

ATTACHMENT 1

BWR SUPPRESSION POOL
TEMPERATURE EVALUATION

D.D. Jones, Senior Engineer
Containment and Radiological Engineering

General Electric Company
San Jose, California
December 17, 1982

BWR SUPPRESSION POOL TEMPERATURE EVALUATION

KEY POINTS

- o POOL TEMPERATURE EVALUATION PROCESS IS CONSERVATIVE
 - o LIMITING TRANSIENTS ANALYZED ARE VERY LOW PROBABILITY EVENTS
 - o INCORPORATION OF NEW OPERATOR GUIDELINES ELIMINATES SRV DISCHARGE TO HOT POOL CONCERN
 - o ANALYSIS ASSUMPTIONS ARE BOUNDING
 - o POOL TEMPERATURE LIMIT IS CONSERVATIVE

- o MODEL DEVELOPED/QUALIFIED AGAINST SUFFICIENT DATA
 - o PLANT DATA USED IN DEVELOPMENT
 - o MARK I POOLS GEOMETRICALLY AND DIMENSIONALLY SIMILAR
 - o BROAD DATA BASE USED TO QUALIFY

- o ALTERNATE DETERMINATION CONFIRMS CONSERVATISM OF PLANT SUBMITTALS
 - o PLANT SUBMITTAL TEMPERATURE BOUNDS ALTERNATE CALCULATION USING REALISTIC ASSUMPTIONS AND ACTUAL DATA BOUNDING ΔT PEAK-BULK

BWR SUPPRESSION POOL TEMPERATURE EVALUATION

- POOL TEMPERATURE EVALUATION PERSPECTIVE
- ANALYSIS DESCRIPTION/DEVELOPMENT/QUALIFICATION
- ALTERNATE DETERMINATION OF PEAK POOL TEMPERATURE

Plant Submittals are
Conservative Calculations of
Pool Temperature During
SRV Discharge

DDJ

12/17/82

SUPPRESSION POOL TEMPERATURE EVALUATION PERSPECTIVE

- SYSTEM OPERATIONS ASSUMPTIONS ARE BOUNDING
 - Impact on Temperature 20 - 60°F
- METHODOLOGY IS CONSERVATIVE 10 - 20°F
- ANALYSIS ASSUMPTIONS ARE BOUNDING
 - Impact on Temperature 15 - 30°F
- LIMITING TRANSIENTS ARE VERY LOW PROBABILITY EVENTS
 - Typically 10 - 20°F Higher Than Other Transients
- POOL TEMPERATURE LIMIT IS CONSERVATIVE
 - Conservative Definition of Local Temperature
 - Bounds Data
 - No Credit for Wetwell Pressurization
- # OF FAILURES REQUIRED IS GREATER THAN FSAR DESIGN BASIS

Highly Unlikely Events Have Been Analyzed
With A Conservative Methodology To
Demonstrate Compliance With Regulatory
Requirements

DDJ
12/17/82

BWR SUPPRESSION POOL TEMPERATURE EVALUATION

● ANALYSIS DESCRIPTION

Plant Submittal Transients

- Analytical Model Description
- TPOOL Development
- TPOOL Qualification
- TPOOL Application

DDJ

12/17/82

PLANT SUBMITTAL TRANSIENTS

- NUREG-0783 REQUIRED TRANSIENT ANALYSIS
 - SORV/Power Operation
 - SRV/Isolation
 - SRV/SBA

- SRV/SBA - TYPICALLY MOST LIMITING
 - Conservative Transient Sequence Analyzed
 - Worst Case RHR Availability
 - Highest Bulk Temperature
 - Maximum $\Delta T_{\text{peak-bulk}}$

- OTHER TRANSIENTS HAVE SUBSTANTIALLY LOWER PEAK TEMPERATURES (180 - 190°F)

DDJ
12/17/82

SRV/SBA TRANSIENT

- SRV/SBA TRANSIENT SEQUENCE SCENARIO
 - Bounding System Assumptions
 - New Operator Guidelines Not Considered

- KEY SYSTEM BEHAVIOR
 - Automatic SRV's
 - HPCI
 - Depressurization
 - RHR Operation

