MPR ASSOCIATES, INC.

June 19, 1986

Dear Mr. Paulson:

Enclosed are six (6) copies of the view-graphs used at the meeting among USNRC, the B&W Owners Group, and MPR on June 19, 1986.

Sincerely,

H. Estrada

H. Estrada, Jr.

Enclosure

Mr. Walter Paulson
United States Nuclear Regulatory Commission
Philips Building, Mail Stop P-214
7920 Norfolk Avenue
Bethesda, MD 20814

VIA FEDERAL EXPRESS

cc: S. Rose, Duke Power
L. Reed, Duke Power
R. Skillman, GPU-N

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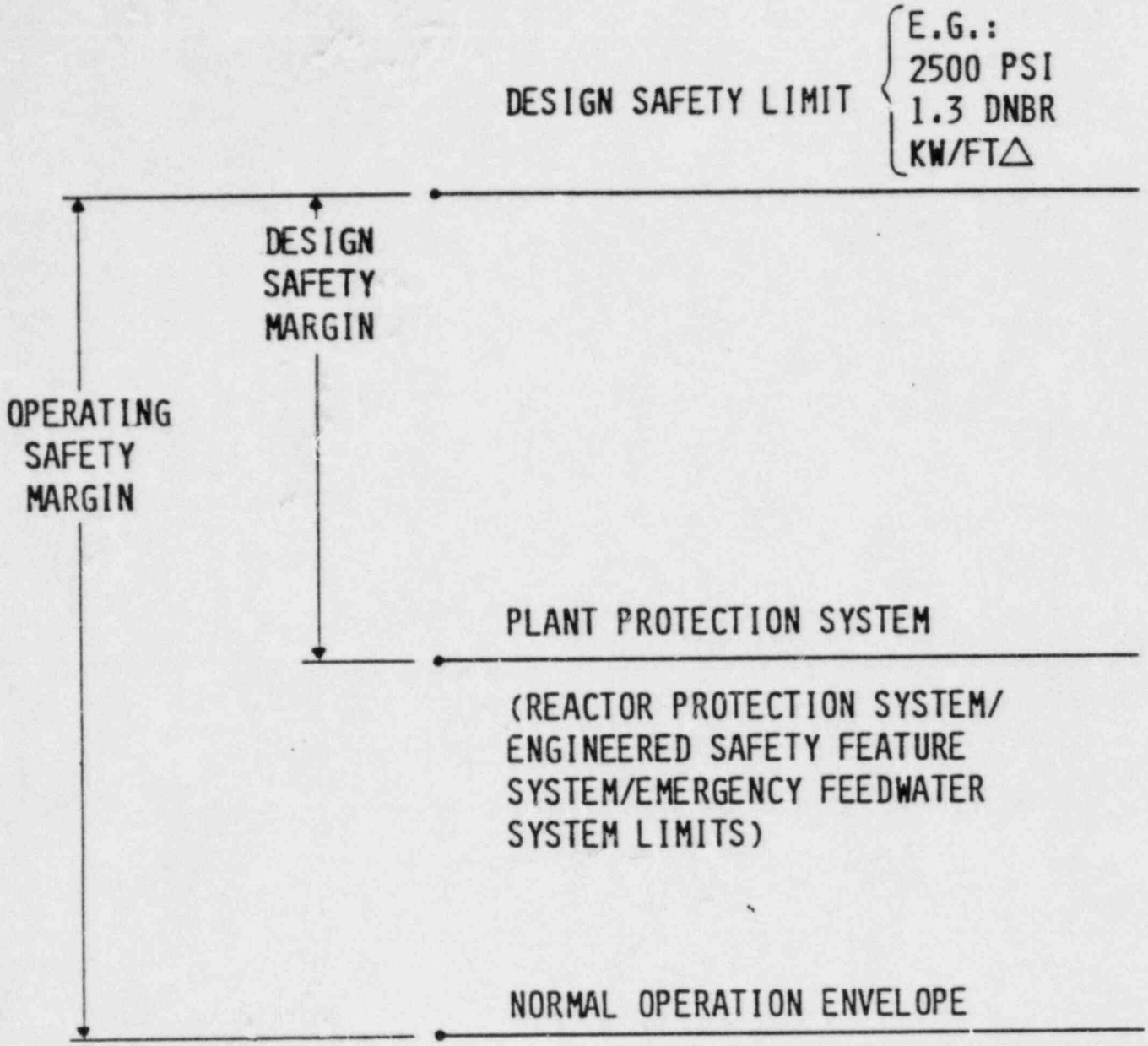
AGENDA

1.	OPENING COMMENTS	G. R. SKILLMAN
2.	GENERAL OBJECTIVES OF THE SENSITIVITY STUDY	MPR
3.	DESCRIPTION OF MODELS	MPR
4.	COMPARATIVE ANALYSIS MATRIX	MPR
5.	VERIFICATION PROCESS	MPR
6.	SCHEDULE FOR PEER REVIEW MEETINGS	CHARLES TURK
7.	CONCLUDING REMARKS	G. R. SKILLMAN

GENERAL OBJECTIVES OF THE SENSITIVITY STUDY

- FOR B&W PLANTS VS. OTHER PWRs
  - CHARACTERIZE RESPONSE
    - NORMAL CONDITIONS
    - UPSETS AND ACCIDENTS INCLUDING COMPOUND UPSETS NOT NORMALLY INCLUDED IN FSARs
  - EVALUATE SAFETY MARGINS:
    - OVERPRESSURE
    - DNBR
    - KW/FOOT
    - OTHER, IF APPROPRIATE
- RECOMMEND CORRECTIVE MEASURES FOR B&W UNITS, IF
  - UPSETS OF A SPECIFIC KIND ARE MORE LIKELY
  - SAFETY MARGINS IN SPECIFIC UPSETS ARE SIGNIFICANTLY SMALLER



- MARGINS
- TIME TO REACH LIMITS
- FREQUENCY OF OCCURRENCE

DESCRIPTION OF MODELS

- UNITS ANALYZED

  - TWO B&W UNITS

    [MAY ADD A THIRD]

  - ONE CE UNIT, PRE-75

    WILL EXAMINE DIFFERENCES WITH A POST-75 UNIT

  - ONE W UNIT, RECENT, D-TYPE RSGs

    WILL EXAMINE DIFFERENCES WITH A PRE-75 UNIT

ANALYSIS MATRIX: STUDY OF THE SENSITIVITY OF B&W PWRs VS. OTHER PWRs
PRELIMINARY

TRANSIENTS ANALYZED	MODEL	FSAR	PURPOSE
1. SMALL DISTURBANCES, WITHOUT CONTROLS			
A. REACTIVITY STEPS			
(1) HIGH POWER	x		
(2) LOW POWER	x		
B. STEAM FLOW STEPS			° QUANTIFY TIME TO REACH DEFINED LIMITS FOR KEY VARIABLES WITH THE "BARE" PLANT (NO CONTROLS) AS A QUANTITATIVE MEASURE OF SENSITIVITY FOR B&W, W AND CE PLANTS.
(1) HIGH POWER	x		
(2) LOW POWER	x		
C. FEED FLOW STEPS			
(1) HIGH POWER	x		
(2) LOW POWER	x		
D. REACTIVITY IMPULSES			
(1) HIGH POWER	x		
(2) LOW POWER	x		
E. STEAM FLOW IMPULSES			° DETERMINE TRANSFER FUNCTIONS (INPUT-OUTPUT MAGNITUDE AND PHASE VS. FREQUENCY) FOR PURPOSES OF CHARACTERIZING DIFFICULTY OF CONTROL.
(1) HIGH POWER	x		
(2) LOW POWER	x		
F. FEED FLOW IMPULSES			
(1) HIGH POWER	x		
(2) LOW POWER	x		

