BWR PLANT TRANSIENT ANALYSIS PROGRAM AT BROOKHAVEN NATIONAL LABORATORY

PREPARED FOR PRESENTATION TO THE COMMISSION ON NOVEMBER 10, 1980

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BNL PROGRAM SCOPE

- MODEL A BWR-4 PLANT FOR VARIOUS ATWS CONSEQUENCE ANALYSES INCLUDING THE BROWNS FERRY-3 PARTIAL SCRAM EVENT ACCOMPANIED BY A LIMITING ANTICIPATED TRANSIENT SUCH AS MSIV CLOSURE

- PREPARE GENERIC PLANT MODELS FOR A TYPICAL BWR-3, BWR-5 AND BWR-6 FOR ATWS AND OTHER TRANSIENT CONSEQUENCE ANALYSES

- PERFORM AUDIT ANALYSES INVOLVING A SERIES OF LOSS OF FEEDWATER TRANSIENTS FOR A BWR-4 PLANT DESCRIBED IN GE'S REPORT NEDO-24708

BNL PROGRAM OBJECTIVES

- DEVELOP CAPABILITY TO AUDIT VENDOR / LICENSEE ANALYSES

- DEVELOP CAPABILITY TO PERFORM RAPID ANALYSES OF ALL BWRS (OPERATING AND TO BE LICENSED) TO DETERMINE SAFETY IMPACT OF OPERATING TRANSIENTS AND TO PROVIDE BETTER BASES FOR DECISIONS INVOLVING OPERATING REACTORS

- DEVELOP BETTER UNDERSTANDING OF THE TRANSIENT/ACCIDENT BEHAVIOR/RESPONSE OF BWRS FOR DEVELOPING EMERGENCY GUIDELINES AND PLANT OPERATING PROCEDURES

- INDEPENDENT AUDIT(S)/ASSESSMENT(S) OF ADEQUACY OF SAFETY FEATURES

MSIV CLOSURE PLUS BF-3 PARTIAL SCRAM

TRANSIENT ANALYZED

- PEACH BOTTOM UNIT 2 - GENERIC BWR/4 (EOC CONDITIONS)
- INITIAL POWER - 104% OF RATED
- MAIN STEAM ISOLATION VALVE CLOSURE
- BF-3 PARTIAL SCRAM CONFIGURATION
- POWER LEVEL AFTER INSERTION 10% (NOMINAL)
- AUTOMATIC RECIRCULATION PUMP TRIP
- HIGH PRESSURE COOLANT INJECTION (HPCI) + (RCIC)
- MANUAL INITIATION OF RESIDUAL HEAT REMOVAL (RHR) SYSTEM (POOL COOLING MODE)
- MANUAL INITIATION OF BORON INJECTION (SLCS)

MSIV CLOSURE PLUS BF-3 PARTIAL SCRAM

BASIS OF RELAP-3B INPUT

DATA OBTAINED FROM FSAR AND BNL ANALYSES

- BASIC PEACH BOTTOM UNIT 2 MODEL GEOMETRY AND INITIAL CONDITIONS OBTAINED FROM DESIGN INFORMATION

- REACTIVITY FEEDBACK MODELS OBTAINED FROM PREVIOUS BNL LICENSING CALCULATIONS (VOID, DOPPLER, MODERATOR TEMPERATURE)

