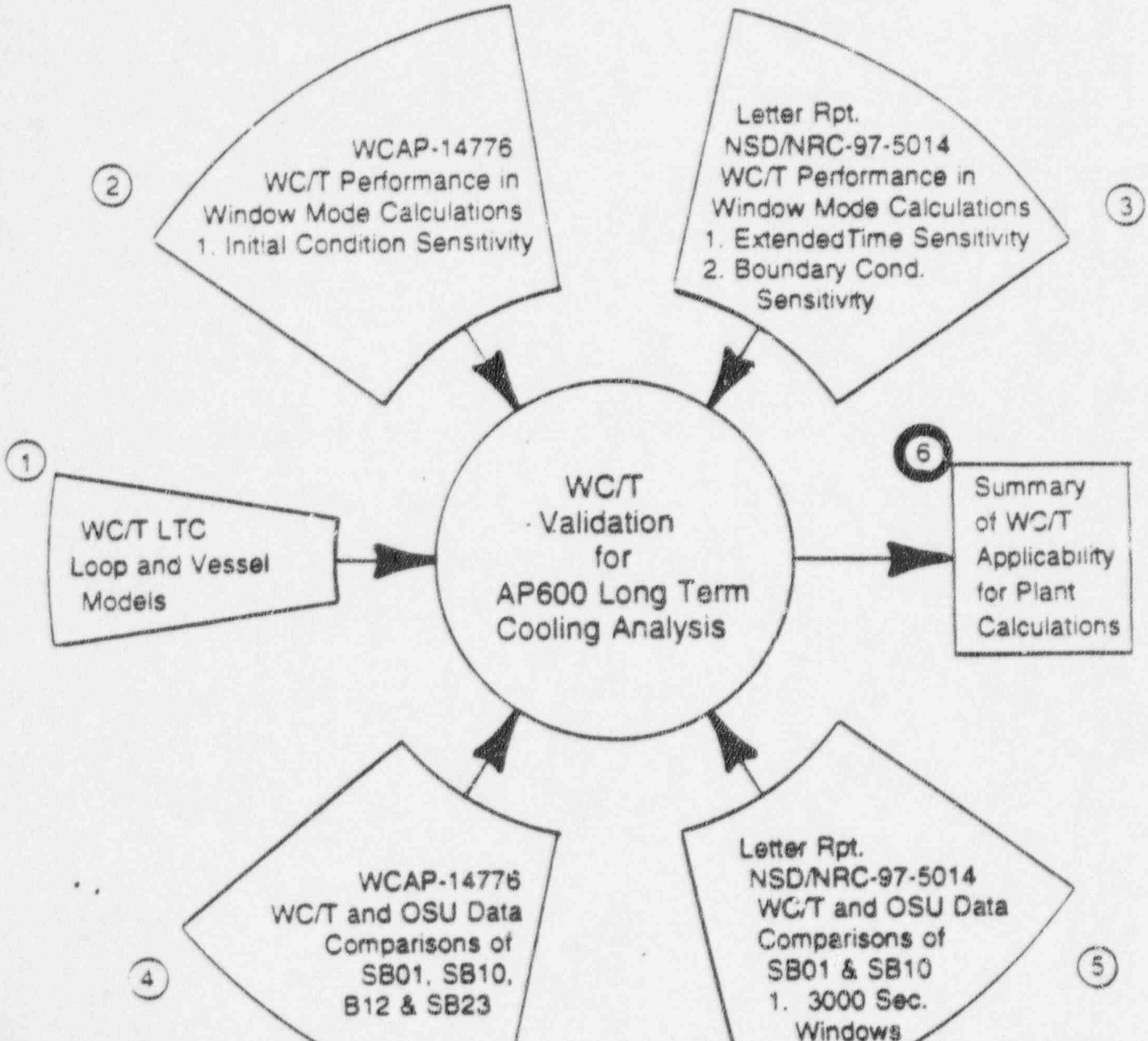
Figure 2.5-7

Figure 2.5-8

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
- Vessel Pressure Comparison

Downcomer Liquid Level Comparison

(a.b.c

Upper Plenum Liquid Level Comparison

(a,b,c

Reactor Vessel Total Inflow Comparison

(a,b

Reactor Vessel Total Outflow Comparison

(a,b,c

vessel Pressure Data Comparison

- Measured vessel (upper head) pressure range is 15.5 psia to 16.0 psia with a pressure sensor uncertainity of ± 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 excellant comparison with the measure values, i.e. well within the uncertainity bands.

