Docket file

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

February 16, 1994

Docket No. 50-443

LICENSEE: North Atlantic Energy Service Corporation, et. al.

FACILITY: Seabrook Station, Unit 1

SUBJECT: APPLICATION OF YAEC-1856P METHODOLOGY TO THE SEABROOK STATION

On December 21, 1993, the staff held a meeting with representatives of North Atlantic Energy Service Corporation (North Atlantic), Yankee Atomic Electric Company (YAEC), and International Technical Services (ITS). YAEC is providing consulting services to North Atlantic and ITS is a consultant to the NRC staff. The meeting was requested by the staff to discuss the additional information required to complete the review of the topical report YAEC-1856P, the "Systems Transient Methodology Using RETRAN for PWR Applications". A copy of the discussion material is included as Enclosure 1. Enclosure 2 is a list of meeting attendees.

The YAEC-1856P topical incorporates and summarizes all the systems methodologies used by Yankee for Maine Yankee, Vermont Yankee, Yankee Rowe and Seabrook. Several RETRAN versions were used in previous analyses, in addition, the GEMINI code was also used for certain non-LOCA transients. Previous topical reports received NRC approval but covered only part of the transients applied for in YAEC-1856P. The new RETRAN applications include those using GEMINI and loss of flow and feedwater line break.

The information submitted in YAEC-1856P did not include specific RETRAN runs and justification with plant specific data, UFSAR comparisons for all of the plants, the transients, or the nodalizations for which approval is sought. Instead, RETRAN performance was surmised from comparisons of GEMINI or previous RETRAN versions. The staff made it clear that topical report approval requires that all transients for all plants for which approval is requested are justified with plant data and the UFSAR transients.

Due to the compressed schedule for this review and the schedular requirements for the next Seabrook reload, it was decided to proceed with a modified review that would be limited to the Seabrook Station and would be completed by the end of March 1994. Applicability for other plants would be a separate

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review. Later, when plant specific information for Maine Yankee and Vermont Yankee is submitted, the report applicability will be extended to these plants as well.

Original signed by:

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Office of Nuclear Reactor Regulation

Enclosure:
1. Discussion Materials
2. List of Attendees

cc w/enclosures 1 & 2:
See next page

Distribution w/enclosures 1 & 2:
Docket File
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PDI-4 Memo
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TMurley/FMiraglia
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See next page

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ENCLOSURE 1

Proprietary material has been deleted from this enclosure at the locations so indicated

RESPONSE TO RAI FOR YAEC-1856P

• 1, 14	RETRAN Approvals	P.A. Bergeron
• 2, 3, 5, 6, 8, 10	Transient-by-Transient Discussion	A. E. Ladieu
• 11, 12, 13	Plant Data Comparisons	All
• 4, 15	Geometry and Boron Transport Model	All
• 7, 9	FSAR Application YAEC-1871	All

OVERVIEW OF YAEC LICENSING HISTORY

RETRAN

	PLANT	TRANSIENT	SCOPE	VERSION	SUBMITTAL	NRC APPROVAL
1981	Maine Yankee	MSLB	Reload	01 MOD 3	Ref. 9	Ref. 11
1981	Vermont Yankee	BWR reload transients	Reload	15F	YAEC-1233	NRC SER Nov. 1981
1983	Yankee Rowe	MSLB	Reload	02 MOD 2	Ref. 8	Ref. 10
1984-85	Maine Yankee	MSLB	Reload	02 MOD 2	YAEC-1447	NRC SER Oct. 1985
1989	Vermont Yankee	BWR transients 1-D kinetics	Generic	02 MOD 04	Ref. 12	Ref. 13
1990-91	Maine Yankee	MSLB/rod ejection	Generic	02 MOD 05 STAR/CHIC-KIN	Ref. 15	Ref. 14
1991	Seabrook	SGTR	Address licensing issue	02 MOD 02	Ref. 16	--
1992	Seabrook	Loss of Load	Safety valve	02 MOD 05	Ref. 17	Ref. 18

RETRAN VERSION	ADDED FEATURES
02 MOD 02	
02 MOD 03	error correction to MOD 02
02 MOD 04	multi-control rod, heat conductors in NEQ volumes
02 MOD 05	general transport, 1979 ANS decay heat, reactivity edits for 1-D

YAEC RELOAD ANALYSIS EXPERIENCE

PLANT	CORES	
Yankee Rowe	11 - 22	12
Vermont Yankee	9 - 17	9
Maine Yankee	3 - 14*	12
Seabrook	1 - 3**	3

* including two power uprates
** limited scope; boron dilution

SUMMARY OF YAEC NON-LOCA TRANSIENT

PWR APPROVED APPLICATIONS

TRANSIENT	GEMINI	RETRAN	STAR (RETRAN/CHIC-KIN)
MSLB		X	X
SGTR		⊗	
Rod Ejection			X
Loss of Load	X	X	
Loss of FW	X		
Rod Drop	X	NEW RETRAN APPLICATION	
Rod Withdrawal	X		
Loss of Flow			
Excess Load	X		
Excess Feedwater	X		
FWLB			

YANKEE METHODOLOGY FOR PWR TRANSIENT ANALYSIS USING RETRAN

- Key Features of the Base RETRAN Model in YAEC-1856-P

- Illustration of Application to Specific Non-LOCA Transients

  -- For each transient:

  a) Goal (output) of the RETRAN analysis

  b) Initial conditions

  c) Model changes (if any)

  d) Transient-specific input

  e) Sensitivity studies

- Transient-Specific Illustrations Available in YAEC-1871 (Submitted on the Seabrook Docket)