ANALYSIS MATRIX: STUDY OF THE SENSITIVITY OF B&W PWRs VS. OTHER PWRs
PRELIMINARY

TRANSIENTS ANALYZED	MODEL	FSAR	PURPOSE
2. SIGNIFICANT DISTURBANCES, WITHOUT CORRECTIVE ACTION			
A. ROD DROPS			
SMALL δK	x	x	° ASSESS DIFFERENCES AMONG PWRS IN SAFETY MARGINS FOR THIS DISTURBANCE. ° "CALIBRATE" MODEL FOR SAFETY MARGIN ESTIMATION FOR DISTURBANCES OF THIS TYPE. ° VERIFY MODEL DYNAMICS FOR REACTIVITY DISTURBANCES.
LARGE δK	x	x	
B. TURBINE TRIP	x		° ASSESS DIFFERENCES AMONG PWRS IN SAFETY MARGINS FOR THIS DISTURBANCE.
C. LOSS OF ONE FEED PUMP	x		° ASSESS DIFFERENCES AMONG PWRS IN SAFETY MARGINS FOR THIS DISTURBANCE.
D. LOSS OF ALL FEED PUMPS	x		° ASSESS DIFFERENCES AMONG PWRS IN SAFETY MARGINS FOR THIS DISTURBANCE.
E. LOSS OF ONE COOLANT PUMP	x		
3. SIGNIFICANT DISTURBANCES, WITH CORRECTIVE ACTION			
A. ROD WITHDRAWAL ACCIDENT, HIGH POWER		x	° ASSESS DIFFERENCES AMONG PWRS IN SAFETY MARGINS FOR THIS DISTURBANCE.
B. TURBINE TRIP			
(1) NORMAL STEAM RELIEF W/RX CUTBACK	x		° EVALUATE CAPABILITY OF PWRS TO WITHDSTAND LOAD REJECTION WITHOUT TRIP.
(2) NORMAL STEAM RELIEF W/RX TRIP	x	x	° ASSESS DIFFERENCES AMONG PWRS IN SAFETY MARGINS FOR THIS DISTURBANCE.

ANALYSIS MATRIX: STUDY OF THE SENSITIVITY OF B&W PWRs VS. OTHER PWRs
PRELIMINARY

TRANSIENTS ANALYZED	MODEL	FSAR	PURPOSE
3. SIGNIFICANT DISTURBANCES, WITH CORRECTIVE ACTION			
B. TURBINE TRIP (CONTINUED)			
(3) STEAM RELIEF SYSTEM MALFUNCTIONS	x		° EVALUATE SUSCEPTABILITY OF PWRs TO OVERCOOLING ON STEAM RELIEF CONTROL MALFUNCTION.
C. LOSS OF ONE FEED PUMP	x		° ASSESS DIFFERENCES AMONG PWRs IN SAFETY MARGINS FOR THIS DISTURBANCE. ° EVALUATE CAPABILITY OF PWRs TO WITHSTAND THIS DISTURBANCE WITHOUT TRIP.
D. LOSS OF ALL FEED PUMPS			
RX TRIP			
(1) NORMAL EMERGENCY FEED	x	x	° "CALIBRATE" MODEL FOR SAFETY MARGIN ESTIMATION FOR DISTURBANCES OF THIS TYPE.
(2) DELAYED EMERGENCY FEED	x		° ASSESS DIFFERENCES AMONG PWRs IN SAFETY MARGINS FOR THIS DISTURBANCE.
(3) NO EMERGENCY FEED, BLEED-AND-FEED DECAY HEAT REMOVAL	OTHER ANALYSES VERIFIED FOR THE PURPOSE		° ASSESS DIFFERENCES AMONG PWRs IN SAFETY MARGINS FOR THIS DISTURBANCE.
(4) EXCESSIVE EMERGENCY FEED	x		° ASSESS DIFFERENCES AMONG PWRs IN SAFETY MARGINS FOR THIS DISTURBANCE. ° EVALUATE SUSCEPTABILITY OF PWRs TO OVERCOOLING ON THIS DISTURBANCE.

ANALYSIS MATRIX: STUDY OF THE SENSITIVITY OF B&W PWRs VS. OTHER PWRs
PRELIMINARY

TRANSIENTS ANALYZED	MODEL	FSAR	PURPOSE
3. SIGNIFICANT DISTURBANCES, WITH CORRECTIVE ACTION (CONTINUED)			
E. CONTROL SYSTEM UPSETS			
ICS POWER FAILURES* WITH			
(1) VARYING FEED SYSTEM INITIAL CONDITIONS	X		° ASSESS DIFFERENCES AMONG PWRs IN SAFETY MARGINS FOR THIS DISTURBANCE. ° EVALUATE SUSCEPTABILITY OF PWRs TO OVERCOOLING ON THIS DISTURBANCE.
(2) VARYING FEED SYSTEM CONFIGURATIONS	X		
F. LOSSES OF COOLANT FLOW			
(1) LOSS OF ONE PUMP	X		° ASSESS DIFFERENCES AMONG PWRs IN SAFETY MARGINS FOR THIS DISTURBANCE. ° EVALUATE CAPABILITY OF PWRs TO WITHSTAND THIS DISTURBANCE WITHOUT TRIP.
(2) LOSS OF ALL PUMPS	X	X	° ASSESS DIFFERENCES AMONG PWRs IN SAFETY MARGINS FOR THIS DISTURBANCE. ° "CALIBRATE" MODEL DYNAMICS FOR DISTURBANCES OF THIS TYPE. ° ASSESS DIFFERENCES AMONG PWRs IN SAFETY MARGINS FOR THIS DISTURBANCE.

* FOR PLANTS OTHER THAN B&W, PLAUSIBLE POWER SUPPLY FAILURES WILL BE EVALUATED ON AN AD HOC BASIS.

ANALYSIS MATRIX: STUDY OF THE SENSITIVITY OF B&W PWRs VS. OTHER PWRs
PRELIMINARY

TRANSIENTS ANALYZED	MODEL	FSAR	PURPOSE
G. LOSSES OF COOLANT SPECTRUM OF BREAK SIZES		x**	ASSESS DIFFERENCES AMONG PWRs IN SAFETY MARGINS FOR THIS DISTURBANCE.
4. CONTROL SYSTEM ANALYSES AND OPERATIONAL BURDEN			
A. RX TRIP WITH AND WITHOUT			
(1) SECURING STEAM LOADS	x		° ASSESS DIFFERENCES AMONG PWRs IN OPERATOR BURDEN FOR A RELATIVELY FREQUENT UPSET.
(2) INCREASING MAKEUP	x		
B. OPERATOR MANUAL CONTROL REQUIREMENTS IN RESPONDING TO SELECTED FAILURES OF AUTOMATIC CONTROL LOOPS	x		° ASSESS DIFFERENCES AMONG PWRs IN BACKING UP AUTOMATIC CONTROLS.
5. VERIFICATION ANALYSES			
A. B&W UNIT RESPONSES			° COMPARE MODEL PREDICTIONS AGAINST ACTUAL PLANT RESPONSES FOR SELECTED TRANSIENTS.
(1) TURBINE TRIP WITH RX TRIP	x		
(2) LOSS OF ONE FEED PUMP	x		
(3) TURBINE TRIP WITHOUT RX TRIP	x		
(4) LOSS OF ALL MAIN FEED PUMPS	x		
DELAYED EMERGENCY FEED	x		

** OTHER ANALYSES AND TEST DATA WILL BE USED IN THIS EVALUATION, AS APPROPRIATE.

ANALYSIS MATRIX: STUDY OF THE SENSITIVITY OF B&W PWRs VS. OTHER PWRs

PRELIMINARY

TRANSIENTS ANALYZED	MODEL	FSAR	PURPOSE
B. CE UNIT RESPONSES			
(1) LOSS OF ALL MAIN FEED PUMPS	X		
C. W UNIT RESPONSES			
(1) PARTIAL LOAD REJECTION	X		
(2) TURBINE TRIP WITH Rx TRIP	X		
(3) PARTIAL LOSS OF FEEDWATER	X		