- HPCI INITIATION AND TERMINATION BASED ON DOWNCOMER COOLANT MASS

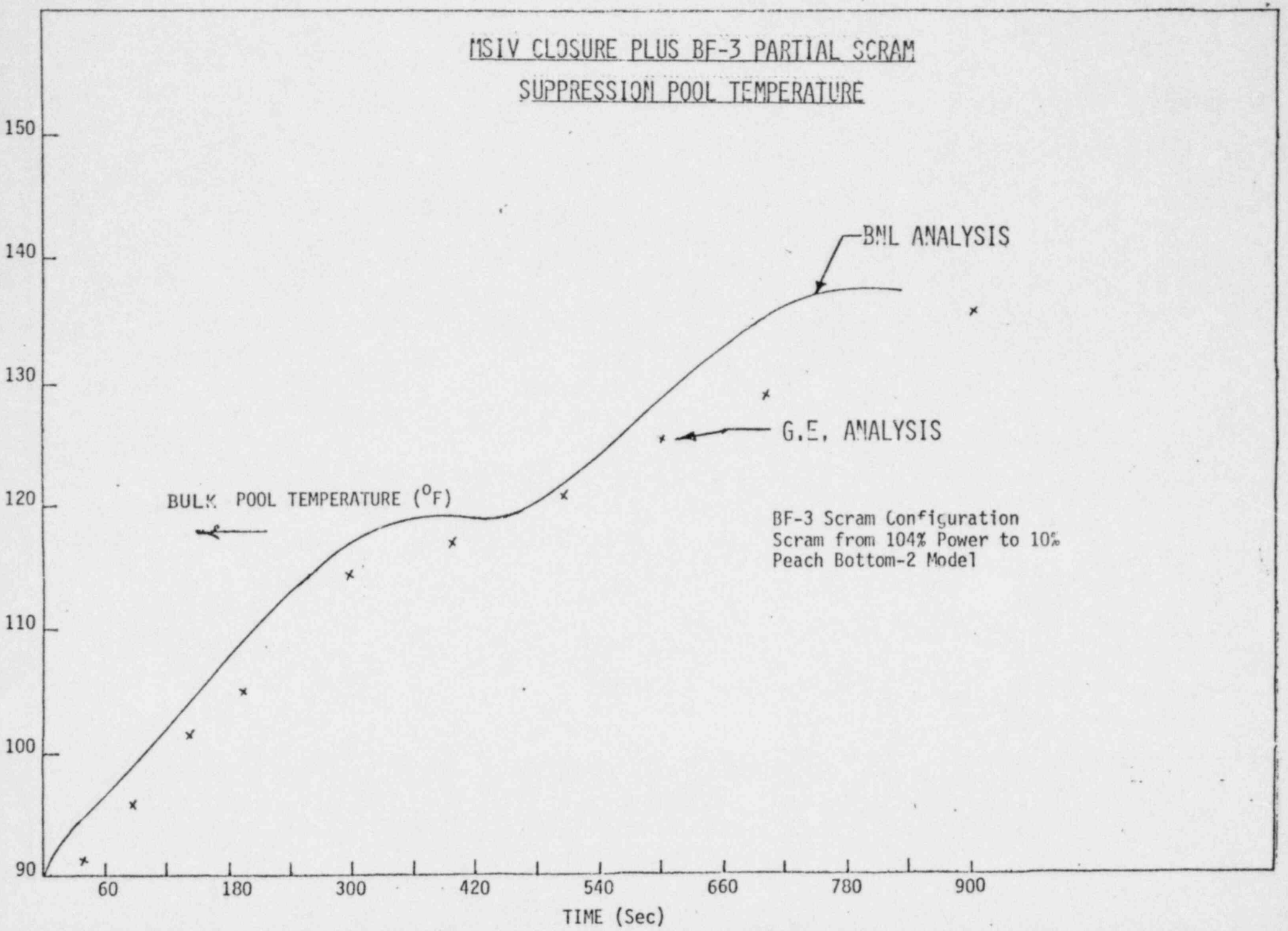
- RPV CHARACTERISTICS AND POOL VOLUME

DATA OBTAINED FROM GE ANALYSIS

- AVERAGE POWER LEVEL AFTER SCRAM 10% (RATED) INCLUDING DECAY HEAT

- FEEDWATER TRANSIENT

- BORON REACTIVITY WORTH AND SOURCE CONCENTRATION


MSIV CLOSURE PLUS BF-3 PARTIAL SCRAM
SUPPRESSION POOL TEMPERATURE
150
140
130
120
110
100
90
BNL ANALYSIS
G.E. ANALYSIS
BULK POOL TEMPERATURE (°F)
BF-3 Scram Configuration
Scram from 104% Power to 10%
Peach Bottom-2 Model
60
180
300
420
540
660
780
900
TIME (Sec)

RAMONA CODE

CODE DESCRIPTION

THERMAL HYDRAULICS

- Multi-Channel Core
- Non-Equilibrium
- Steam Supply System

CORE PHYSICS

- Three Space Dimensions
- Feedback
- 1½ Energy Groups

CODE USAGE

STEADY STATE

- Determination of Control and Scram Worth (In Progress for BF3 Configuration)

TRANSIENT

- Licensing Basis Transients (Turbine Trip Without Bypass)
- Small Break (future)

✓ (26)

ANTICIPATED TRANSIENTS

WITHOUT SCRAM

NUCLEAR SAFETY

JULY/AUGUST 1980

TEST FREQUENCY

TRANSIENT FREQUENCY

REDUCTION IN SAFETY

RELATIVE RISK

WM
11/7/80

RECTIFICATION

HAS KAHL FAILURE BEEN FIXED ?

