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

SEP 19 1988

Docket Nos. 50-445
and 50-446

APPLICANT: Texas Utilities Electric Company (TU Electric)

FACILITY: Comanche Peak Steam Electric Station (CPSES), Units 1 and 2

SUBJECT: SUMMARY OF MEETING ON SEPTEMBER 7, 1988 - BOUNDING ANALYSIS FOR STRESS CONDITION OF THE PRESSURIZER SURGE LINE

At a meeting held on August 18, 1988 in Rockville, Maryland between NRC staff and representatives of TU Electric concerning the proposed application of advanced fracture mechanics analyses (also referred to as "leak-before-break methodology") to the pressurizer surge line at CPSES.* It was decided at that meeting that a follow-up meeting should be held within about two weeks to discuss (1) what specific thermal stratification data are available and why they characterize the pressurizer surge line at Comanche Peak; (2) what instrumentation TU Electric would install to collect Comanche Peak-specific data and how those data compare to other available data; and (3) what operational method (start-up) is planned for the Comanche Peak pressurizer. These discussions were planned to provide the NRC staff with a basis for deciding whether the data collection and analysis approach proposed by the applicant is appropriate and whether the staff could give further consideration to applying leak-before-break (LBB) methodology to the pressurizer surge line.

The follow-up meeting was held on September 7, 1988 in Rockville, Maryland. The meeting notice and the list of attendees are provided as Enclosures 1 and 2. The presentation slides are provided as Enclosures 3 and 4. A portion of the meeting concerned discussions of proprietary data. Presentation slides for that portion of the meeting are likewise proprietary and have been excluded from this meeting summary.

Data from instrumented pressurizer surge lines at the Trojan Nuclear Plant and the Beaver Valley Power Station Unit 2 was discussed together with the applicability of these data to the CPSES. The proposed instrumentation for the CPSES Unit 1 pressurizer surge line was discussed as well as the schedule for conduct of hot functional testing. In addition, the operational methods for start-up and shutdown and their influence on thermal stratification in the CPSES pressurizer surge line were discussed.

* See Summary of Meeting on August 18, 1988 - Application of Leak-Before-Break (LBB) Methodology to the Pressurizer Surge Line dated August 31, 1988.



DFP1
1/1

The applicant discussed with the staff in more detail the proposal presented at the meeting on August 18, 1988 to instrument the Unit 1 surge line and analyze the effects of thermal stratification on the piping. The applicant feels that the proposed analysis methodology is likely to result in conservatively bounding the stress condition in the pressurizer surge line at CPSES and establishing the surge line's integrity for approximately 5 to 10 years. For a long-term resolution, the applicant proposes to supplement the bounding analysis with a plant-specific analysis using data obtained during hot functional testing from the instrumented CPSES Unit 1 pressurizer surge line and with the results of the Westinghouse Owners Group surge line stratification program. The staff indicated that the applicant's plans for analyzing the effects of thermal stratification in the surge line was proceeding in a technically sound manner.

The decision as to whether to permit application of leak-before-break methodology to the pressurizer surge line in the event that the applicant's analyses demonstrate a service life less than 40 years will be further evaluated by the staff. The staff recognizes that not allowing the application of LBB methodology to the pressurizer surge line will likely result in a significant impact on the CPSES licensing schedule while plant modifications are made. The staff indicated that it would provide additional feedback to the applicant in approximately a week.