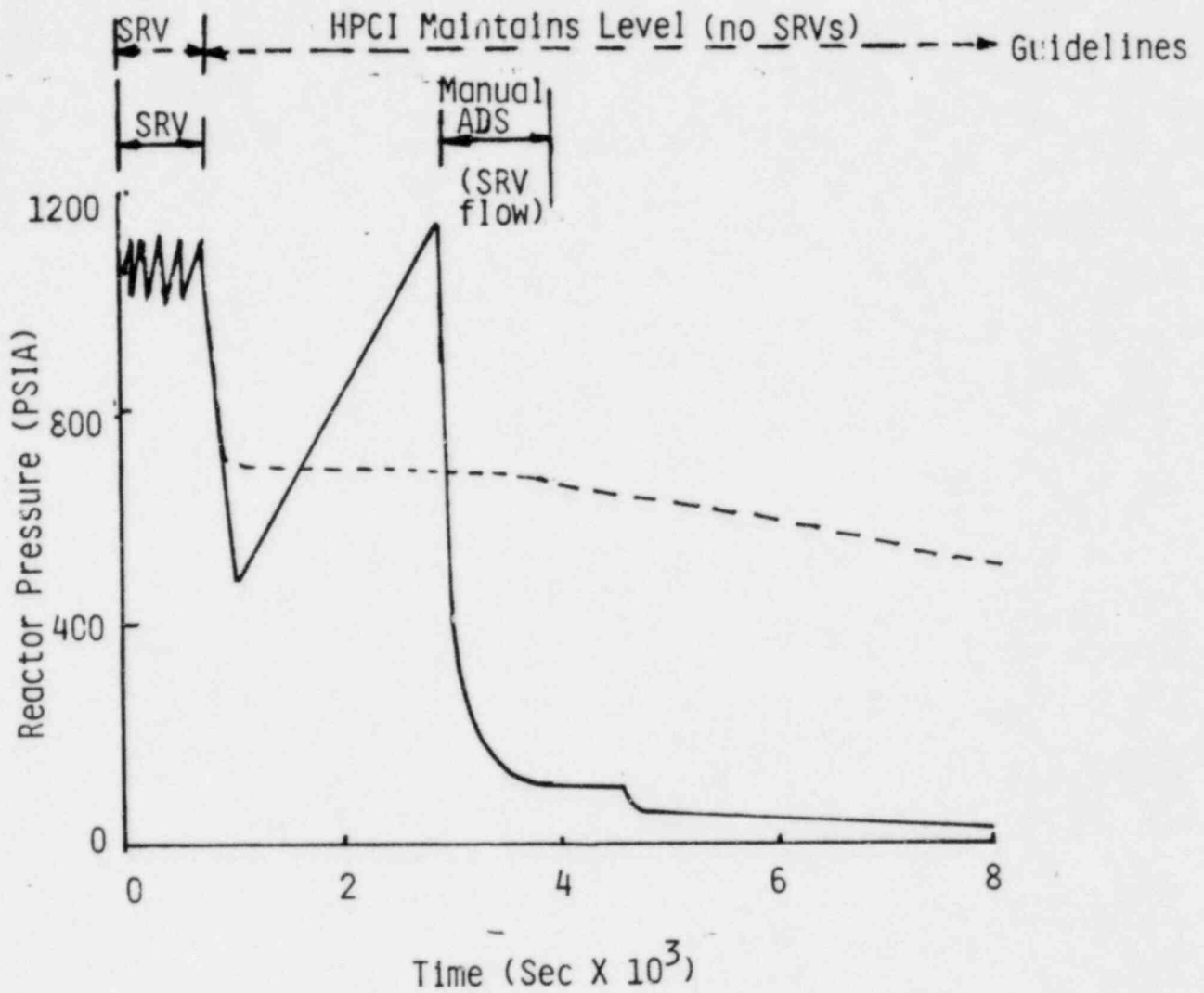
- BASED ON NEW OPERATOR GUIDELINES
 - SRV Discharge When Pool Cold
 - No SRV Discharge When Pool Hot

Incorporation of New Operator Guidelines
Eliminates SRV Discharge to Hot Pool
Concern