REACTOR VESSEL PRESSURES DURING IRWST DRAINING

OSU Test sb01, sb12, sb18, & sb23

(a,b,c)

ЕЕ

Conclusions from WC/T Code Validation for AP600 Application

1. Several extended WC/T calculations show no indications of solution divergence at 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 providing a degree of conservatism.

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

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

AP600 LONG TERM COOLING SSAR CALCULATIONS WITH WCOBRA/TRAC

- LONG TERM COOLING OF AP600 IS UNIQUE
  - PASSIVE SAFETY-RELATED SYSTEMS
  - QUASI-STEADY-STATE CONDITIONS
- ESTABLISH AND VERIFY A SIMPLIFIED WCOBRA/TRAC NODALIZATION
  - VESSEL CHANNELS USED FOR HOT LEGS, COLD LEGS
  - VALIDATE AGAINST OSU LONG TERM TEST RESULTS
- CALCULATE AP600 PERFORMANCE AT LIMITING, DISCRETE TIMES USING WINDOW MODES

METHODOLOGY TO PERFORM A WINDOW MODE ECCS PERFORMANCE ANALYSIS

1. IDENTIFY LIMITING PORTION(S) 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.

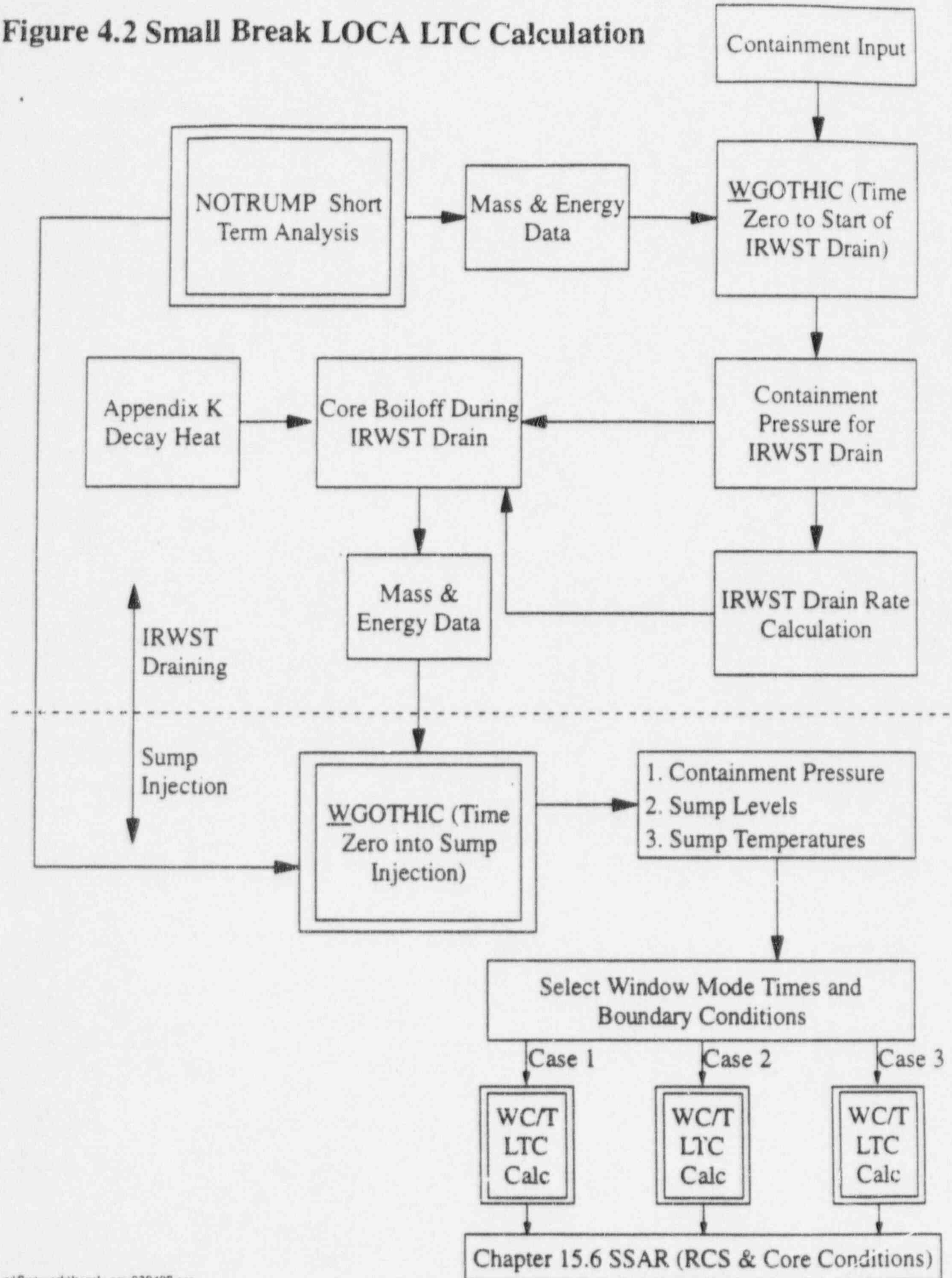
SSAR LONG TERM COOLING ANALYSIS STRATEGY

- ANALYZE IN COMPLIANCE WITH APPENDIX K
- APPLY CONSERVATISM IN GENERATING CONDITIONS FOR THE WINDOW CALCULATIONS: FOR START OF SUMP RECIRCULATION:
  - MAXIMIZE IRWST DRAIN RATE FOR MAXIMUM DECAY HEAT AT SUMP INITIATION
  - MAXIMIZE ENERGY OF LIQUID EXITING ADS-4 DURING IRWST INJECTION TO MAXIMIZE SUMP TEMPERATURE AND MINIMIZE CONTAINMENT PRESSURE
- ADDRESS THE SPECTRUM OF LOCA BREAK SIZES

WGOTHIC COMPUTES CONTAINMENT CONDITIONS THROUGHOUT THE TRANSIENT

- LOW PRESSURE STIPULATED BY APPENDIX K
- CONSERVATIVE ASSUMPTIONS APPLIED
  - MASS/ENERGY RELEASES
  - GUTTERS PRESUMED INOPERATIVE
  - MAXIMUM PCS WATER FLOW EXTERNAL TO CONTAINMENT
  - MINIMUM PCS WATER TEMPERATURE
  - 1.05* BEST ESTIMATE FREE VOLUME
  - NO HEAT TRANSFER MODELING PENALTIES
  - MINIMIZE INITIAL AIR MASS PRESENT