RETRAN Nodalization

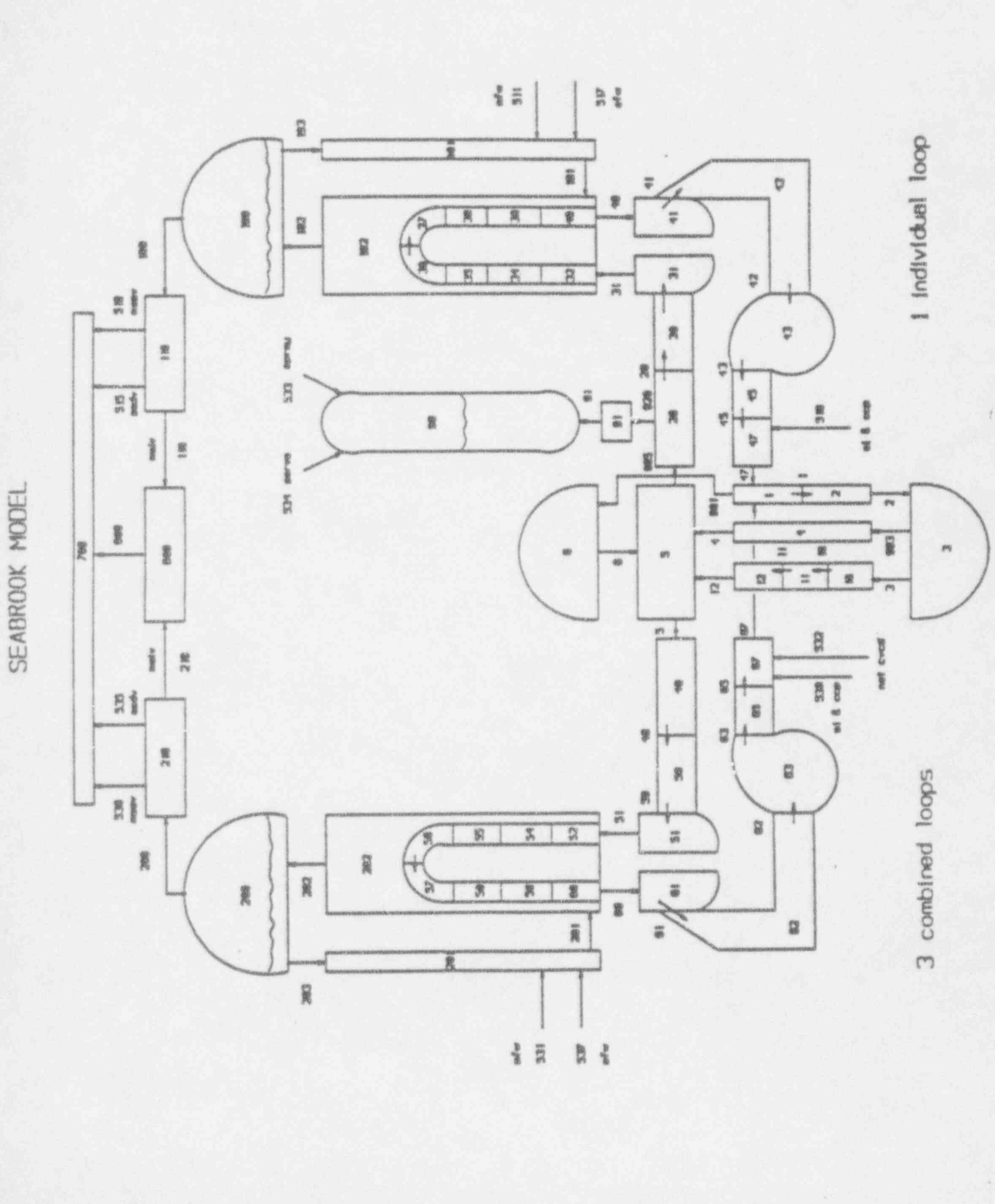


TABLE 5.0-3

TRIP POINTS AND TIME DELAYS TO TRIP ASSUMED IN ACCIDENT ANALYSES

Trip Function	Limiting Trip Point Assumed In Analysis	Time Delays (Seconds)
Power Range High Neutron Flux, High Setting	118%	0.5
Power Range High Neutron Flux, Low Setting	35%	0.5
High Neutron Flux, P-8	50%	0.5
Overtemperature ΔT	Variable	6.0*
Overpower ΔT	Variable	6.0*
High pressurizer pressure	2425 psia	2.0
Low pressurizer pressure	1935 psia	2.0
Low reactor coolant flow (from loop flow detectors)	87% loop flow	1.0
Undervoltage Trip	70% nominal	1.5
Turbine Trip	Not applicable	1.0
Low-low steam generator level	0% of narrow range level span**	2.0
High steam generator level trip of the feedwater pumps and closure of feedwater system valves, and turbine trip	94% of narrow range level span	2.0
Safety Injection Actuation	1665 psia	30.0

* Total time delay (including RTD time response and trip circuit channel electronics delay) from the time the temperature difference in the coolant loops exceeds the trip setpoint until the rods are free to fall.

** Zero percent of the narrow range level span is the limiting trip point based on the feedwater system pipe break analysis. All other analyses assume a trip point corresponding to 10 percent of narrow range span.

LIST OF NON-LOCA TRANSIENTS

- MSLB
- Loss of Feedwater
- Feedwater Line Break
- Turbine Trip

- Dropped Rod
- Bank & Single Rod Withdrawal
- Loss of Flow
- RCP Locked Rotor and Shaft Break
- 10% Step Load Increase
- Feedwater Flow Increase
- Accidental Depressurization

LOSS OF FEEDWATER (Continued)

- Transient-Specific Input:

  -- Maximum EFW delay and limiting single failure (1 out of 2 EFW pumps operate)

  -- Main FW flow is terminated at the start

  -- Pressurizer PORVs, spray, ASDVs, and Steam Dump are disabled

  -- Rods in manual (no response)

  -- Trip on high pressurizer pressure trip disabled (occurs prior to low SG level)

  -- Hot FW must be swept before cold EFW reaches the SGs

- Sensitivity Studies:

  -- Loss of offsite power (both reported in YAEC-1871)

  -- Passive heat conductors; RCS pipe walls, RV walls and internals, SG walls and internals (slightly more limiting results without)

  -- Sensitivity of primary to secondary heat transfer to tube uncovery (local fluid conditions heat transfer option):

    a) No effect on peak RCS and MSS pressures

    b) SG minimum inventory was lower without local conditions heat transfer (difference ≈ 1.5% of initial mass)

FEEDWATER SYSTEM PIPE BREAK

- **Goals:**

  -- Show that the EFW capacity is adequate to:

  a) remove decay heat,

  b) prevent RCS overpressurization

  c) prevent fuel damage (DNB)

  -- Maximum RCS heatup

- **Initial Conditions:**

  -- RCS temperatures, pressure, core power = maximum + uncertainties

  -- Minimum steam volume in pressurizer

  -- Most positive MTC

  -- Faulted SG level = nominal + uncertainty (delays trip & EFW actuation)

  -- Intact SG levels = nominal - uncertainty (maximizes heatup)

- **Model Changes:**

  -- DEG break of FW line at SG. Choked flow (extended Henry & Moody)

  -- SG low level trip setpoint conservatively calculated using minimum SG mass at the low level setpoint (see Loss of FW Flow)

- **Transient-Specific Input:**

  -- Offsite power available (RCP heat addition maximizes heatup)

  -- Pressurizer pressure and level control disabled

  -- Turbine trip at time of break

  -- ASDV's and Steam Dump disabled

FEEDWATER SYSTEM PIPE BREAK (Continued)

- Sensitivity Studies:

  -- Local conditions heat transfer option versus standard heat transfer model in SG boiler region. Peak RCS and MSS pressures not sensitive. Timing of peak RCS pressure affected. (Local conditions model = more limiting)

  -- Limiting single failure in the EFW system (1 of 2 pumps versus a failed-closed branch line control valve to one of the intact steam generators) (1 EFW train is limiting)

  -- Containment backpressure effect on break flow (no sensitivity)

LOSS OF LOAD/TURBINE TRIP

- Goal:

  -- Determine peak RCS and MSS pressures

- Initial Conditions:

  -- RCS temps and core power = maximum + uncertainties

  -- RCS pressure = nominal - uncertainty (delays high pressure trip and maximizes core heat input)

  -- RCS flow = TDF

  -- Most positive MTC

  -- Least negative doppler

- Transient-Specific Input:

  -- EFW, ASDV's, Steam Dump disabled

  -- Main FW flow terminated at time of trip

  -- Rod control system disabled to maximize heat input prior to trip

- Sensitivity Studies:

  -- Comparison to UFSAR show in YAEC-1856P

  -- Initial SG pressure:

    a) Low is conservative for RCS peak pressure
    b) High is conservative for MSS peak pressure

  -- RCS pressure control:

    a) off = maximum RCS pressure
    b) on = maximum MSS pressure

  -- MTC (most positive limiting)

  -- Pressurizer level (no sensitivity from YAEC-1847)

DROPPED RCCA

- **Goal:**
  - -- Calculate Core T&H conditions for DNB analysis during power overshoot

- **Initial Conditions:**
  - -- Nominal RCS temperatures, pressures, and flow (uncertainties in DNBR limit value)
  - -- Core power = variable
  - -- Doppler = least negative
  - -- MTC = variable
  - -- Pressurizer pressure control

- **Model Changes:**
  - -- Turbine inlet junction modeled as negative fill with constant flow (i.e., constant turbine load)

- **Transient-Specific Input:**
  - -- Dropped rod worth (up to full bank)
  - -- Limiting single failure in rod control system causes power overshoot
  - -- Rods in automatic

- **Sensitivity Studies:**
  - -- Dropped rod worth
  - -- MTC
  - -- Doppler (least negative)
  - -- Initial power level (limiting at high powers but affected by ΔI bandwidth)

DROPPED RCCA (Continued)

- Sensitivity Studies (Continued):
  - Rods in manual (rods in automatic)
  - Control bank worth (high worth)
  - Excore nuclear power "tilt" factor (smaller factor conservative)

BANK WITHDRAWAL ANALYSIS

- **Goals:**
  - Plant T&H response for DNB analysis
  - Demonstrate RTS coverage/effectiveness