DDJ
12/17/82

EFFECT OF OPERATOR GUIDELINES ON REACTOR PRESSURE and

SRV OPERATION

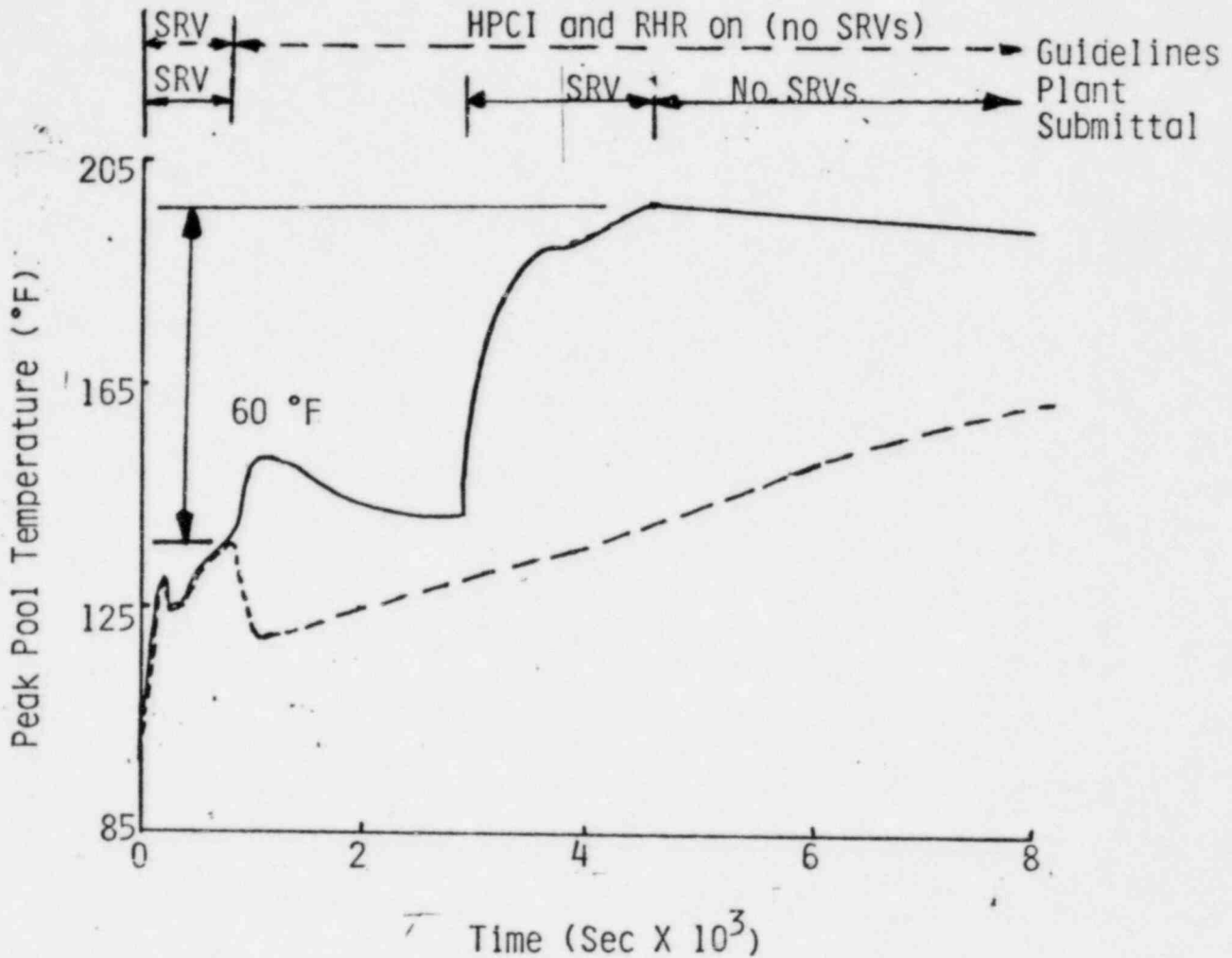


● TRANSIENT PER OPERATOR GUIDELINES

- Initial SRV Discharge Same
- HPCI Maintains Level Resulting in Decreasing Pressure
- No Long Term SRV Discharge

DDJ
12/17/82

EFFECT OF GUIDELINES ON POOL TEMPERATURE



● POOL TEMPERATURE RESPONSE PER GUIDELINES

- No ADS To Hot Pool.
- Uniform Pool Heatup
- SRV Discharge to Cold Pool Only

Transient Per Operator Guidelines
Eliminates SRV Discharge to
Hot Pool Concern

SUPPRESSION POOL TEMPERATURE EVALUATION PERSPECTIVE

- SYSTEM OPERATIONS ASSUMPTIONS ARE BOUNDING
 - Impact on Temperature 20 - 60°F
- METHODOLOGY IS CONSERVATIVE 10 - 20°F
- ANALYSIS ASSUMPTIONS ARE BOUNDING
 - Impact on Temperature 15 - 30°F
- LIMITING TRANSIENTS ARE VERY LOW PROBABILITY EVENTS
 - Typically 10 - 20°F Higher Than Other Transients
- POOL TEMPERATURE LIMIT IS CONSERVATIVE
 - Conservative Definition of Local Temperature
 - Bounds Data
 - No Credit for Wetwell Pressurization

Highly Unlikely Events Have Been Analyzed
With A Conservative Methodology To
Demonstrate Compliance With Regulatory
Requirements

DDJ
12/17/82

BWR SUPPRESSION POOL TEMPERATURE EVALUATION

● ANALYSIS DESCRIPTION

- Plant Submittal Transients
- Analytical Model Description
- TPOOL Development
- TPOOL Qualification
- TPOOL Application

ANALYTICAL MODEL DESCRIPTION

- BULK POOL TEMPERATURE
 - Calculate Pool Bulk Temperature Based on Energy Additions by SRVs/Breaks and Removal by RHR.

- PEAK POOL TEMPERATURE
 - Use TPOOL To Calculate Peak Pool Temperature Following SRV Discharge With Or Without RHR Operation.

DDJ

12/17/82

DESCRIPTION OF TPOOL

- LUMPED PARAMETER MODEL
 - Maximum 40 Half-Bays
 - 8 Elevations Per Half-Bay

- MODELS INCLUDED
 - RHR Discharge
 - Quencher End-Cap Discharge
 - Irreversible Losses Due To Structures, Turns and Wall Friction

- SOLUTION METHODOLOGY
 - Momentum Equation for Pool Velocity Transient
 - Energy Equation for Node Temperature Transient
 - Semi-Empirical Model for Recirculation Flow and Thermal Mixing Based on Plant Data

DDJ

12/17/82

BWR SUPPRESSION POOL TEMPERATURE EVALUATION

● ANALYSIS DESCRIPTION

- Plant Submittal Transients
- Analytical Model Description
- TPOOL Development
- TPOOL Qualification
- TPOOL Application

DDJ

12/17/82

TPOOL DEVELOPMENT and QUALIFICATION

• DATA PREVIOUSLY USED IN CODE DEVELOPMENT

- Monticello Quencher Performance Tests
November, 1978

• OTHER DATA USED FOR TPOOL QUALIFICATION

- Monticello Quencher Performance Tests
January, 1977
- Fitzpatrick SRV Load Test
- Caorso Quencher Performance

Actual Plant Data Used
for TPOOL Qualification

DDJ

12/17/82

TPOOL DEVELOPMENT

- MONTICELLO QUENCHER PERFORMANCE TESTS (Nov., '78)
USED FOR CODE DEVELOPMENT
 - Two Tests
 - without RHR
 - with RHR
 - RHR With Elbows
 - SRV Open 11 Minutes

- DATA USED FOR SEMI-EMPIRICAL CONSTANTS.

Actual Plant Data Used
for TPOOL Development

DDJ
12/17/82

JUSTIFICATION FOR APPLICATION OF TPOOL

- EMPIRICAL CONSTANTS BASED ON CONDITIONS WHERE THE CODE WAS TO BE APPLIED

- GEOMETRICAL CONSIDERATION
 - All Mark I Pools Geometrically Similar
 - Dimensions are Similar