  - MAXIMIZE EXTERNAL SURFACE WETTING

Figure 4.2 Small Break LOCA 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
  - STEAM GENERATOR SECONDARY SIDE 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

- 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

- KEY VARIABLE REMAINS 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

- 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 WC/T OSU FINAL VALIDATION REPORT
- CASES TO SHOW ADEQUATE CORE COOLING IN THE LONG TERM

AP600 SSAR LONG-TERM COOLING WINDOW MODE CASES

SET 1 - DOUBLE-ENDED DVI LINE BREAKS

CASE I - DESIGN BASIS: ONLY PASSIVE SYSTEMS OPERATE

- WINDOW INCLUDES THE LATE IRWST INJECTION PHASE ON INTO STABLE SUMP INJECTION
- REPRESENTS EARLIEST SWITCHOVER TO SUMP INJECTION AND, THEREFORE, THE HIGHEST DECAY POWER FOR SUMP INJECTION

CASE II - SYSTEMS INTERACTION: RNS OPERATION INITIALLY

- RNS FAILURE ASSUMED AT THE TIME OF SUMP SWITCHOVER, AFTER IRWST HAS BEEN DISCHARGED RAPIDLY BY PUMPS
- IN THIS WINDOW, SUMP INJECTION BEGINS EVEN EARLIER THAN IT DOES IN CASE I

CASE 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

AP600 SSAR LONG-TERM COOLING WINDOW MODE CASES (CONT'D)

SET 2 - SMALL COLD LEG BREAKS

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

- WINDOW INCLUDES THE LATE IRWST INJECTION PHASE ON INTO STABLE SUMP INJECTION
- REPRESENTATIVE OF SMALL BREAK LOCA SWITCHOVER TO INJECT FROM A NEAR-SATURATED SUMP

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

- SINGLE FAILURE SENSITIVITY CASE

AP600 SSAR LONG-TERM COOLING WINDOW MODEL CASES (CONT'D)

SET 3 - LARGE COLD LEG (DECLG) BREAK

CASE I - CONTINUE SHORT-TERM TRANSIENT BEYOND ADS 1-3 INJECTION LEVEL

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

CASE II - WINDOW CONSIDERS IRWST INJECTION AT THE TIME AT WHICH THE SUMP LEVEL HAS RISEN TO WITHIN THE PERIMETER OF THE BROKEN COLD LEG