- **Initial Conditions:**
  - 10%, 70%, 100%
  - Nominal RCS temperature, pressures, & power level

- **Model Changes:**
  - None

- **Transient-Specific Input:**
  - Pressurizer pressure + level controls systems functional (to minimize pressure)
  - Rod control disabled

- **Sensitivity Studies:**
  - Reactivity Insertion Rate (power level dependent)
  - Minimum and maximum reactivity feedback (power level dependent)
  - B_{eff} (weak sensitivity, conservative = large)

SINGLE RCCA WITHDRAWAL

- **Goal:**
  - -- Plant T&H response for DNB analysis

- **Initial Conditions:**
  - -- RCS temperatures, pressure, and core power = nominal
  - -- MTC = most positive
  - -- Doppler = least negative

- **Model Changes:**
  - -- None

- **Transient-Specific Input:**
  - -- Reactivity addition for withdrawal of a single rod at maximum rate
  - -- Control banks frozen

- **Sensitivity Studies:**
  - -- Core power = variable
  - -- Minimum/Maximum feedback (least negative feedback)
  - -- Minimum/Maximum B_{eff} (no sensitivity)
  - -- Pressure + level control operable/disabled (operable more limiting)
  - -- Withdrawn RCCA location (limiting = bank D diagonal)

LOSS OF FLOW

- **Goals:**
  - -- Calculate Core T&H conditions for DNB analysis (need flow coastdown only)
  - -- Flow coastdown shown in YAEC-1856P
  - -- Calculate peak RCS pressure response

- **Initial Conditions:**
  - -- RCS pressure, temperature, core power = maximum + uncertainty
  - -- Most positive MTC
  - -- Least negative Doppler

- **Model Changes:**
  - -- None

- **Transient-Specific Input:**
  - -- RCP's tripped
  - -- Pressure and level control disabled
  - -- ASDVs and Steam Dump disabled
  - -- Main FW flow terminated at time of trip

- **Sensitivity Studies:**
  - -- None

RCP LOCKED ROTOR AND SHAFT BREAK

- **Goals:**
  - -- Plant T&H response
  - -- Peak RCS and MSS pressures
  - -- Normalized core flow to DNB (fuel failure) analysis
  - -- Reactor trip time

- **Initial Conditions:**
  - -- RCS temps, pressure, and core power = maximum + uncertainties
  - -- Most positive MTC
  - -- Least negative Doppler

- **Model Changes:**
  - -- None

- **Transient-Specific Input:**
  - -- Pressurizer PORVs, spray, ASDVs, and Steam Dump disabled
  - -- Main feed flow terminated at time of trip
  - -- Shaft break simulated by forcing pump torque to zero, allowing reserve rotation, and simulating pump impeller inertia only
  - -- Locked rotor simulated by forcing pump speed to zero

RCP LOCKED ROTOR AND SHAFT BREAK (Continued)

- Sensitivity Studies:
  - Looked at Locked Rotor/Shaft Break/LOOP (most conservative = Locked Rotor with LOOP)
  - Looked at normalized coastdown from TDF and Minimum Measure Flow (no difference)
  - Looked at most negative Doppler (least negative Doppler is most limiting)

10% STEP LOAD INCREASE

- Goal:
  - -- Calculate core T&H conditions for DNB analysis
- Initial Conditions:
  - -- RCS temperatures, core power = maximum + uncertainty (conservative)
  - -- RCS pressure = nominal - uncertainty (conservative)
- Model Change:
  - -- Turbine throttle valve junction is changed to a negative fill junction to model 10% step increase in steam flow
- Transient-Specific Input:
  - -- Pressurizer heaters and charging/letdown are disabled (yields minimum pressure)
- Sensitivity Studies:
  - -- Most positive & most negative MTC
  - -- Rods in automatic and manual

FEEDWATER FLOW INCREASE

- **Goals:**
  - -- Calculate plant T&H response
  - -- Verify that reactivity insertion rates are bounded by the RCCA bank withdrawal analysis
  - -- Perform DNBR check

- **Initial Conditions:**
  - -- RCS temperature, core power = maximum + uncertainties (conservative)
  - -- RCS pressure = nominal - uncertainties (conservative)
  - -- MTC = most negative
  - -- Doppler = least negative

- **Model Changes:**
  - -- Split RV model from MSLB analysis (no mixing between affected loop and other loops)
  - -- Split core model from MSLB analysis (with reactivity weighting)

- **Transient-Specific Input:**
  - -- Step increase in FW flow to one SG disabled
  - -- Pressurizer heaters and charging/letdown

- **Sensitivity Studies:**
  - -- HZP & HFP
  - -- With and without reactor trip on turbine trip (turbine trip is from high SG level)

ACCIDENTAL RCS DEPRESSURIZATION

- Goal:
  - -- Calculate Core T&H conditions for DNB analysis
- Initial Conditions:
  - -- RCS temperatures and core power = maximum + uncertainties
  - -- RCS pressure = nominal - uncertainty
  - -- Most positive MTC
  - -- Least negative Doppler
- Model Changes:
  - -- Pressurizer safety valve:
    - a) Single valve stuck open
    - b) Critical flow (extended Henry & Moody)
    - c) Area adjusted to provide rated flow
- Transient-Specific Input:
  - -- Main FW flow terminated at time of trip
  - -- ASDVs, Steam Dump and pressurizer heaters disabled
  - -- Level control disabled
  - -- Rod control system in manual
- Sensitivity Studies:
  - -- None