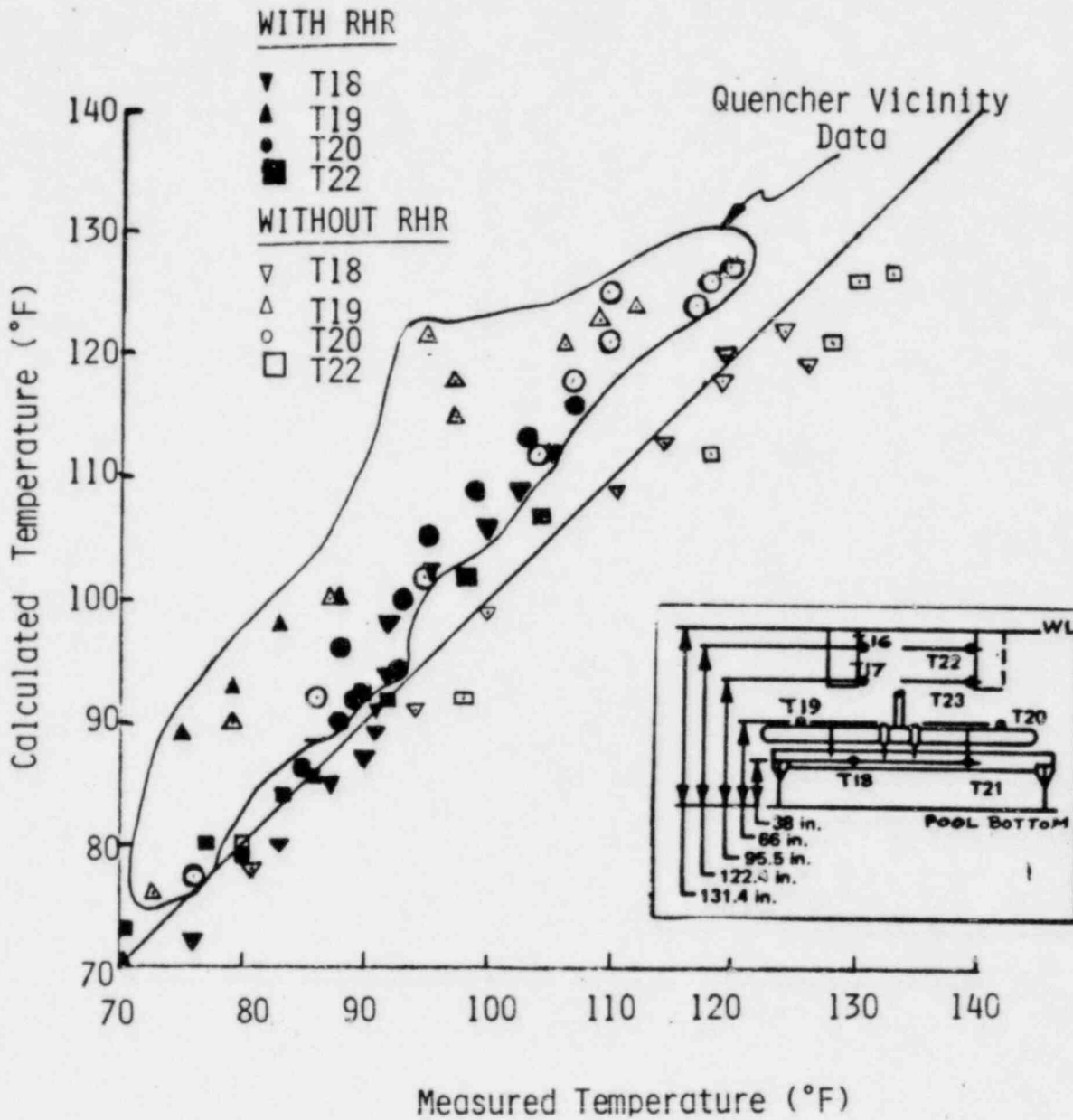
- KEY OPERATING PARAMETERS
 - Bulk Pool Movement (RHR Operation)
 - Quencher Discharge

 - Cycling
 - Extended Blowdown

TPOOL Development Basis Justified
Use For All Mark I Plant Submittals

DDJ
12/17/82

TPOOL DEVELOPMENT DATA COMPARISON



Chosen Semi-Empirical Coefficients
Overpredict in Vicinity of Quencher

OTHER QUALIFICATION DATA

● MONTICELLO QUENCHER PERFORMANCE TESTS

(Jan., '77)