- EPRI:

  FAILED AT T = 1/20

  IF NOT FIXED

  P(NO FAIL, 19T) $\leq$ 0.02

  NO FAILURE

  THEREFORE FIXED

- STAFF

  IF NOT FIXED

  P(NO FAIL, 19T) $\leq$ 0.39

  INCONCLUSIVE

WM
11/10/80

RECTIFICATION

EFFECT ON P(ATWS)

1. CONSTANT FAILURE RATE

	FAILURES		
CONF	ONE	NONE	RATIO
95%	3.0×10^{-4}	2.0×10^{-4}	1.5
50%	1.1×10^{-4}	4.6×10^{-5}	2.4
STAFF	1.1×10^{-4}	3.0×10^{-5}	3.6

2. MULTIPLE FAILURE MODES
(10 MODES, EACH 10^{-5})

MODES	10	9	1.1
P(ATWS)	10^{-4}	9×10^{-5}	1.1

TEST FREQUENCY

- EFFECTIVE TEST FREQUENCY

  RPS TESTED IN PARTS

  DIFFERENT FREQUENCIES

  HOW COMBINE ?

- VALIDITY OF TESTS

  PART = WHOLE ?

  CONDITIONS

  TEST = CHALLENGE ?

- ONLY REACTOR TRIP (ELECTRICAL)

  SINGLE ROD SCRAMS

- CONSIDERED BY STAFF

	UNAVAILABILITY	
TESTS/YEAR	ELECTRICAL	MECHANICAL
12	8.0×10^{-5}	3.0×10^{-5}
50	1.9×10^{-5}	---
100	1.0×10^{-5}	---
STAFF	1.5×10^{-5}	1.5×10^{-5}

TRANSIENT FREQUENCY

	STAFF	EPRI	RATIO
BWR	8	3.5	2.3
PWR	5	1.2	4

EPRI EXCLUDED

SOME TRANSIENTS

TRANSIENTS BELOW 25% POWER

EPRI EXTRAPOLATED

STAFF - AVERAGE FIRST 5 YEARS

EPRI - AVERAGE 40 YEARS

WM
11/7/80

REDUCTION IN SAFETY
(NUCLEAR SAFETY ARTICLE)

- EPRI

COMPARE PROB. LOCA GIVEN AT S

VALVE STICK OPEN = TKQ

VALVE STICK CLOSED = TKP

TOO FEW VALVES = TK(PMTC)

	U(FAILURE/DEMAND)	
# VALVES	3	4
Q	1.0×10^{-2}	1.3×10^{-2}
P	$3.0\ 10^{-5}$	0
PMTC	0	0

- STAFF

	U(FAILURE/DEMAND)	
# VALVES	1	2
Q	3.0×10^{-3}	6.0×10^{-3}
P	3.0×10^{-5}	0
PMTC	4.0×10^{-1}	1.0×10^{-2}
	4.0×10^{-1}	1.6×10^{-2}

ADDING VALVES DECREASES P(LOCA) (IF ATWS UNMITIGATED

REDUCTION IN SAFETY
(EPRI PRESENTATION)

- EPRI

EVENT	FREQ	ESF	MELT
PORV (TQ)	3×10^{-2}	1.7×10^{-2}	5×10^{-4}
ATWS (TK)	2×10^{-4}	1.0	2×10^{-4}

STUCK VALVE DOMINATES HENCE ADDITIONAL VALVES INCREASE RISK

COMPARE MITIGATED VERSUS UNMITIGATED ATWS

1. PORV DOMINATES
2. ATWS DOMINATES

REDUCTION IN SAFETY

A. PORV DOMINATES

1. ATWS UNMITIGATED

#	SYS	TRANS	U	ESF	MELT
1	PORV	10	3×10^{-3}	1.7×10^{-2}	5×10^{-4}
1	S/V	1	1×10^{-3}	1.7×10^{-2}	2×10^{-5}
	RPS	6	3×10^{-5}	4×10^{-1}	7×10^{-5}
					5.9×10^{-4}

2. ATWS MITIGATED

1	PORV	10	3×10^{-3}	1.7×10^{-2}	5×10^{-4}
1	S/V	1	1×10^{-3}	1.7×10^{-2}	2×10^{-5}
1	S/V	0.1	1×10^{-3}	1.7×10^{-2}	2×10^{-6}
	RPS	6	3×10^{-5}	1.0×10^{-2}	2×10^{-6}
					5.2×10^{-4}

IF OTHER SEQUENCES DOMINATE, ATWS HAS SMALL EFFECT, BUT STILL A REDUCTION IN RISK

RELATIVE RISK

RISK = P(MELT) P(RELEASE) DOSE

CONSEQUENCES = P(RELEASE) DOSE

- EPRI

$$\frac{\text{COMPETING}}{\text{ATWS}} = \frac{6.6 \times 10^{-5}}{6.4 \times 10^{-5}} \quad 5000$$