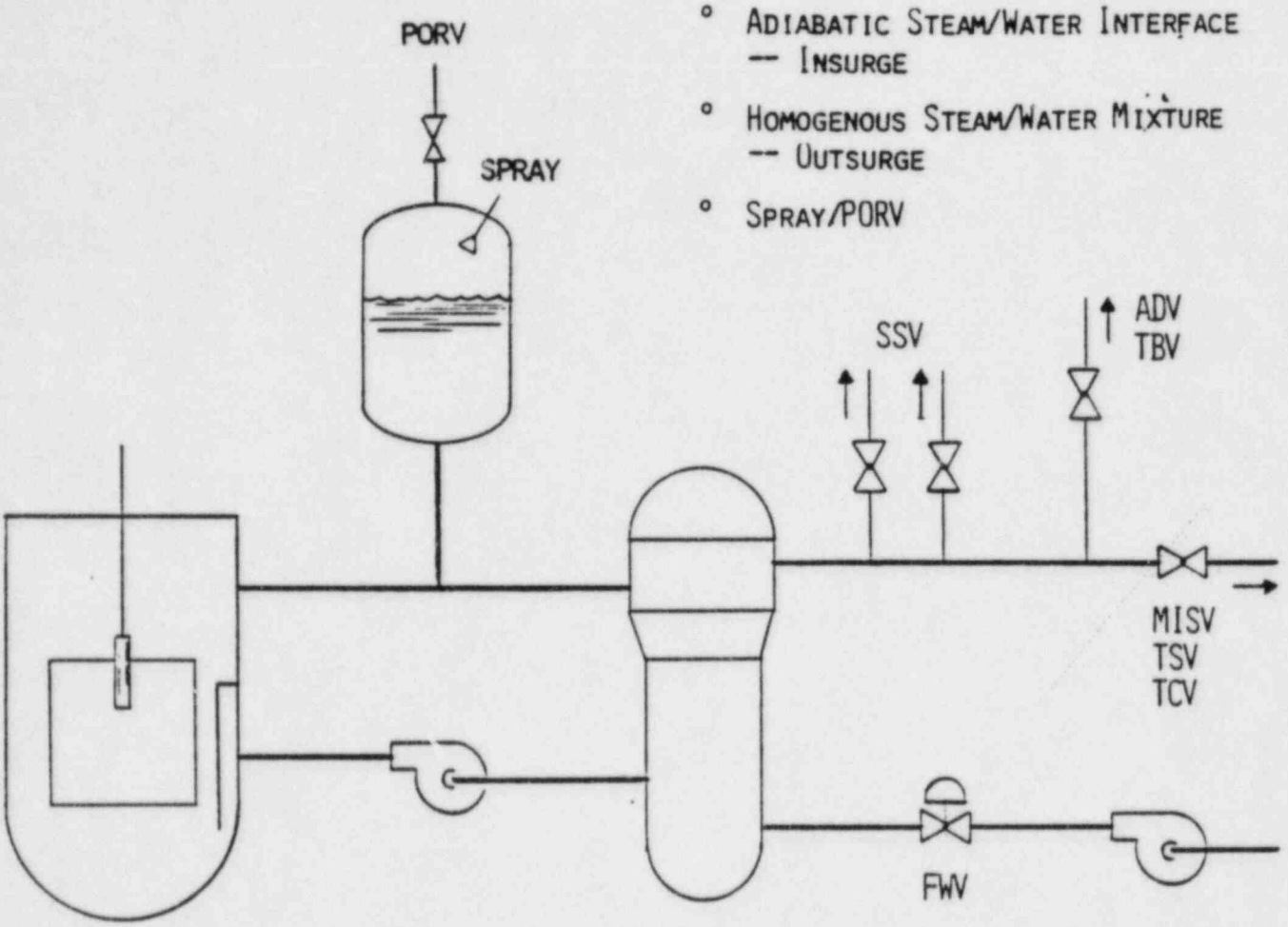
APPROACH TO VERIFICATION OF MODELS

- ADD COMPLEXITY AS REQUIRED
  - BOUNDARY CONDITIONS
  - CONTROLS AND PROTECTION DETAILS
  - MODELING SUPHISTICATION

OVERALL PLANT

PZR

- ADIABATIC STEAM/WATER INTERFACE -- INSURGE
- HOMOGENOUS STEAM/WATER MIXTURE -- OUTSURGE
- SPRAY/PORV



RX

- 1 GROUP KINETICS, $L^* = 0$
- DOPPLER COEFFICIENT
- MODERATOR COEFFICIENT
- 1 LUMP FUEL ENERGY STORAGE
- SINGLE NODE FUEL /COOLANT HEAT TRANSFER

LOOPS

- HOT LEG ENERGY STORAGE
- COLD LEG ENERGY STORAGE
- PROGRAMMABLE FLOW

SG

- 1 EQUIVALENT SG
- 1 "DUMMY" FOR ASYMMETRIC FLOW

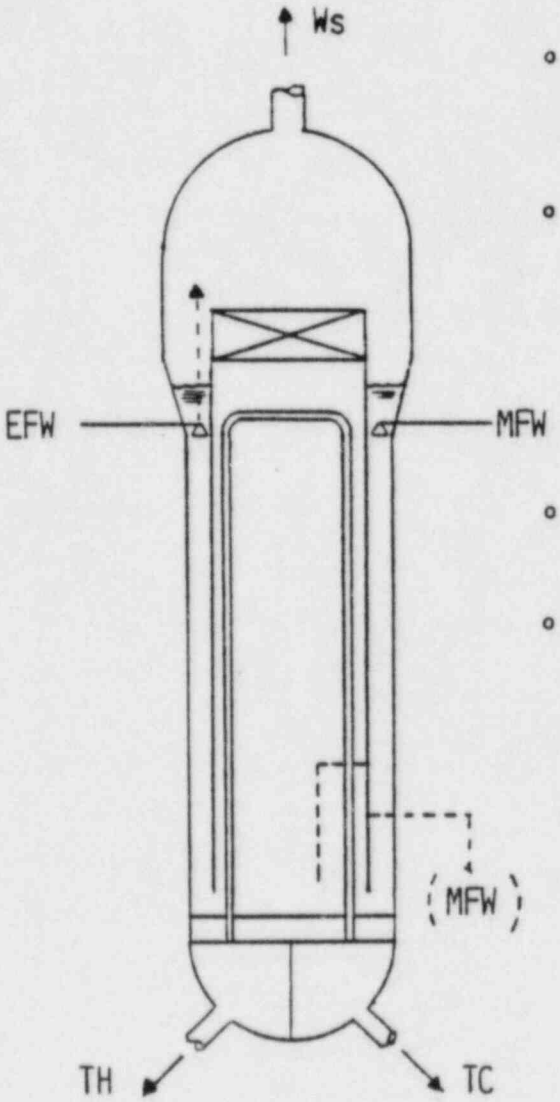
FP

- 1, 2 PUMPS
- VARIABLE SP

MODELING APPROACH

UTSG

- Negligible Change in Vapor Phase Mass Storage
- 100% Effective Separator



- Thermal Equilibrium Between Vapor and Liquid Phases
- Programmed Riser Flow with Steaming Rate
  - Can Implement Dynamic Momentum Balance
- Dynamically Constrained Downcomer Flow
- 1 Lump Dynamic Energy Balance Around Each of Following:
  - Drum
  - Downcomer Upper
  - Downcomer Lower

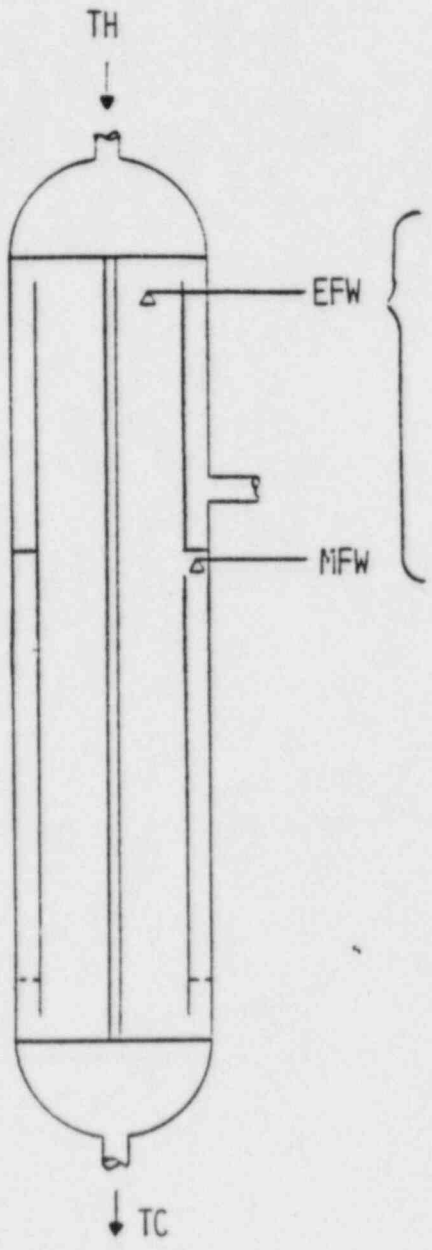
- Constant Heat Addition Rate in Tube Bundle Region
- Equal Steam and Liquid Phase Velocities