- FAIL ONE ADS-4 FLOW PATH

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

- SENSITIVITY TO GUTTER OPERATION (RAI RESPONSE)

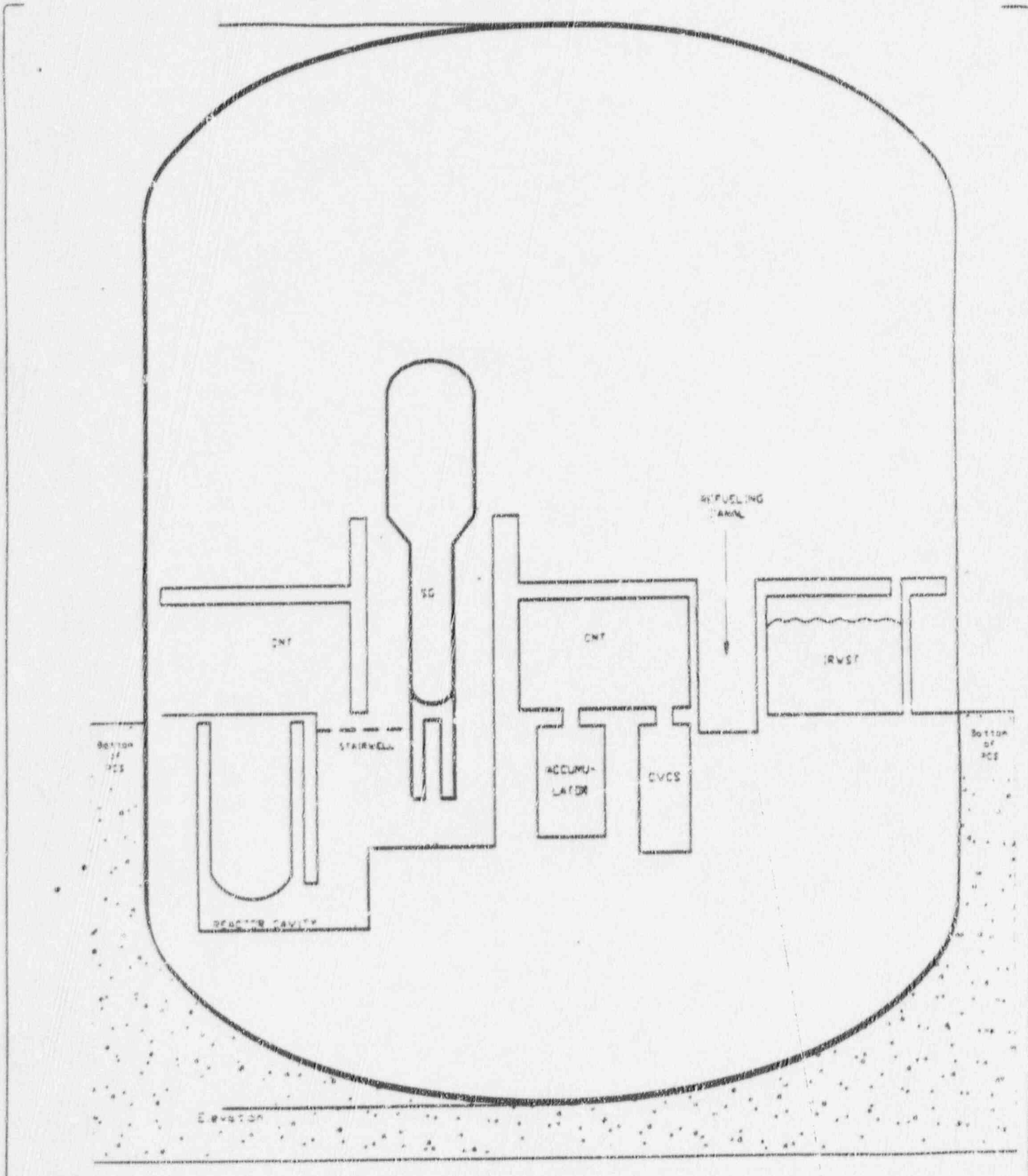
CONCLUSIONS:

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

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

- WINDOWS SELECTED FOR THE SSAR LOCA ANALYSIS INVESTIGATE BOUNDING SCENARIOS

Simplified AP600 Internal Containment Flow Network



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DRAFT AGENDA

Friday, March 28, 1997

LONG TERM COOLING ACRS MEETING

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