- STAFF

CONSEQUENCES

ATWS		LOCA
UNMITIGATED ATWS	>	MITIGATED LOCA

REDUCTION IN SAFETY

B. ATWS DOMINATES

1. ATWS UNMITIGATED

SYS	TRANS	U	ESF	MELT
ALL RSS	--	--	---	3×10^{-5}
RPS	6	3×10^{-5}	4×10^{-1}	7×10^{-5}
				10×10^{-5}

2. ATWS MITIGATED

RPS	6	3×10^{-3}	1.0×10^{-2}	2×10^{-5}
1 S/V	0.1	1×10^{-3}	1.7×10^{-2}	2×10^{-6}
				3×10^{-5}

V6

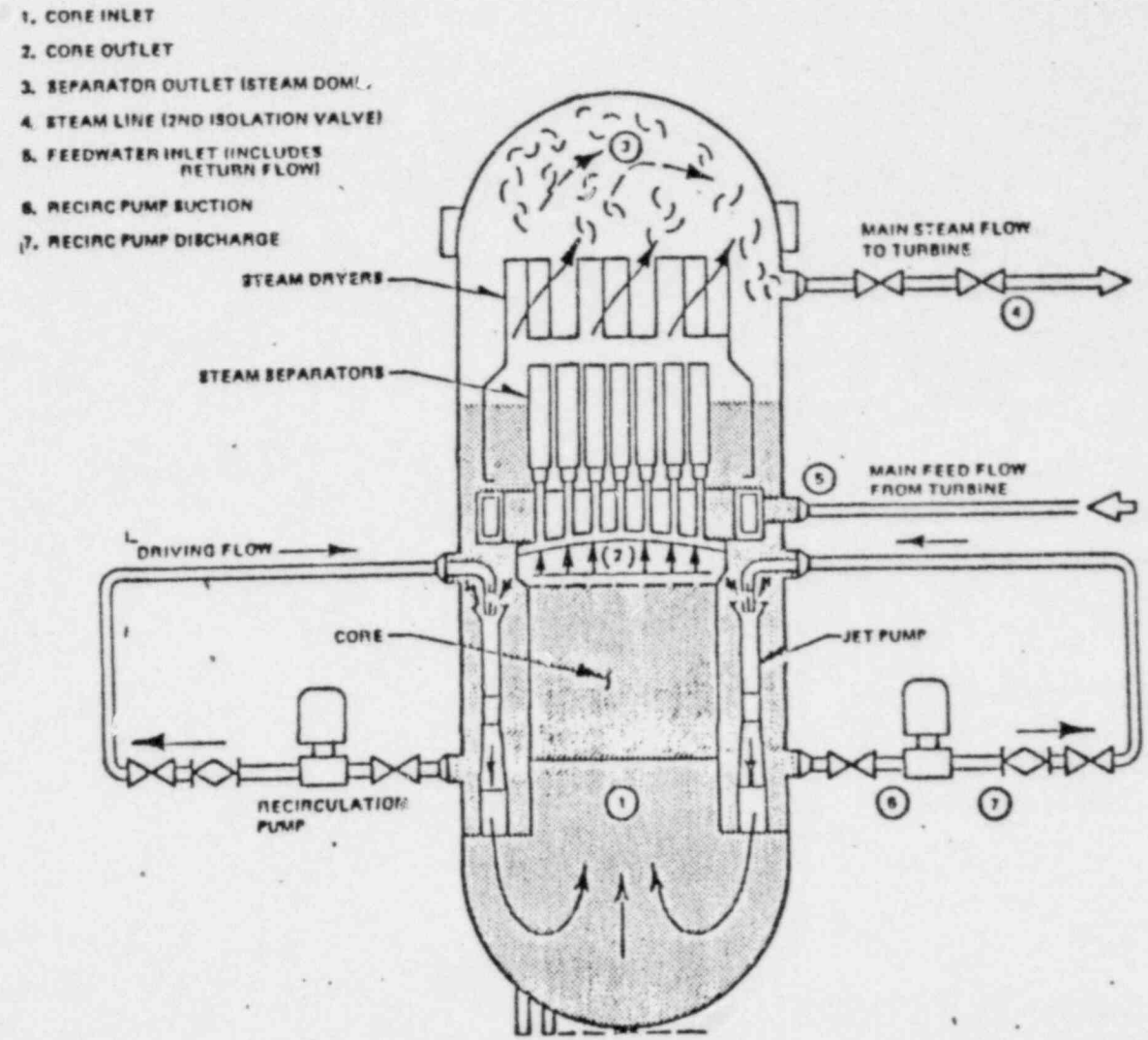


Figure A-3 Jet Pump BWR

REACTOR POWER LEVEL

AND

TOTAL PRIMARY COOLANT INJECTION