Figure 4.1.3
Comparison of RETRAN VS Seabrook Data
4 Pumps Coastdown Test

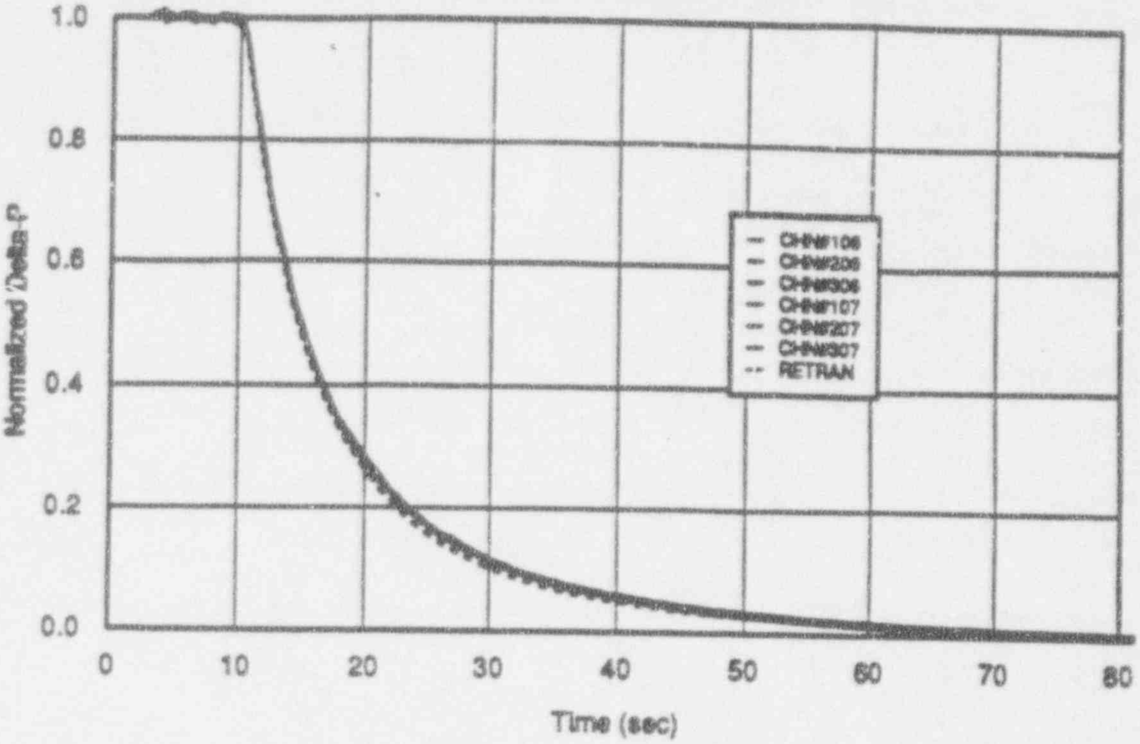
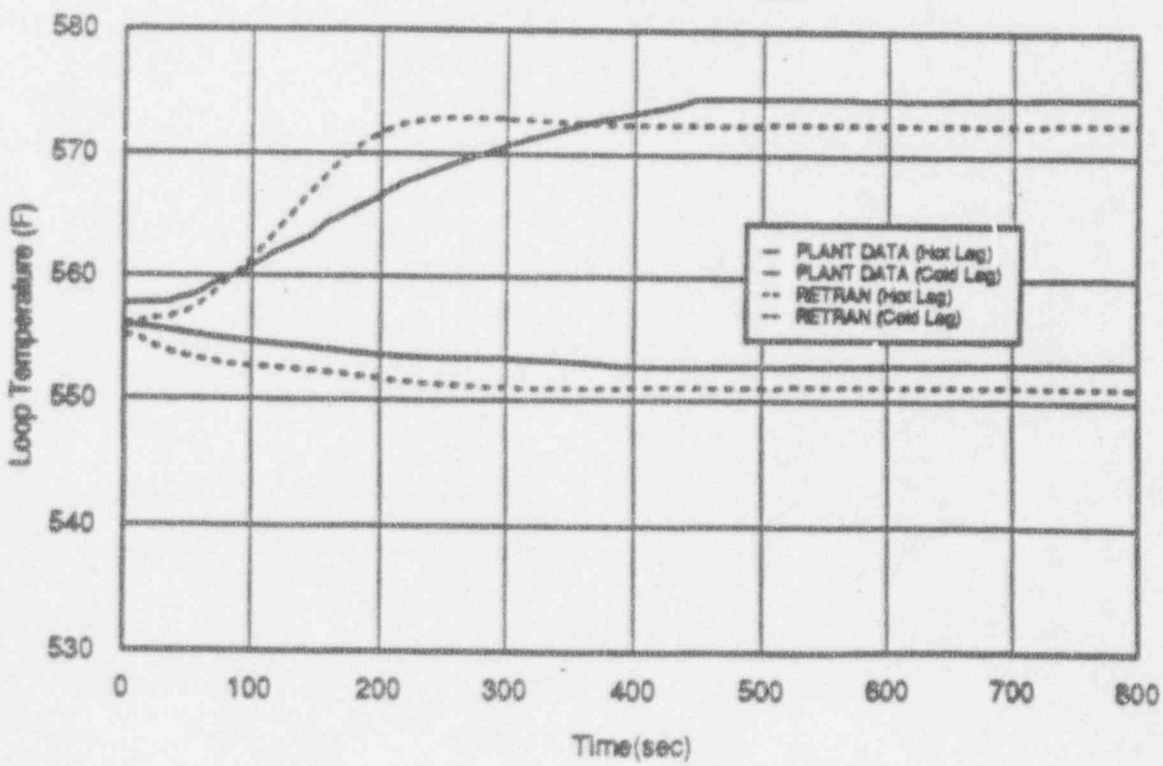


Fig 4.1.4
Comparison of RETRAN VS Seabrook Data
Natural Circulation Test



YR RETRAN SIMULATION

LOSS OF Z-126 HIGH LINE EVENT

(LOSS OF OFF-SITE POWER)