Melinda Malloy, Project Manager
Comanche Peak Project Division
Office of Special Projects

Enclosures:
1. Meeting Notice
2. List of Attendees
3. TU Electric Presentation Slides
4. Duquesne Light Presentation Slides
5. Proprietary Presentation Slides
   (NRC Docket File copy only)

cc: See next page

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Original signed by:

Melinda Malloy, Project Manager
Comanche Peak Project Division
Office of Special Projects

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Distribution w/o Enclosure 5:

| | | |
|---|---|---|
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DFP1
1/1

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ENCLOSURE 1

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

~~August 25, 1988~~

Change Notice #1 August 30, 1988

Docket Nos. 50-445
and 50-446

MEMORANDUM FOR: Christopher I. Grimes, Director
Comanche Peak Project Division
Office of Special Projects

FROM: James H. Wilson, Assistant Director
for Projects
Comanche Peak Project Division
Office of Special Projects

SUBJECT: FORTHCOMING MEETING WITH TU ELECTRIC

Date and Time: ~~Thursday, September 1, 1988~~ Wednesday, September 7, 1988
9:00 am - ~~4:00 pm~~ 3:00 pm

Location: One White Flint North
11555 Rockville Pike
Rockville, MD 20855
Room No. 8B-11

Purpose: Review of Comanche Peak pressurizer surge line stratification

Participants:*

| NRC | TU Electric | Westinghouse | R. L. Cloud |
|---|---|---|---|
| C. Grimes | R. Walker | G. Antaki | W. Server |
| J. Lyons | J. Muffett | D. Poarty | R. Beaudoin |
| J. H. Wilson | D. Rencher | R. Carlson | |
| D. Terao | H. Marvray | R. Brice-Nash | |
| C. Cheng | R. Flores | R. Coffield | |
| K. Wichman | | S. Swamy | |
| M. Hodges | | B. Maurer | |
| L. Marsh | | | |

James H. Wilson, Assistant Director
for Projects
Comanche Peak Project Division
Office of Special Projects

Enclosure: Proposed agenda

cc: See next page

* Meetings between NRC technical staff and applicants for licenses are open for interested members of the public, petitioners, intervenors, or other parties to attend as observers pursuant to "Open Meetings and Statement of NRC Staff Policy," 43 Federal Register 28058, 6/28/78. However, portions of this meeting will be closed to the general public due to the presentation and discussion of proprietary information.

~~8809010330~~ 5pp

ENCLOSURE

## Proposed Agenda

1. Introduction and Agenda
2. Background
3. Description
    a. Systems Operation
    b. Stratification in Pressurizer Surge Line
4. Engineering Evaluation
    a. Monitoring Program
    b. Definition of Transients
    c. Heat Transfer
    d. Piping Global Effects
    e. Piping Local Effects
    f. Piping System and Compartment Qualification
5. Leak-Before-Break
6. Summary

Change Notice #1,
August 30, 1988



Forthcoming meeting with TU Electric on September 1, 1988 to review of the Comanche Peak pressurizer surge line stratification

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ENCLOSURE 2

LIST OF ATTENDEES AT MEETING HELD IN ROCKVILLE, MD ON SEPTEMBER 7, 1988 - PRESSURIZER SURGE LINE

NRC
°P. McKee
°J. Lyons
°J. Wilson
°J. Wiebe
°M. Malloy
°J. Moore
°C. Cheng
°K. Wichman
°S. Lee
°L. Marsh
°S. Hou
°G. Dick
°P. Tam
°T. Chan
°P. T. Kuo

BNL
°G. DeGrassi

TU ELECTRIC
°R. Walker
°J. Muffett
°J. Redding
°A. Marvray
°R. Flores
°D. Rencher

STONE & WEBSTER
°S. Greer

WESTINGHOUSE
°G. Antaki
°D. Roarty
°E. Johnson
°R. Brice-Nash
°S. Swamy
°M. Barlow
°G. Ellis
°B. Maurer
°C. Benton
°H. Sandner
°J. Vota
°R. Carlson
°R. Coffield