- Two Tests
 - . without RHR
 - . with RHR
- No RHR Elbows
- SRV Open 7 Minutes

● FITZPATRICK SRV LOAD TEST

- No RHR
- Cycling SRV

● CAORSO QUENCHER PERFORMANCE

- No RHR
- SRV Open 14 Minutes

Other Data From Actual
Plants Used For TPOOL Qualification

DDJ

12/17/82

CODE QUALIFICATION CHALLENGE

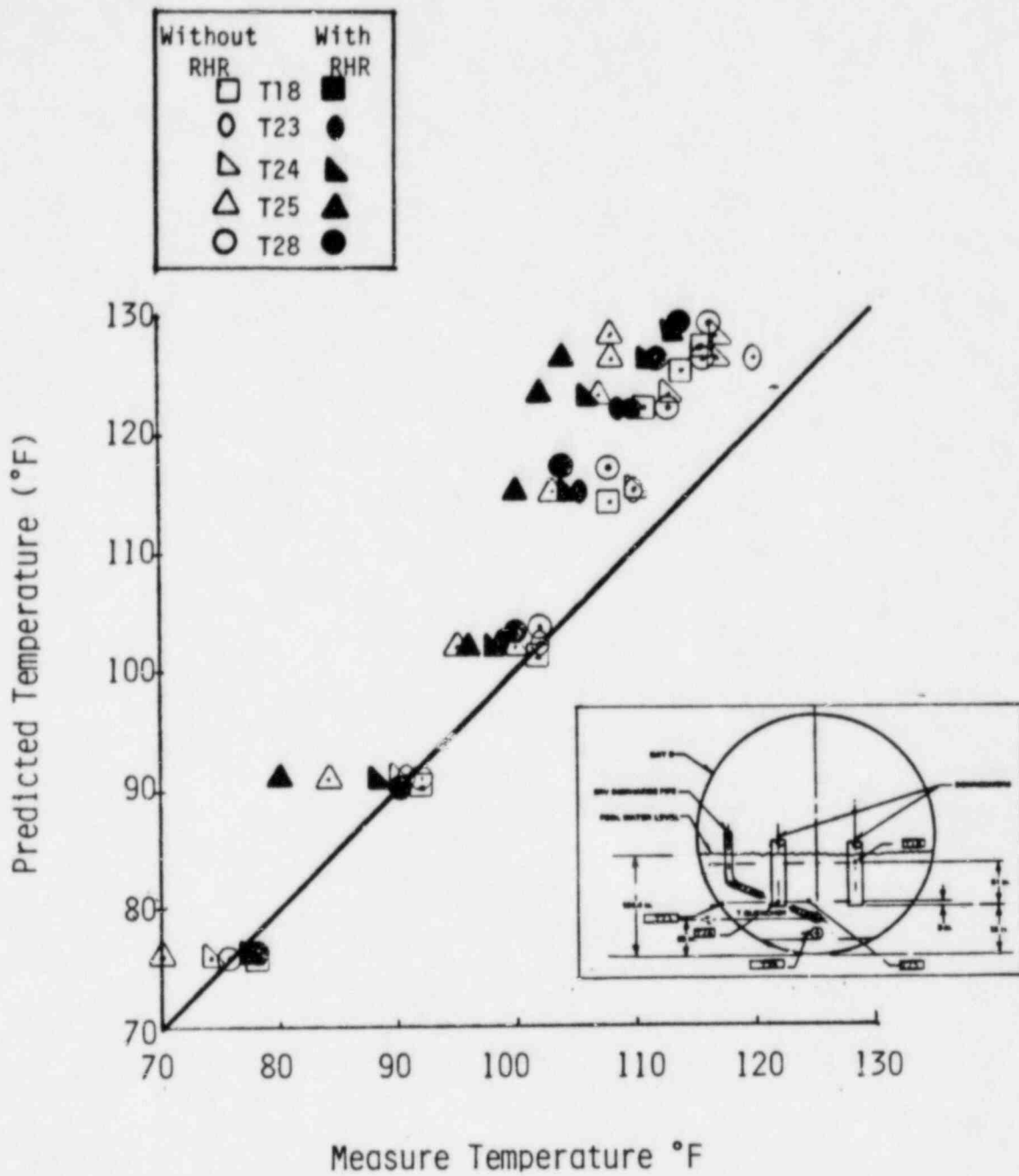
KEY PARAMETER AFFECTING POOL TEMPERATURE	APPLICABLE TEST DATA
POOL GEOMETRY	MARK I TORUS { Monticello '77 Fitzpatrick
	MARK II ANNULUS - Caorso
BULK POOL MOVEMENT	STAGNANT POOL { Fitzpatrick Caorso
	MOVING POOL - Monticello '77
QUENCHER DISCHARGE	INTERMITTENT - Fitzpatrick
	EXTENDED - Monticello '77 Caorso

Available Plant Data
Challenge TPOOL Modeling

DDJ
12/17/82

QUALIFICATION DATA COMPARISON

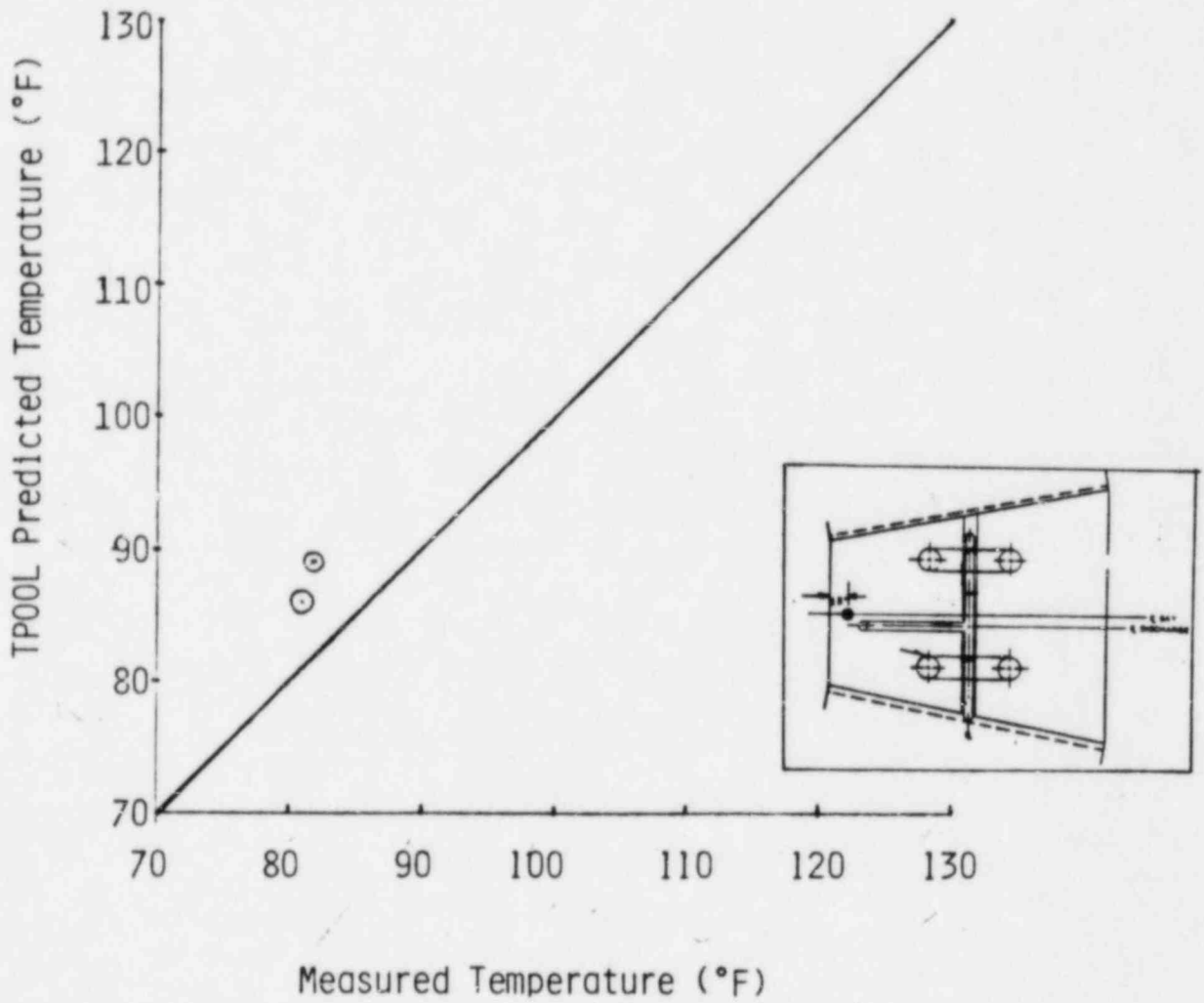
(Monticello'77)