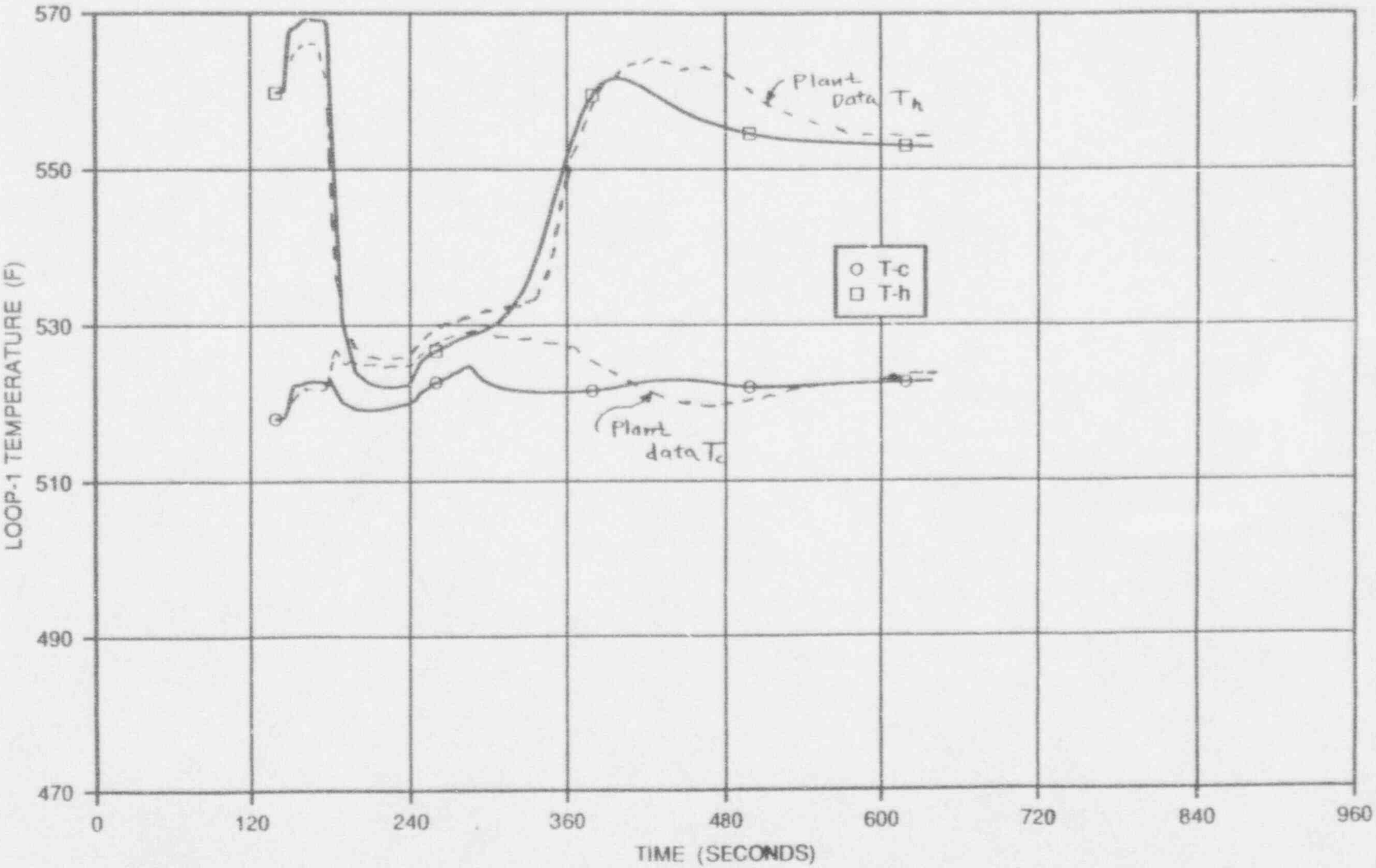


Fig 4.1.5
Comparison of RETRAN VS Maine Yankee Data
Reactor Trip Test

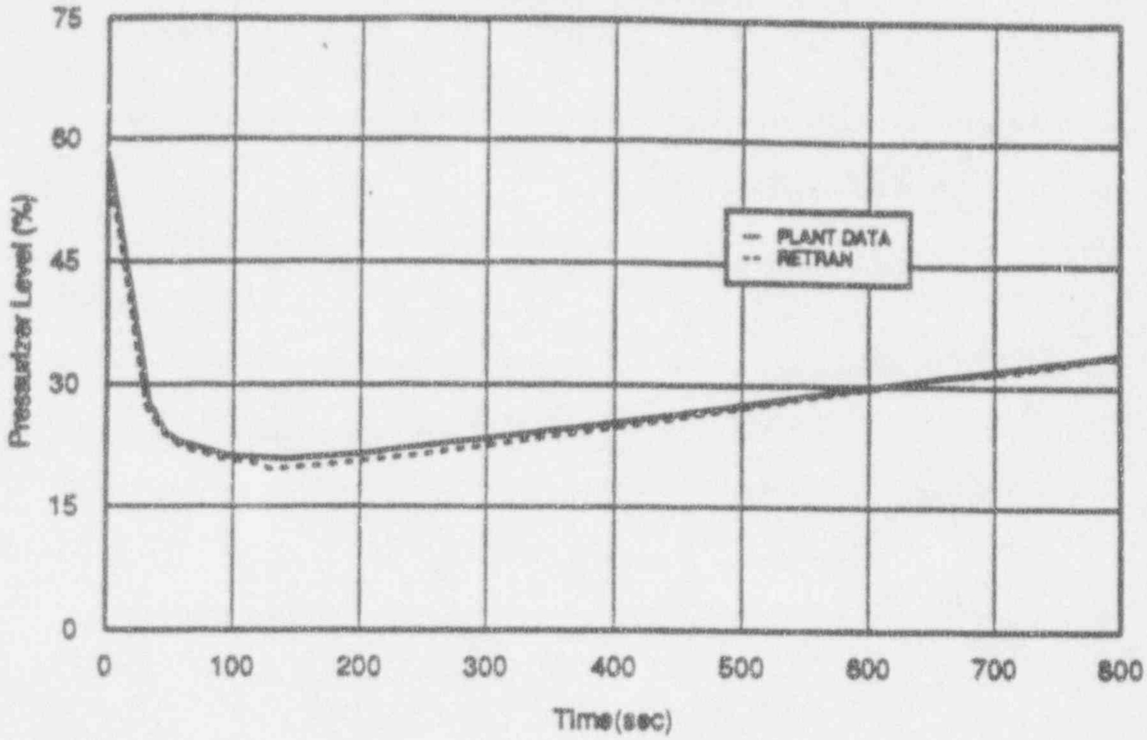


Fig 4.1.6
Comparison of RETRAN VS Main Yankee Data
Reactor Trip Test