DUQUESNE LIGHT
°S. Mukherjee
°M. Testa
°G. Kammerdeiner
°N. Toret

HOUSTON LIGHTING AND POWER
°A. Harrison
°J. Bailey

ENCLOSURE 3

# TU ELECTRIC

## COMANCHE PEAK STEAM ELECTRIC STATION

# PRESSURIZER SURGE LINE STRATIFICATION

## LEAK - BEFORE - BREAK

PRESENTATION TO THE
NUCLEAR REGULATORY COMMISSION

ROCKVILLE, MD

SEPTEMBER 7, 1988

# PRESSURIZER SURGE LINE
# STRATIFICATION

## AGENDA

SEPTEMBER 7, 1988 @ 10:00 A.M.

| | | |
|---|---|---|
| 1. | INTRODUCTION AND AGENDA | R. WALKER (TU ELECTRIC) |
| 2. | BACKGROUND | J. MUFFETT (TU ELECTRIC)<br>G. ANTAKI (W) |
| 3. | DESCRIPTION | |
| | A. SYSTEMS OPERATION | R. CARLSON (W) |
| | B. STRATIFICATION IN PRESSURIZER SURGE LINE | D. ROARTY (W) |
| | C. UTILITY EXPERIENCE | |
| 4. | ENGINEERING EVALUATION (CPSES SPECIFIC) | |
| | A. MONITORING PROGRAM | R. FLORES (TU ELECTRIC)<br>D. ROARTY (W)<br>D. RENCHER (TU ELECTRIC) |
| | B. DEFINITION OF TRANSIENTS | D. ROARTY (W) |
| | C. HEAT TRANSFER | D. ROARTY (W) |
| | D. PIPING GLOBAL EFFECTS | G. ANTAKI (W) |
| | E. PIPING LOCAL EFFECTS | D. ROARTY (W) |
| | F. PIPING SYSTEM AND COMPONENT QUALIFICATION | G. ANTAKI (W) |
| 5. | LEAK-BEFORE-BREAK (CPSES SPECIFIC) | S. SWAMY (W) |
| 6. | SUMMARY | J. MUFFETT (TU ELECTRIC) |

# TU ELECTRIC

# COMANCHE PEAK STEAM ELECTRIC STATION

## LEAK - BEFORE - BREAK

### BACKGROUND

| | |
|---|---|
| APRIL 15, 1988: | CPSES WHIPJET REPORT ON LEAK-BEFORE-BREAK SUBMITTED TO NRC |
| JUNE 22, 1988: | CONFERENCE CALL WITH NRC, TU ELECTRIC, AND CONSULTANTS TO DISCUSS WHIPJET REPORT |
| JUNE 22, 1988: | IE BULLETIN NO. 88-08 ISSUED |
| JUNE 24, 1988: | IE BULLETIN NO. 88-08 SUPPLEMENT 1 ISSUED |
| JULY 20, 1988: | CONFERENCE CALL WITH NRC, TU ELECTRIC, AND CONSULTANTS TO DISCUSS THE PRESSURIZER SURGE LINE |
| AUGUST 4, 1988: | IE BULLETIN NO. 88-08 SUPPLEMENT 2 ISSUED |
| AUGUST 18, 1988: | NRC/TU ELECTRIC MEETING TO DISCUSS LEAK-BEFORE-BREAK |

SUMMARY

- RCL-PRESSURIZER $\Delta T$ OCCUR DURING CERTAIN MODES OF OPERATION, WHICH CAN RESULT IN STRATIFICATION OF FLOW IN SURGER LINE.

- EXTENSIVE DATA FROM REFERENCE PLANT AND LABORATORY TESTS ALLOW US TO UNDERSTAND STRATIFICATION.