TPOOL OVERPREDICTS IN VICINITY OF QUENCHER

DDJ
12/17/82

TPOOL QUALIFICATION DATA COMPARISON
(Fitzpatrick)

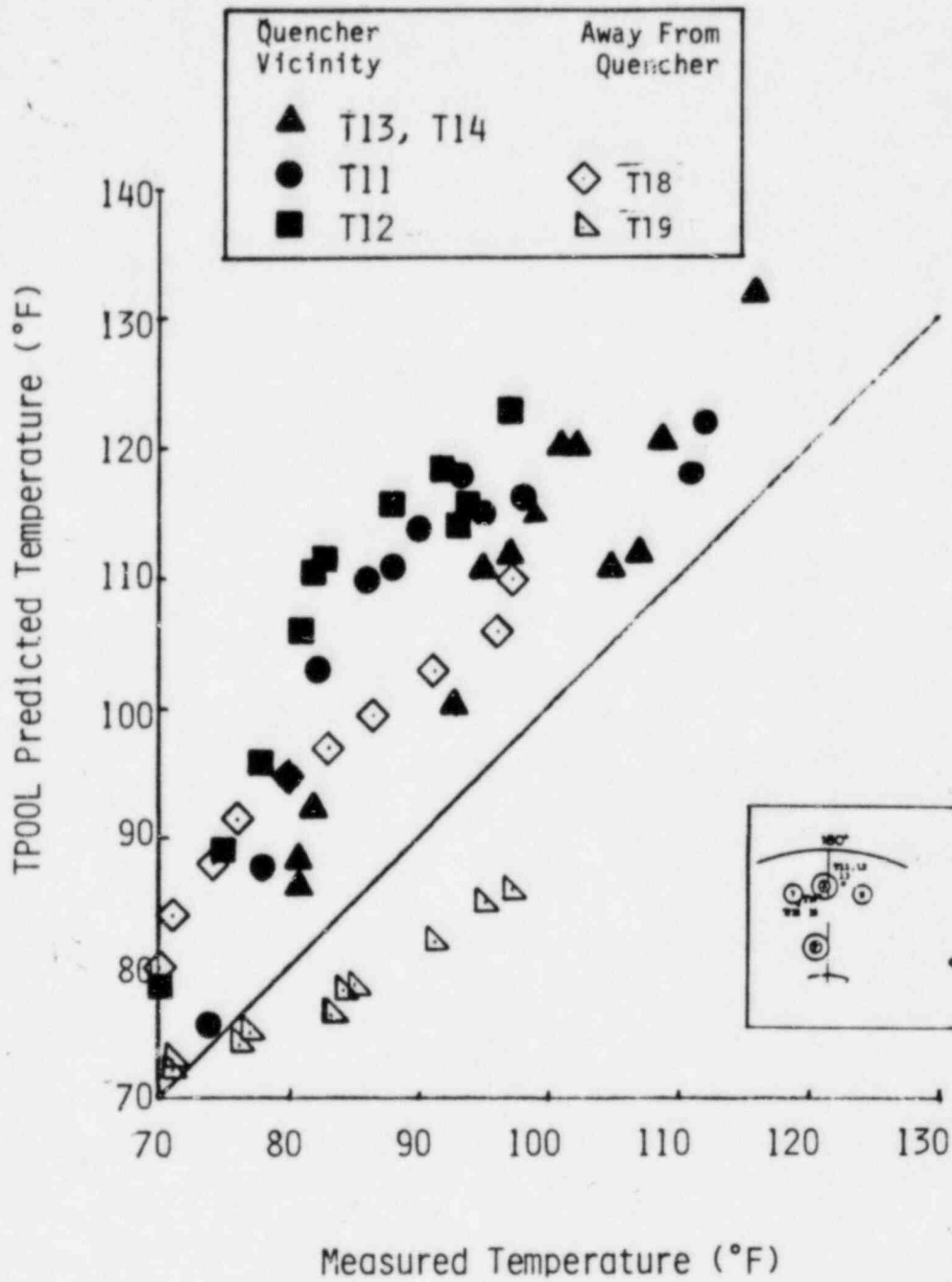


TPOOL OVERPREDICTS
Fitzpatrick Data

DDJ
12/17/82

TP00L QUALIFICATION DATA COMPARISON

(Coorso)