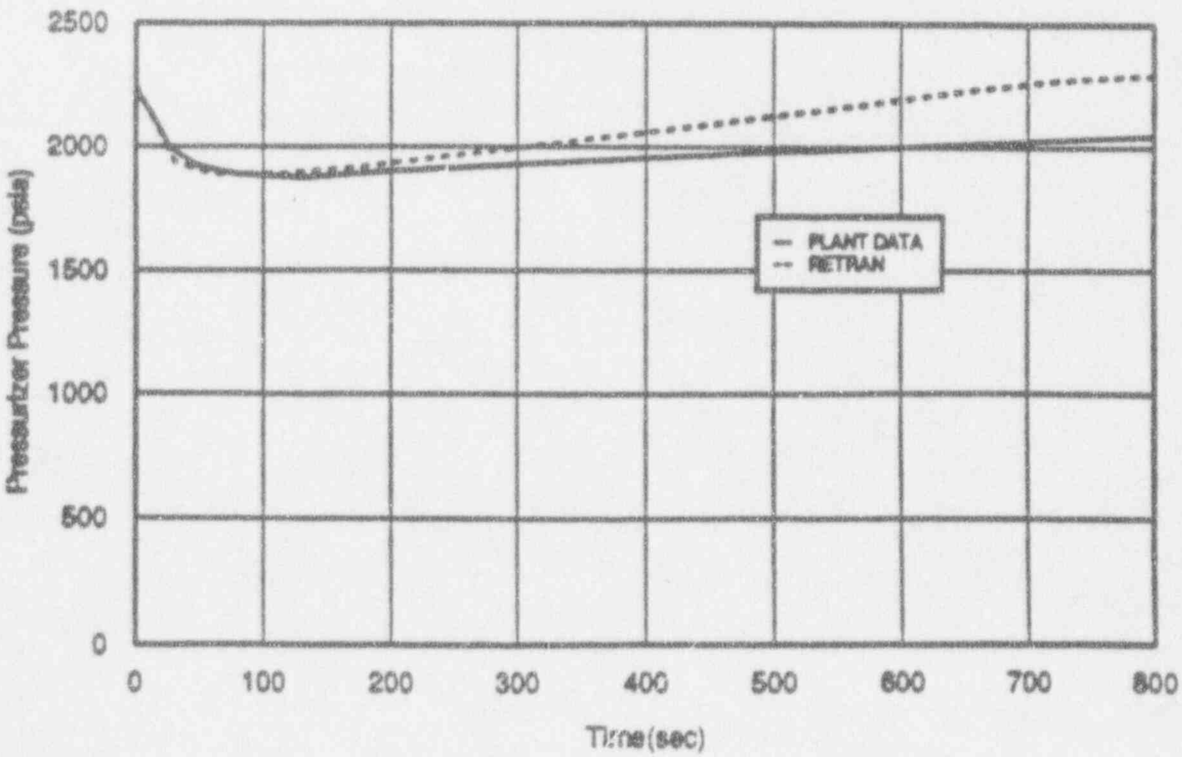


Fig 4.2.1
Results of GEMINI
Pressurizer Model Comparison

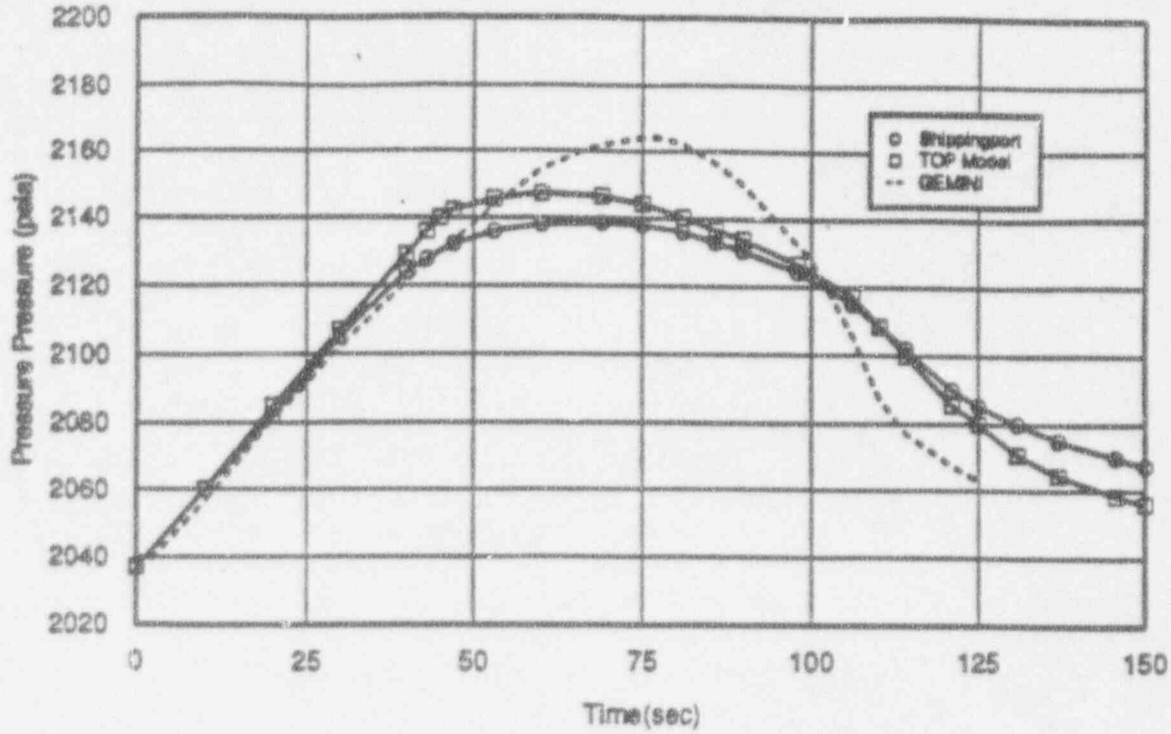
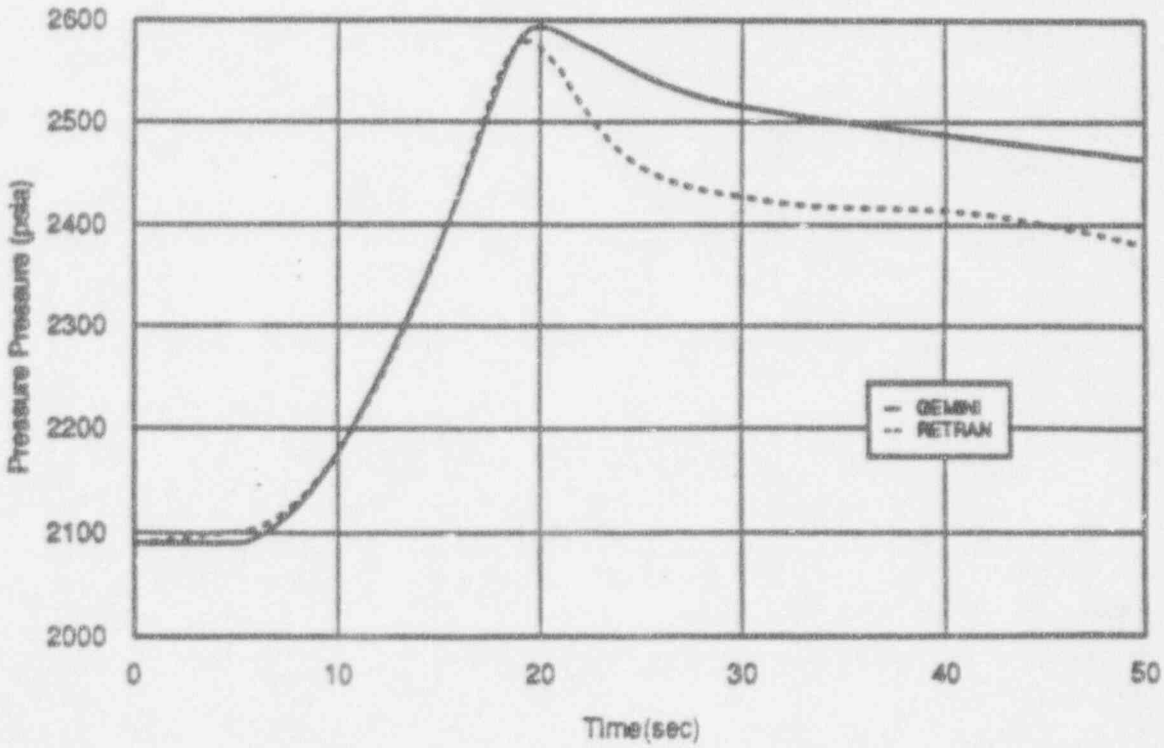
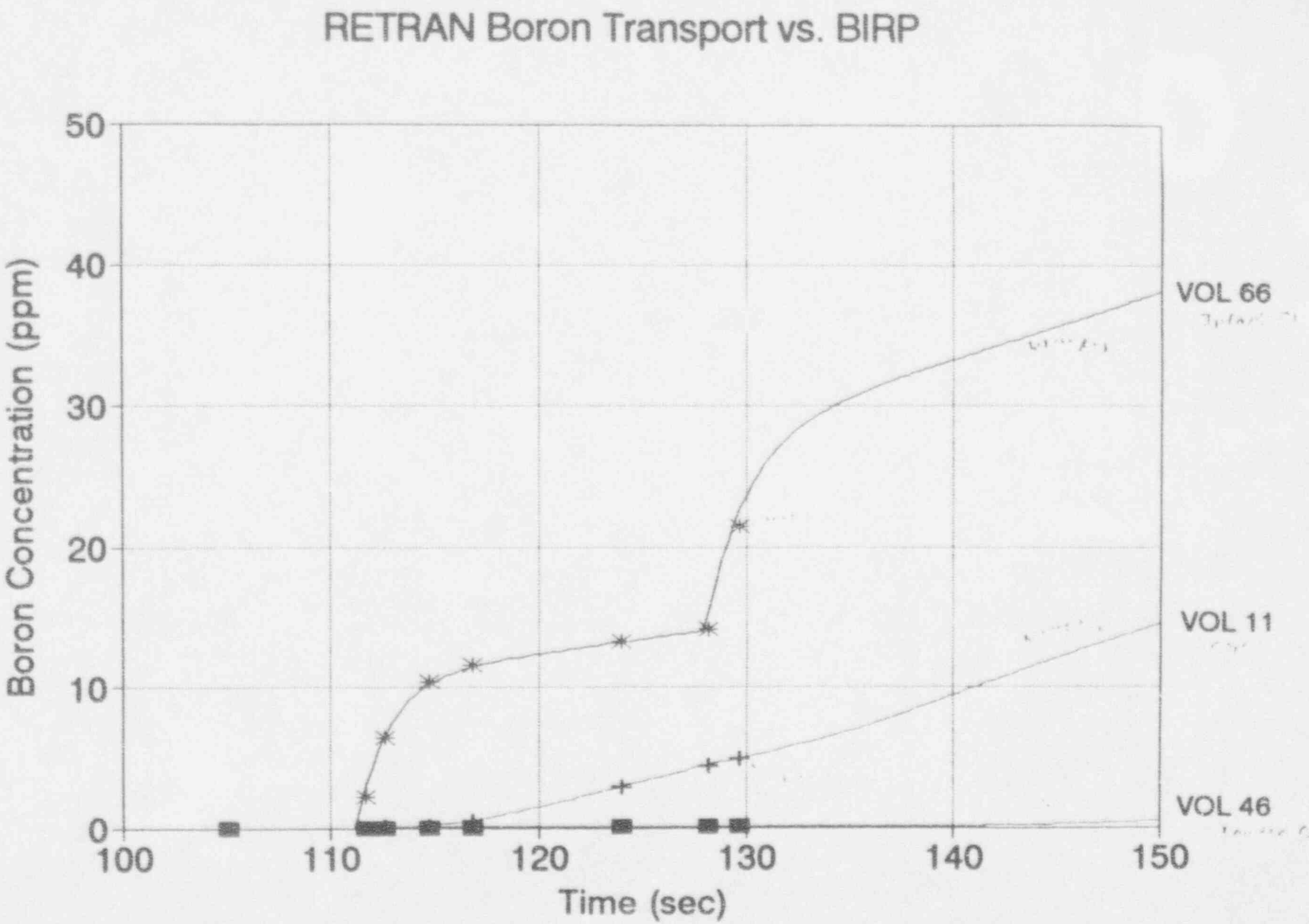