- 1 Lump Dynamic Energy Balance Primary Heat Transfer to Tube Bundle Fluid

MODELING APPROACH

OTSG

- 1 Lump Dynamic Energy Balance Around SH Region
- Rate of Change of Vapor Mass Negligible in Mass Balance Around SH Region



- Evaporative Heat Transfer Over Entire Bundle

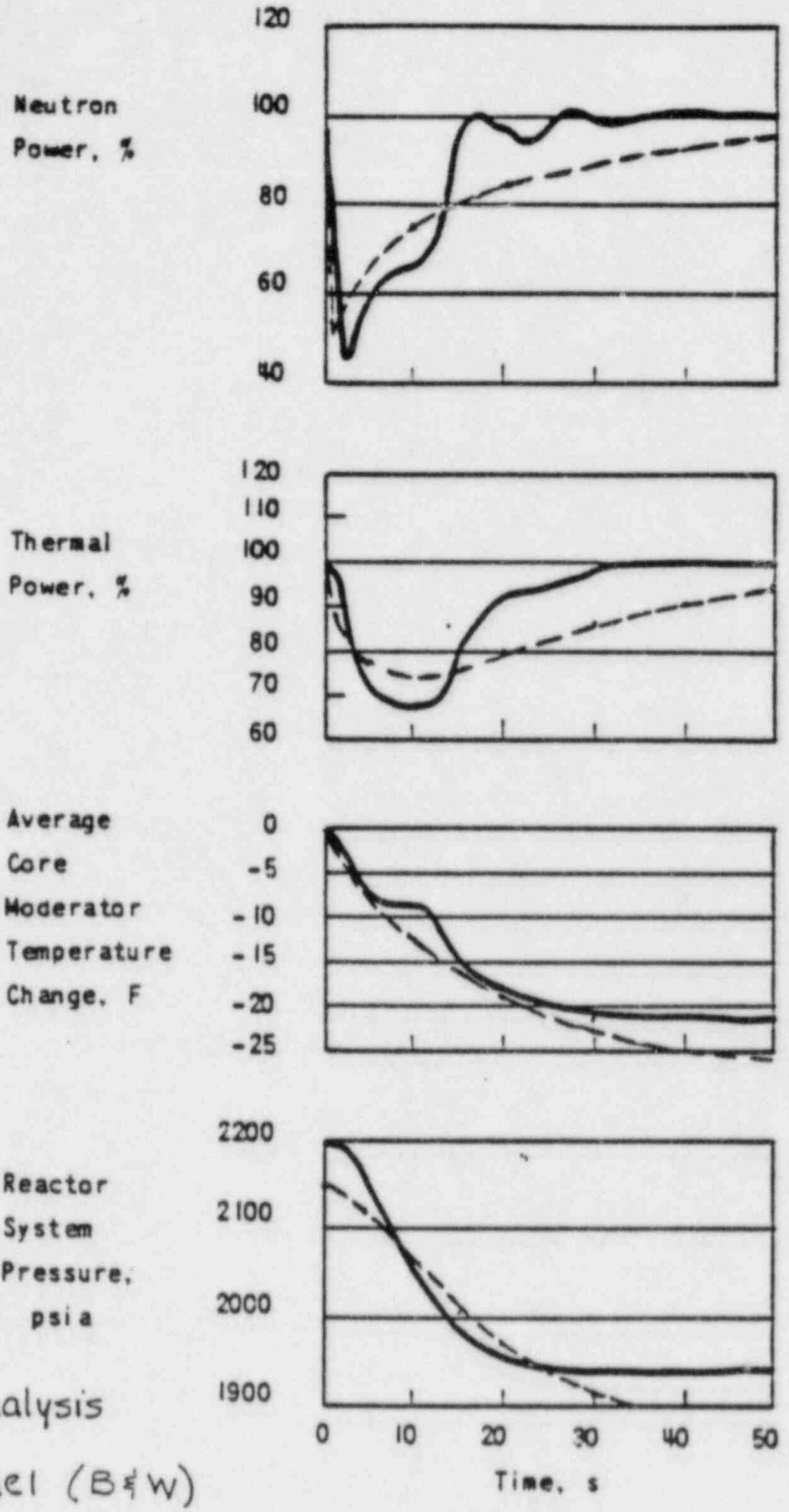
OR

- Evaporative Heat Transfer Over "Submerged" Section Only
- Instantaneous Heat Balance with Aspirating Flow

- Constant Rate of Heat Addition in Boiling Section of Tube Bundle
- Steam and Liquid Phase Velocities Equal
- 1 Lump Dynamic Energy Balance Around Downcomer and Boiling Section

- Downcomer Flow Dynamically Constrained By Momentum Balance Considering
  - Head of Fluid in Tube Bundle
  - Head of Fluid in Downcomer
  - 1 Lump Boiling Region Pressure Loss
  - 1 Lump Downcomer Pressure Loss (Orifice Plate)

MODELING APPROACH



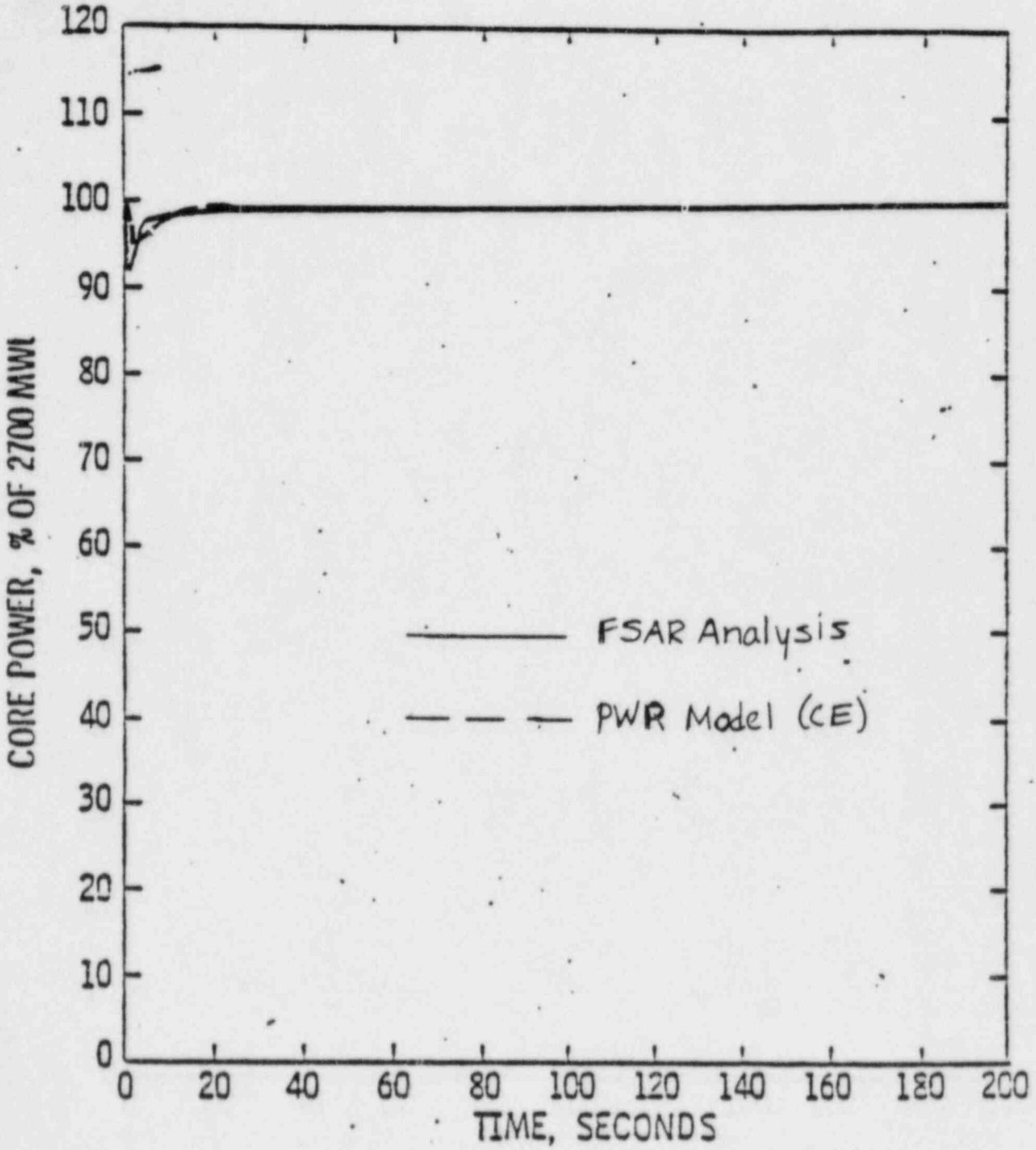
KEY:

——— FSAR Analysis

– – – – PWR Model (B&W)

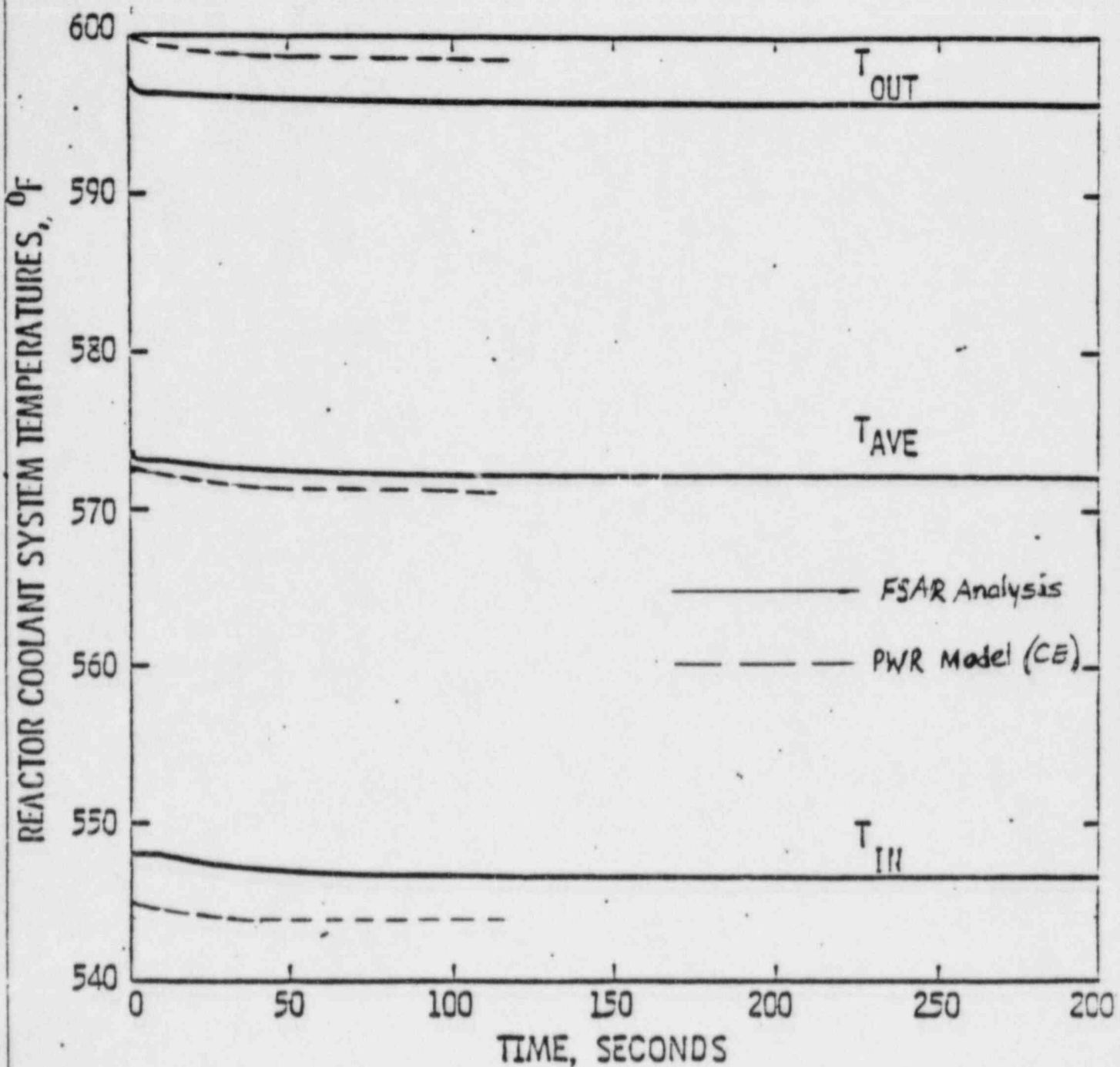
B&W PWR

0.65% Δk/k CRA DROP FROM RATED POWER AT EOL CONDITION



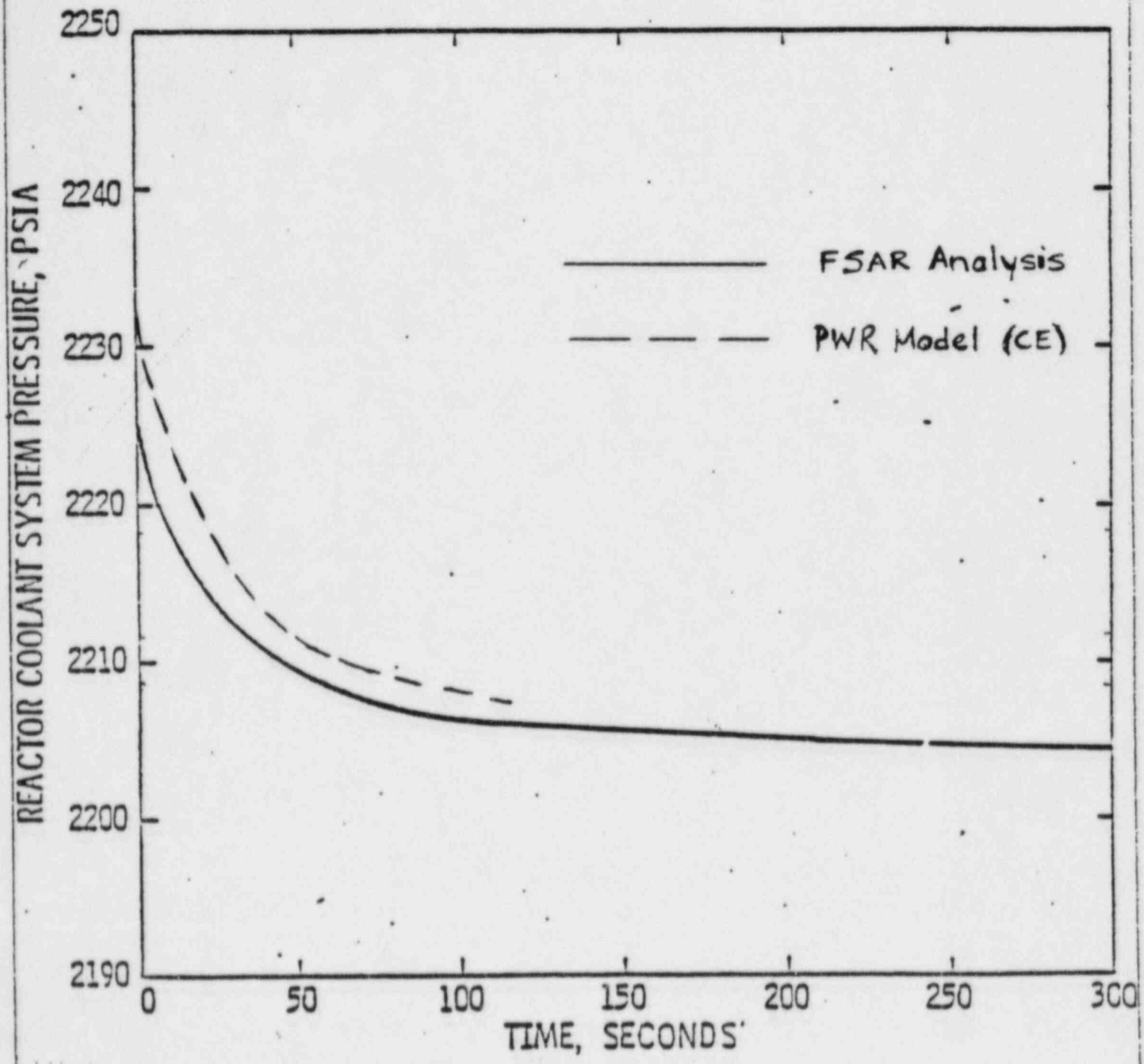
CE PWR - 0.04% $\Delta k/k$ CEA

FULL LENGTH CEA DROP
CORE POWER VS TIME



CE PWR - 0.04 % $\Delta k/k$ CEA

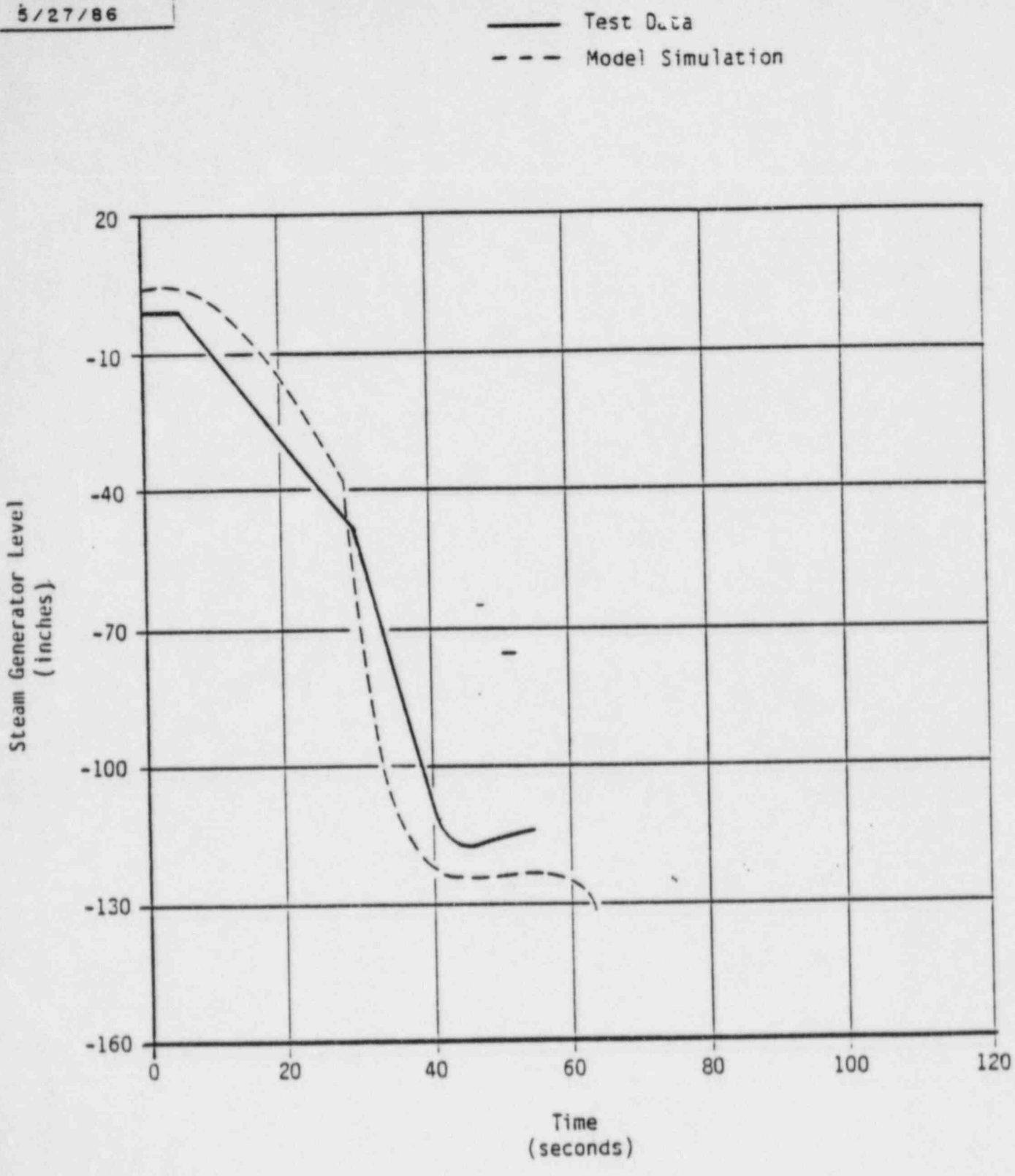
FULL LENGTH CEA DROP