TP00L Overpredicts
Temperatures in Vicinity
of Quencher

DDJ
12/17/82

TPOOL QUALIFICATION

- OTHER PLANT DATA USED FOR TPOOL QUALIFICATION
- PLANT DATA USED ENCOMPASSES RANGE OF APPLICATION

TPOOL Calculations are
Conservative Compared to Actual
Plant Data Near Quencher

DDJ

12/17/82

BWR SUPPRESSION POOL TEMPERATURE EVALUATION

o ANALYSIS DESCRIPTION

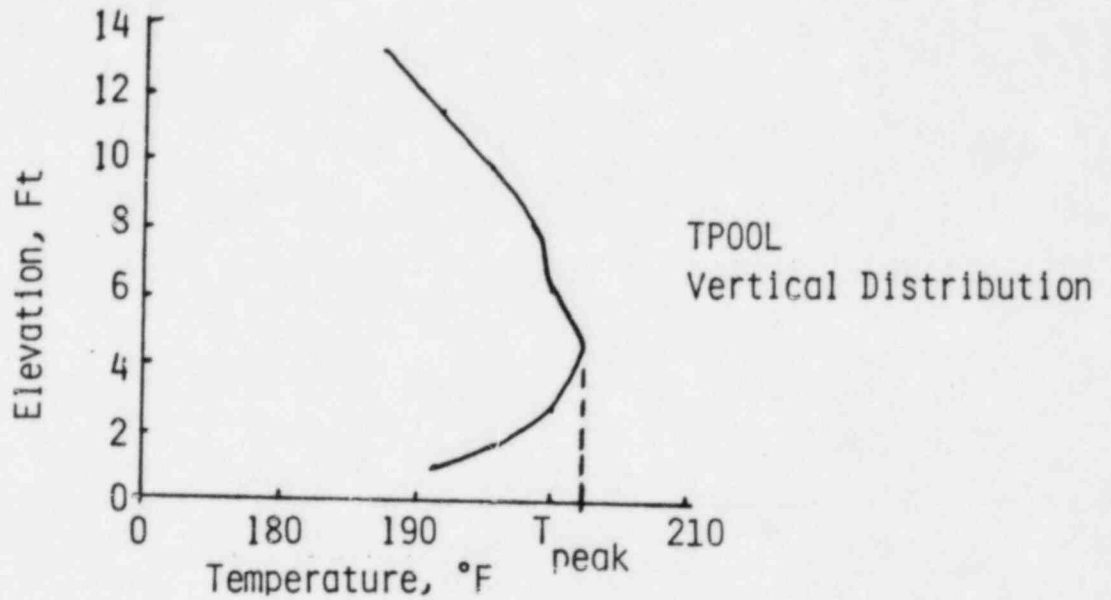
- Plant Submittal Transients
- Analytical Model Description
- TPOOL Development
- TPOOL Qualification
- TPOOL Application

DDJ

12/17/82

TPOOL APPLICATION - PLANT SUBMITTAL

- PLANT SUBMITTAL USES MAXIMUM TEMPERATURE
- WATER FEEDING THE CONDENSATION PROCESS IS LESS THAN PEAK TEMPERATURE



- BREAK FLOW ADDED TO SRV FLOW
- DISCHARGING SRVs NOT ALTERNATED

TPOOL IS APPLIED CONSERVATIVELY

DDJ

12/17/82

TPOOL ANALYSIS AND APPLICATION

- TPOOL SEMI-EMPIRICAL CONSTANTS (DEVELOPMENT)
BASED ON ACTUAL PLANT DATA

- TPOOL HAS BEEN QUALIFIED TO ADDITIONAL DATA
 - Additional data covers wide range of conditions

 - TPOOL calculations are higher than measured

- TPOOL IS APPLIED CONSERVATIVELY

Plant Submittals Using TPOOL Give Conservative
Calculation of the Peak Pool Temperature

DDJ

12/17/82

SUPPRESSION POOL TEMPERATURE EVALUATION PERSPECTIVE

- o SYSTEM OPERATIONS ASSUMPTIONS ARE BOUNDING
 - Impact on Temperature 20 - 60°F
- o METHODOLOGY IS CONSERVATIVE 10 - 20°F
- o ANALYSIS ASSUMPTIONS ARE BOUNDING
 - Impact on Temperature 15 - 30°F
- o LIMITING TRANSIENTS ARE VERY LOW PROBABILITY EVENTS
 - Typically 10 - 20°F Higher Than Other Transients
- o POOL TEMPERATURE LIMIT IS CONSERVATIVE
 - Conservative Definition of Local Temperature
 - Bounds Data
 - No Credit for Wetwell Pressurization

Highly Unlikely Events Have Been Analyzed
With A Conservative Methodology To
Demonstrate Compliance With Regulatory
Requirements

BWR SUPPRESSION POOL TEMPERATURE EVALUATION

- ALTERNATE DETERMINATION OF PEAK POOL TEMPERATURE
 - Realistic Bulk Temperature
 - Experimental Bound of Peak to Bulk Temperature Difference

DDJ

12/17/82

ALTERNATE DETERMINATION OF PEAK POOL TEMPERATURE

- PREVIOUSLY DESCRIBED CALCULATION DETERMINED THE PEAK TEMPERATURE ANALYTICALLY

 - ALTERNATE APPROACH USING DATA DIRECTLY
 - Calculate bulk temperature using realistic calculation assumptions

 - Bound temperature difference between bulk and peak using data
- i.e., plant peak temperature = bulk temperature
+ $\Delta T_{\text{peak-bulk}}$