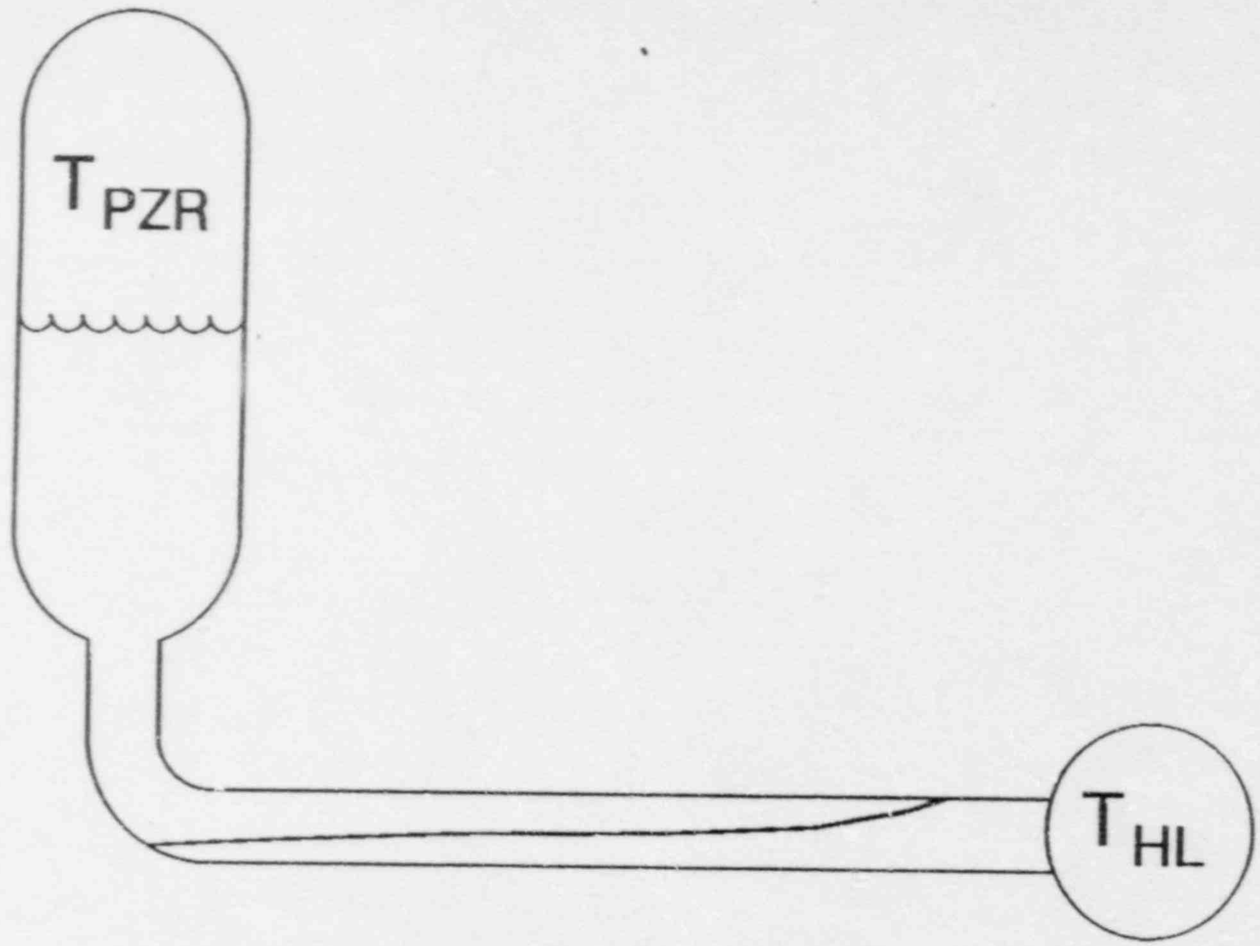
- STRATIFICATION CAN BE PREDICTED AND ANALYZED.

- DESIGN TRANSIENTS WILL BE ADJUSTED TO INCORPORATE STRATIFICATION.

- STRESS ANALYSIS (ASME QUALIFICATION AND LBB) WILL INCORPORATE SURGE LINE STRATIFICATION TRANSIENTS.