REACTOR COOLANT SYSTEM TEMPERATURES VS TIME



CE PWR - 0.04% Δk/k CEA

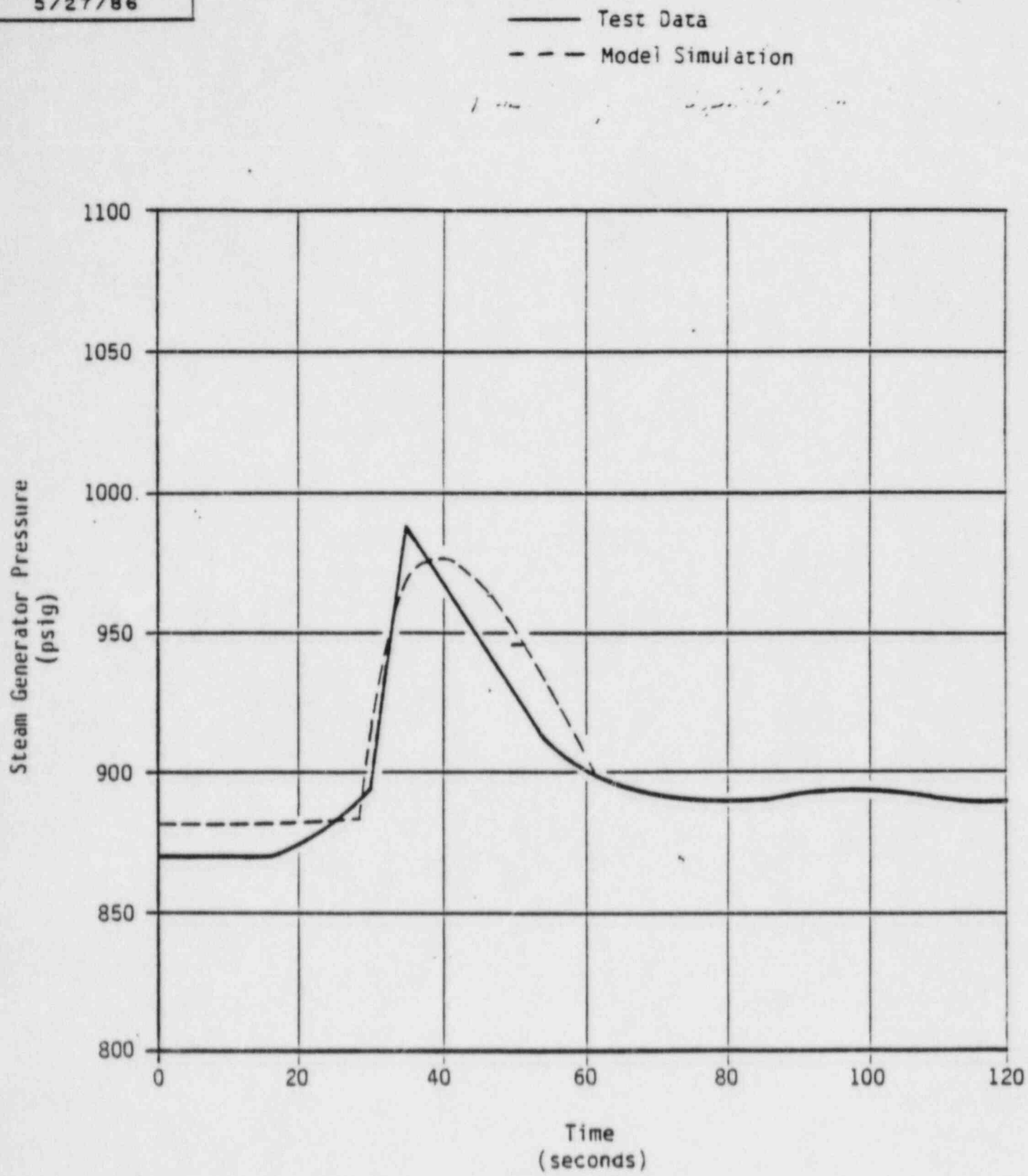
FULL LENGTH CEA DROP
REACTOR COOLANT SYSTEM PRESSURE VS TIME

F-62-27-1
5/27/86



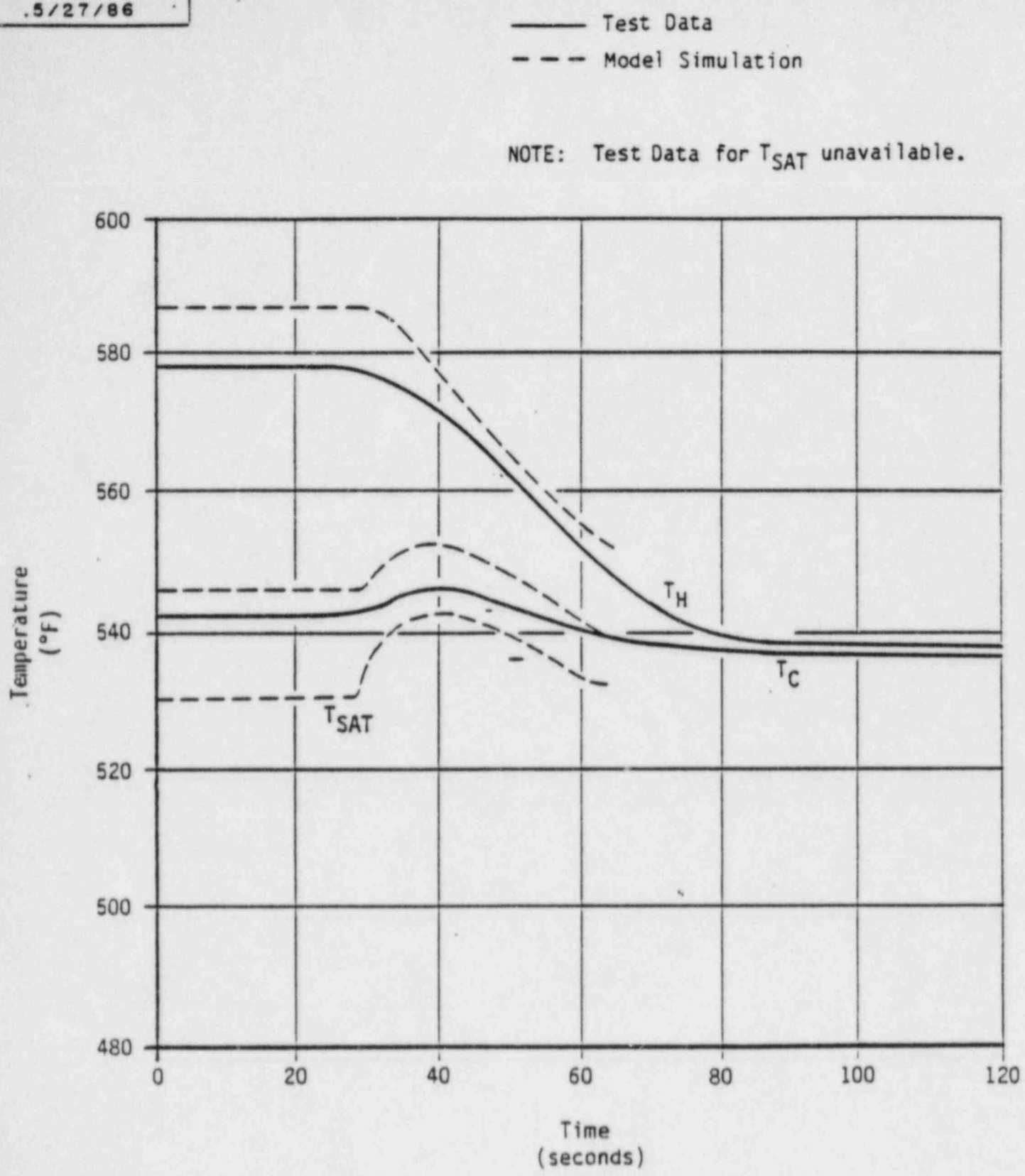
CE PWR MODEL
VERIFICATION RUN
FEED PUMP/REACTOR/TURBINE TRIP - 73% POWER

MPR ASSOCIATES
F-62-27-2
5/27/86



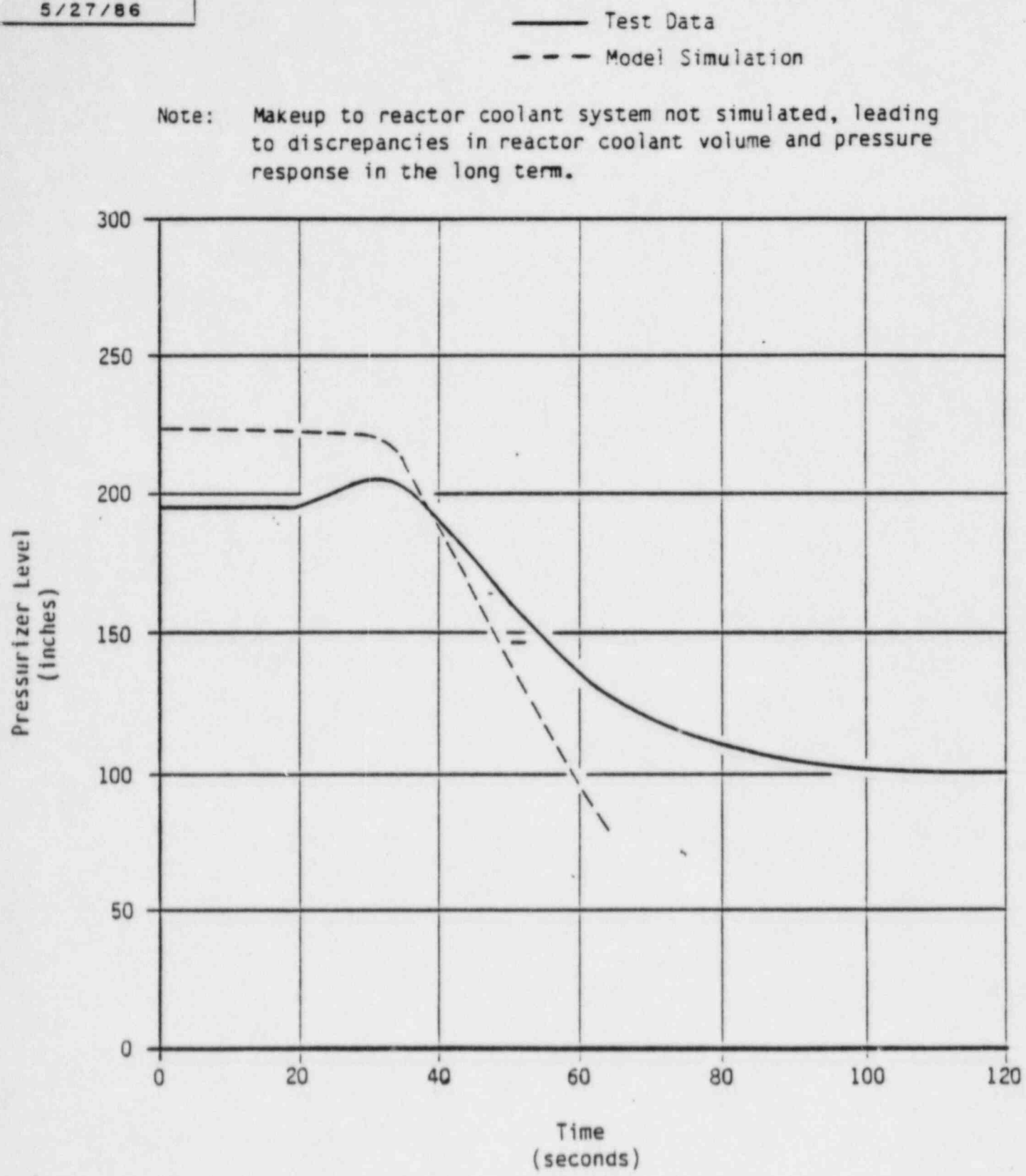