Plant Submittal Peak Temperature Bounds Alternate
Determination Based on Data

DDJ
12/17/82

BULK TEMPERATURE DETERMINATION USING REALISTIC CALCULATIONS

Parameter	Assumption	
	Typical Plant Submittal	Realistic
Power	104% Rated	100% Rated
DECAY HEAT	May-Witt	ANS 5.1
Heat Sinks	No	Yes
Operating Plant Parameters		
- Pool Temp	95°F	75°F
- Pool Level	Low	Normal
- Service Water	89°F	70°F
Heat Exchanger Effectiveness	1.0	1.6

<p>Realistic Bulk Temperature ~20°F Below That in Typical Plant Submittals</p>
--

DDJ

12/17/82

DETERMINATION OF MAXIMUM PEAK TO BULK DIFFERENCE

- PLANT SUBMITTAL USED TPOOL

- USE ACTUAL PLANT DATA TO DEFINE MAXIMUM $\Delta T_{\text{peak-bulk}}$
 - Monticello (Jan., '77)

 - Monticello (Nov., '78)

 - Caorso

- PLANT $\Delta T_{\text{peak-bulk}}$ Are Bounding
 - Continuous Single SRV Discharge

 - High Pressure

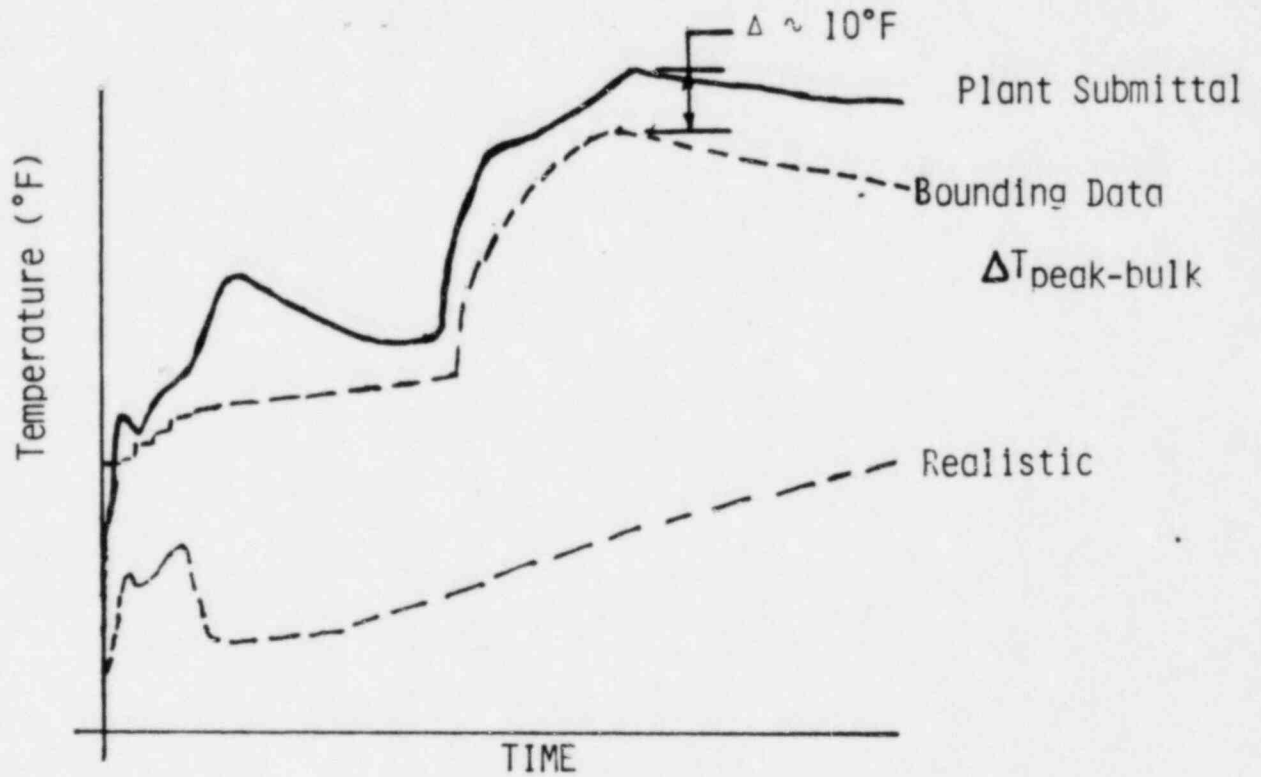
Actual Plant Data Provide

Bounding $\Delta T_{\text{peak-bulk}} = 43 \text{ }^\circ\text{F}$

DDJ

12/17/82

COMPARISON OF PLANT SUBMITTAL TO ALTERNATE CALCULATIONS
OF PEAK TEMPERATURE



Plant Submittal Peak Temperatures
Are Bounding Calculations

DDJ
12/17/82

CONCLUSIONS

- NO SRV DISCHARGE TO HOT POOL EXPECTED WITH OPERATOR FOLLOWING THE GUIDELINES

- PLANT SUBMITTAL USES CONSERVATIVE METHODOLOGY TO CALCULATE PEAK POOL TEMPERATURES
 - Bounding Initial Conditions Assumptions
 - TPOOL Conservatively Qualified With Other Data
 - TPOOL Applied Conservatively

- ALTERNATE DETERMINATION ADDITIONALLY SHOWS THAT PLANT PEAK TEMPERATURES BOUND EXPERIMENTALLY BASED PEAK TEMPERATURES.

Plant Submittals Are
Conservative Calculations Of
Pool Temperature During SRV Discharge

DDJ

12/17/82