Fig 4.2.2
Comparison of RETRAN VS Yankee Rowe FSAR
GEMINI Loss of Load



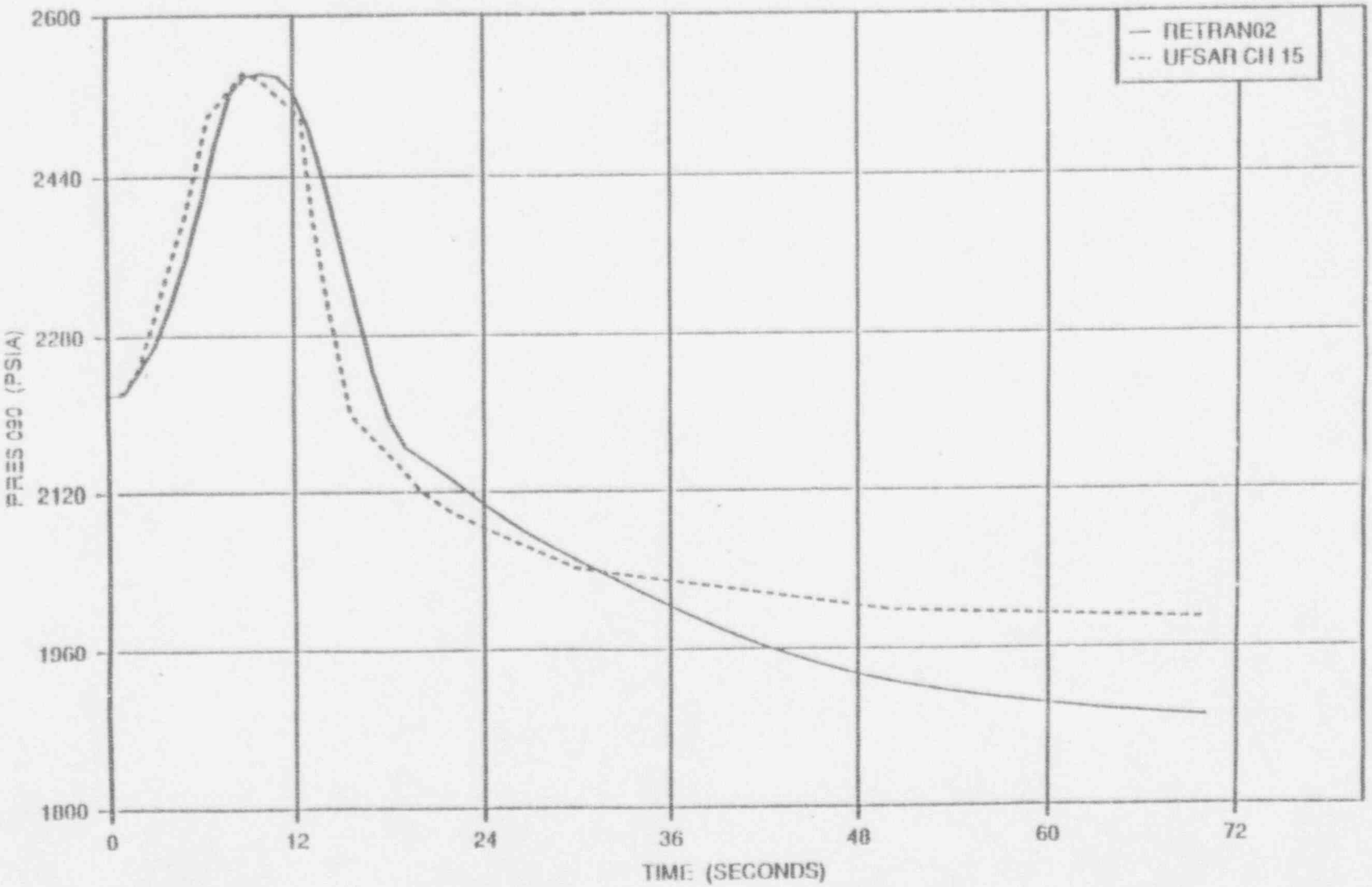


RETRAN Boron Transport vs. BIRP
Boron Concentration (ppm)
Time (sec)
0
10
20
30
40
50
100
110
120
130
140
150
VOL 66
VOL 11
VOL 46