CE PWR MODEL
VERIFICATION RUN
FEED PUMP/REACTOR/TURBINE TRIP - 73% POWER

F-62-27-3
.5/27/86



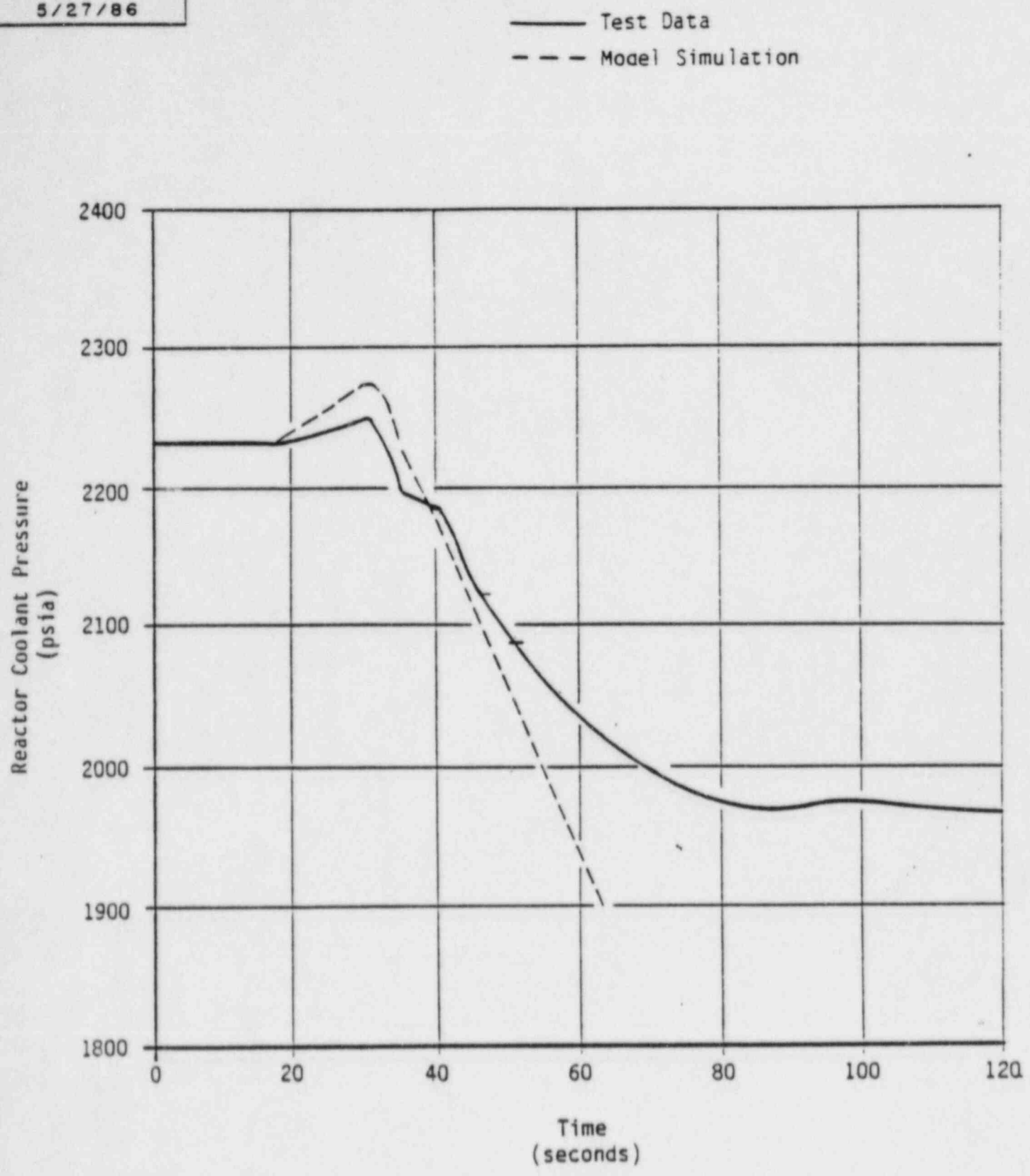
CE PWR MODEL
VERIFICATION RUN
FEED PUMP/REACTOR/TURBINE TRIP - 73% POWER

MPR ASSOCIATES
F-62-27-4
5/27/86

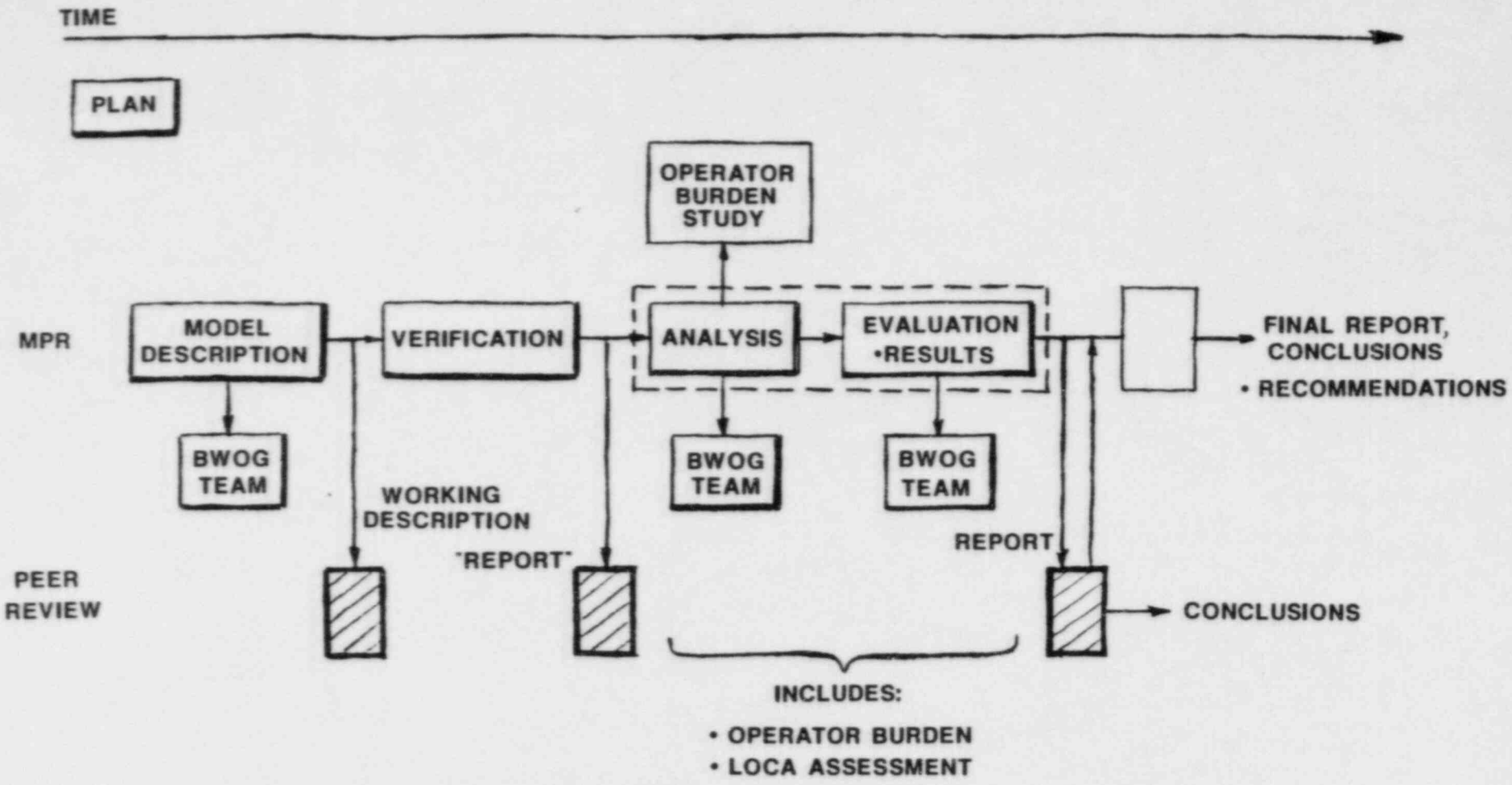


CE PWR MODEL
VERIFICATION RUN
FEED PUMP/REACTOR/TURBINE TRIP - 73% POWER

MPR ASSOCIATES
F-62-27-5
5/27/86



CE PWR MODEL
VERIFICATION RUN
FEED PUMP/REACTOR/TURBINE TRIP - 73% POWER


TIME
PLAN
OPERATOR BURDEN STUDY
MPR
MODEL DESCRIPTION
VERIFICATION
ANALYSIS
EVALUATION •RESULTS
FINAL REPORT, CONCLUSIONS
• RECOMMENDATIONS
BWOG TEAM
BWOG TEAM
BWOG TEAM
WORKING DESCRIPTION
"REPORT"
REPORT
PEER REVIEW
CONCLUSIONS
INCLUDES:
• OPERATOR BURDEN
• LOCA ASSESSMENT