FIGURE 3-2

TURBINE TRIP WITHOUT PRESSURIZER CONTROL, MINIMUM REACTIVITY FEEDBACK

PRESSURIZER PRESSURE VS. TIME - UFSAR BENCHMARK



-6-

FIGURE 3-3

TURBINE TRIP WITHOUT PRESSURIZER CONTROL, MINIMUM REACTIVITY FEEDBACK

NORMALIZED POWER VS. TIME - UFSAR BENCHMARK

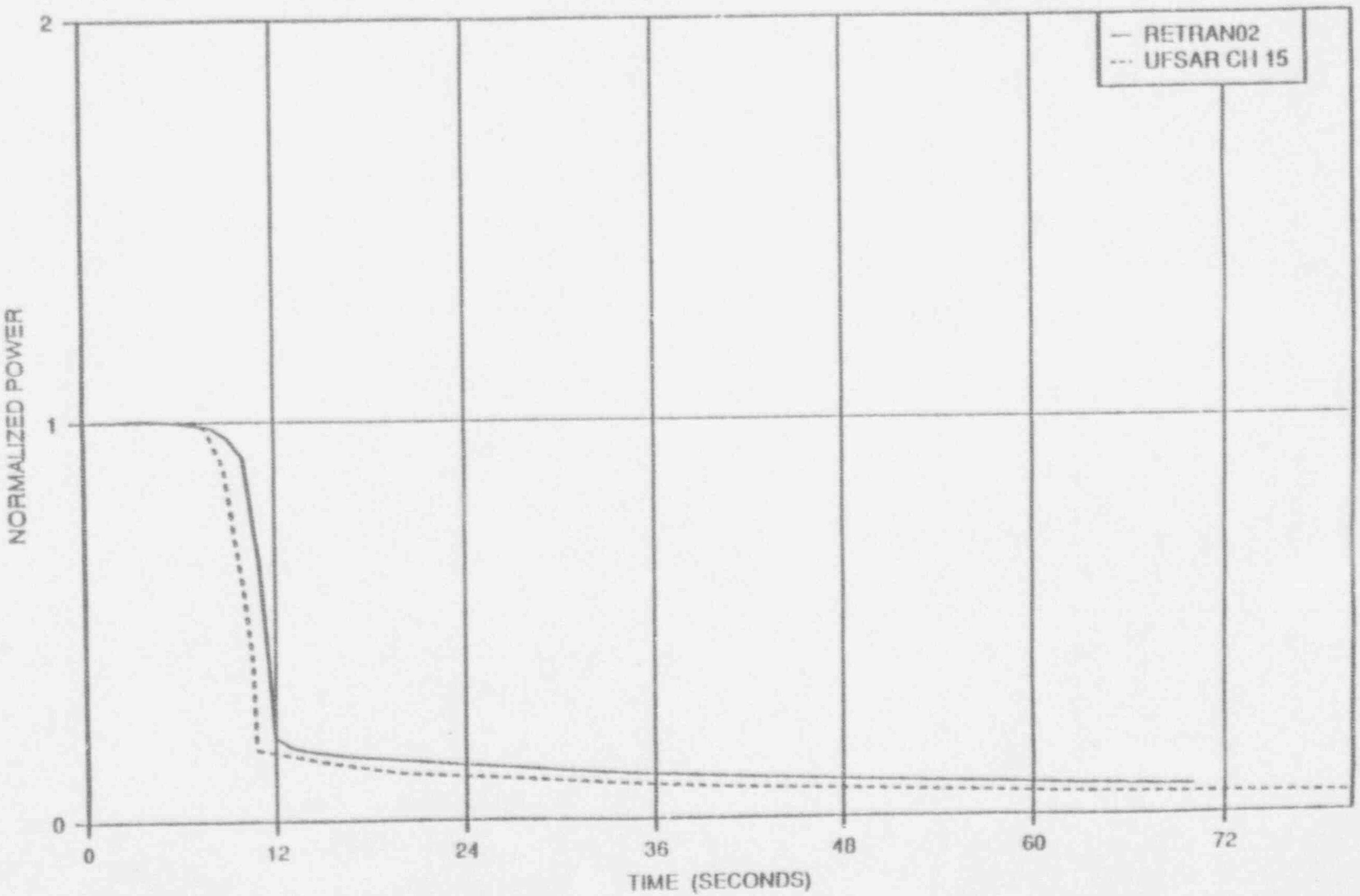


FIGURE 3-4

TURBINE TRIP WITHOUT PRESSURIZER CONTROL, MINIMUM REACTIVITY FEEDBACK

PRESSURIZER LIQUID VOLUME - UFSAR BENCHMARK

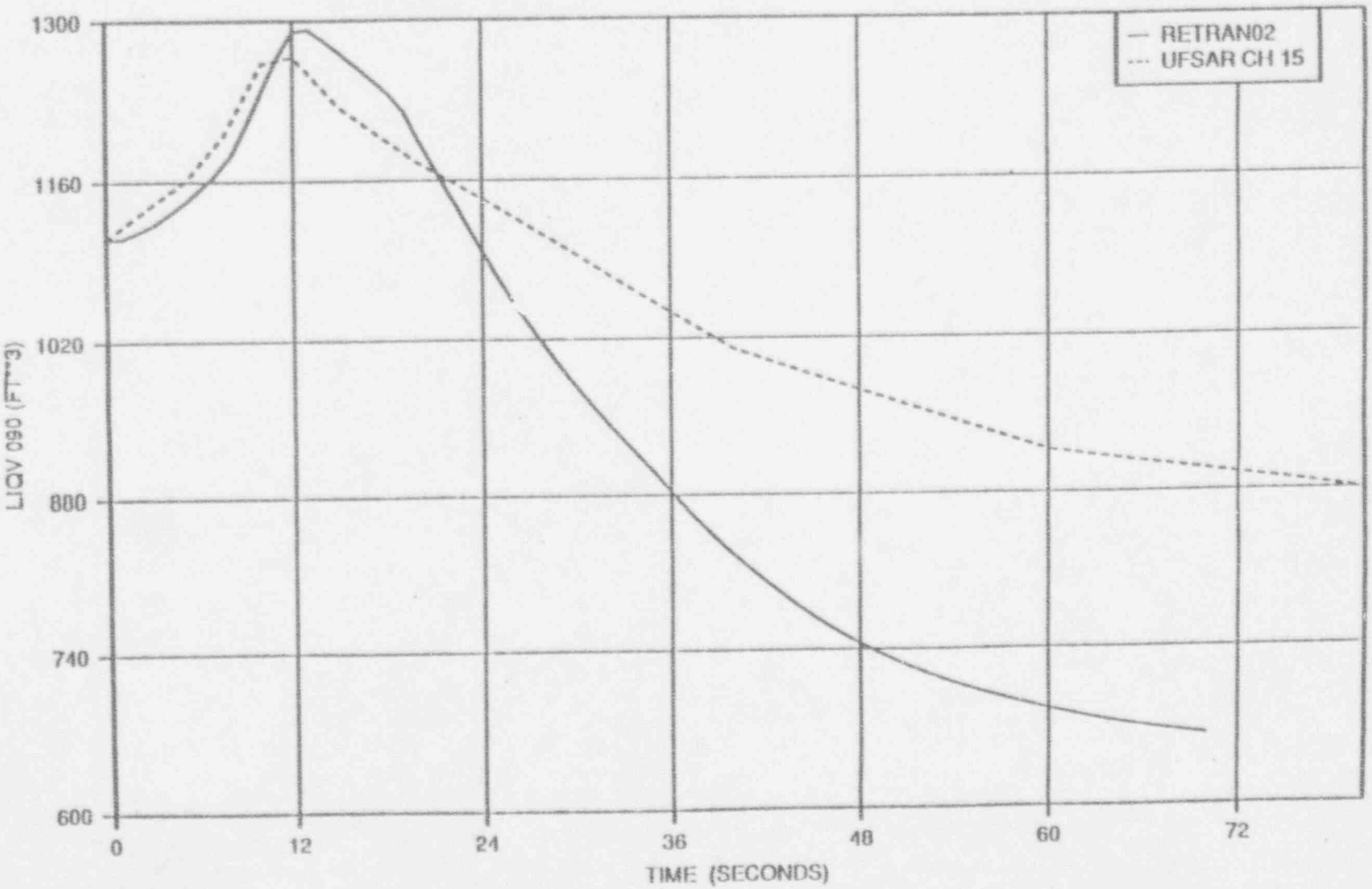
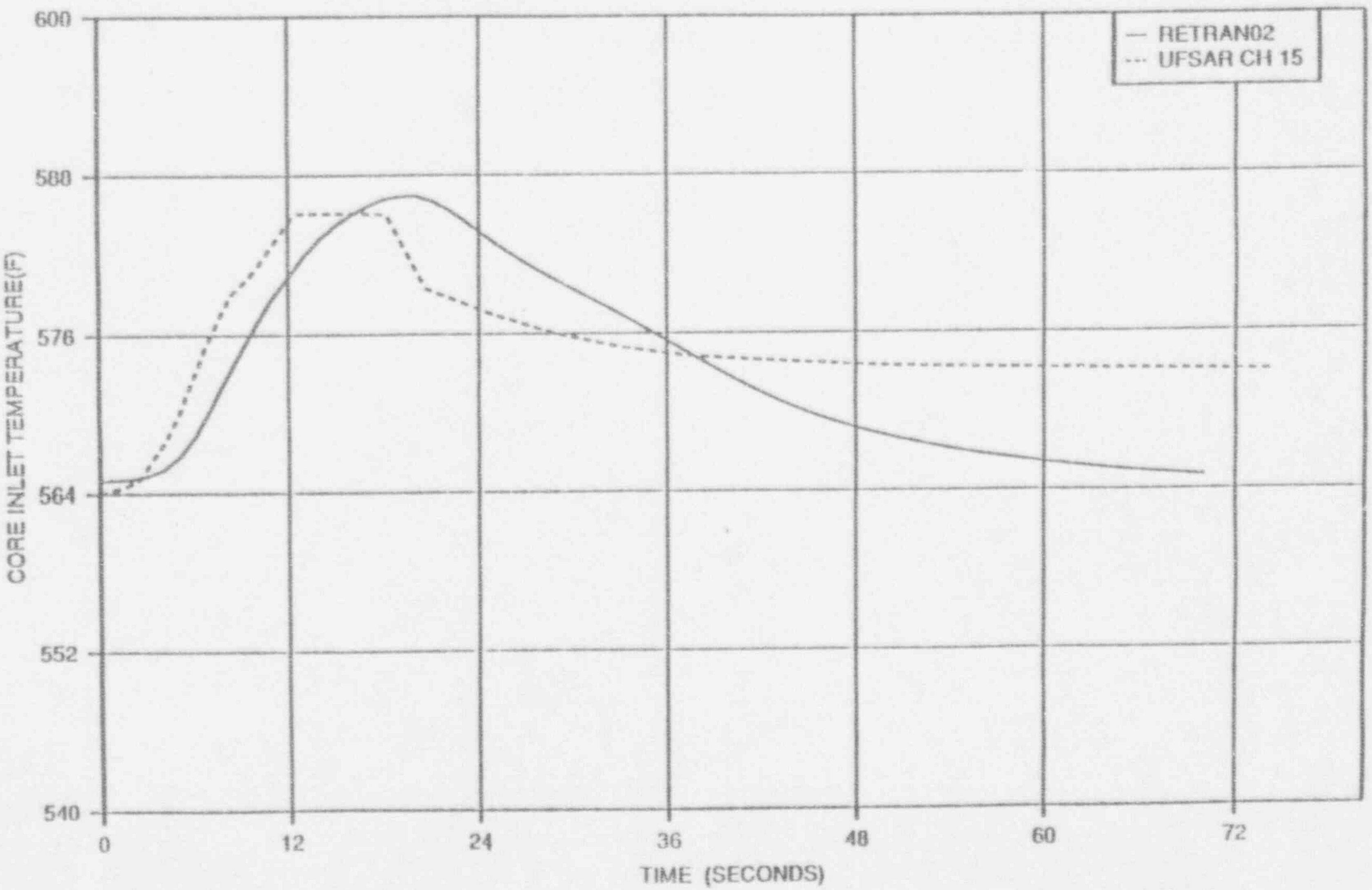


FIGURE 3-5

TURBINE TRIP WITHOUT PRESSURIZER CONTROL, MINIMUM REACTIVITY FEEDBACK

CORE INLET TEMPERATURE VS. TIME - UFSAR BENCHMARK



ENCLOSURE 1

ENCLOSURE 2

MEETING ATTENDEES

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