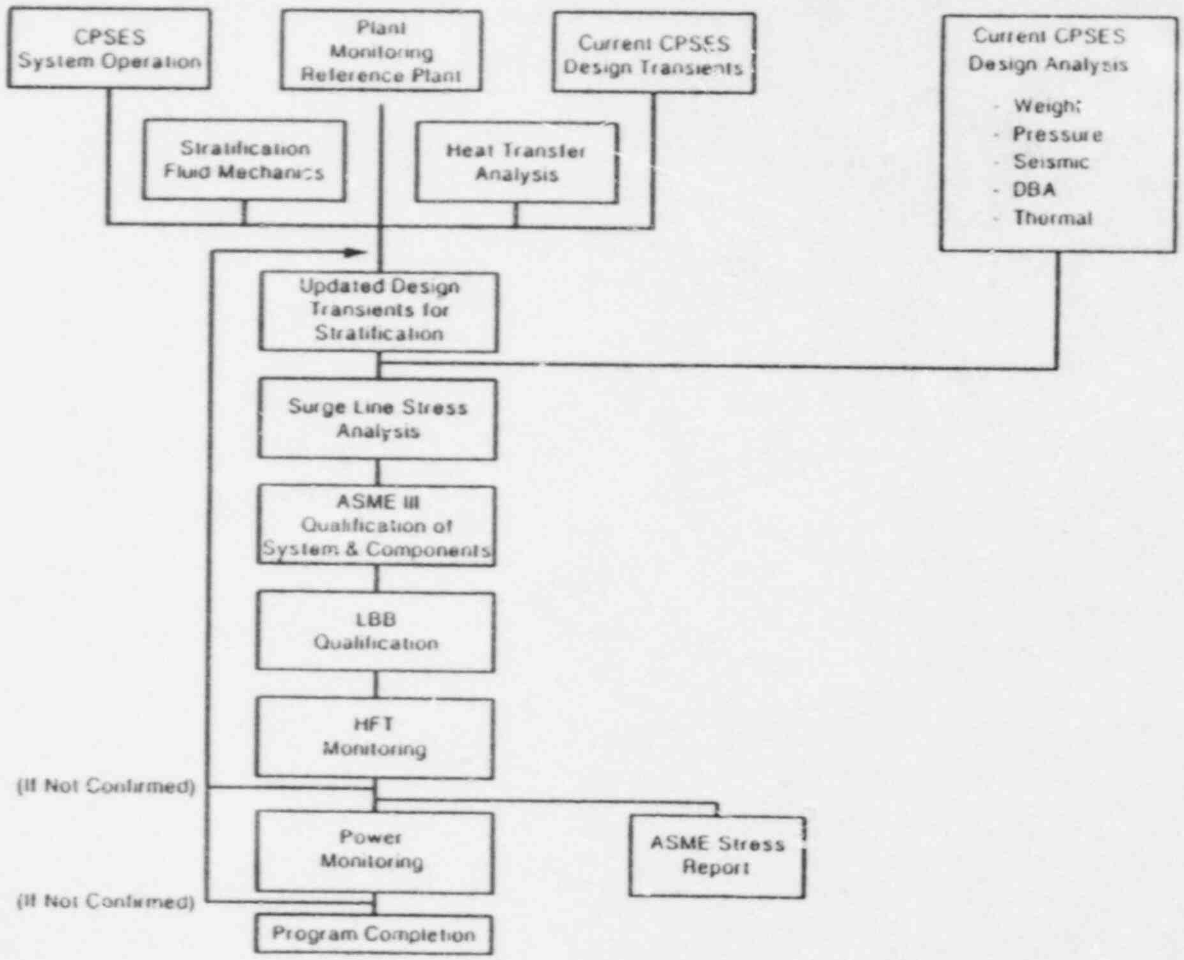
- PROGRESS REPORTS WILL BE PROVIDED TO NRC. A FINAL REPORT (WCAP) WILL BE SUBMITTED.

# Surge Line Stratification




D013 D26914.021

# CPSES Pressurizer Surge Line Stratification ASME III and LBB Qualification Program

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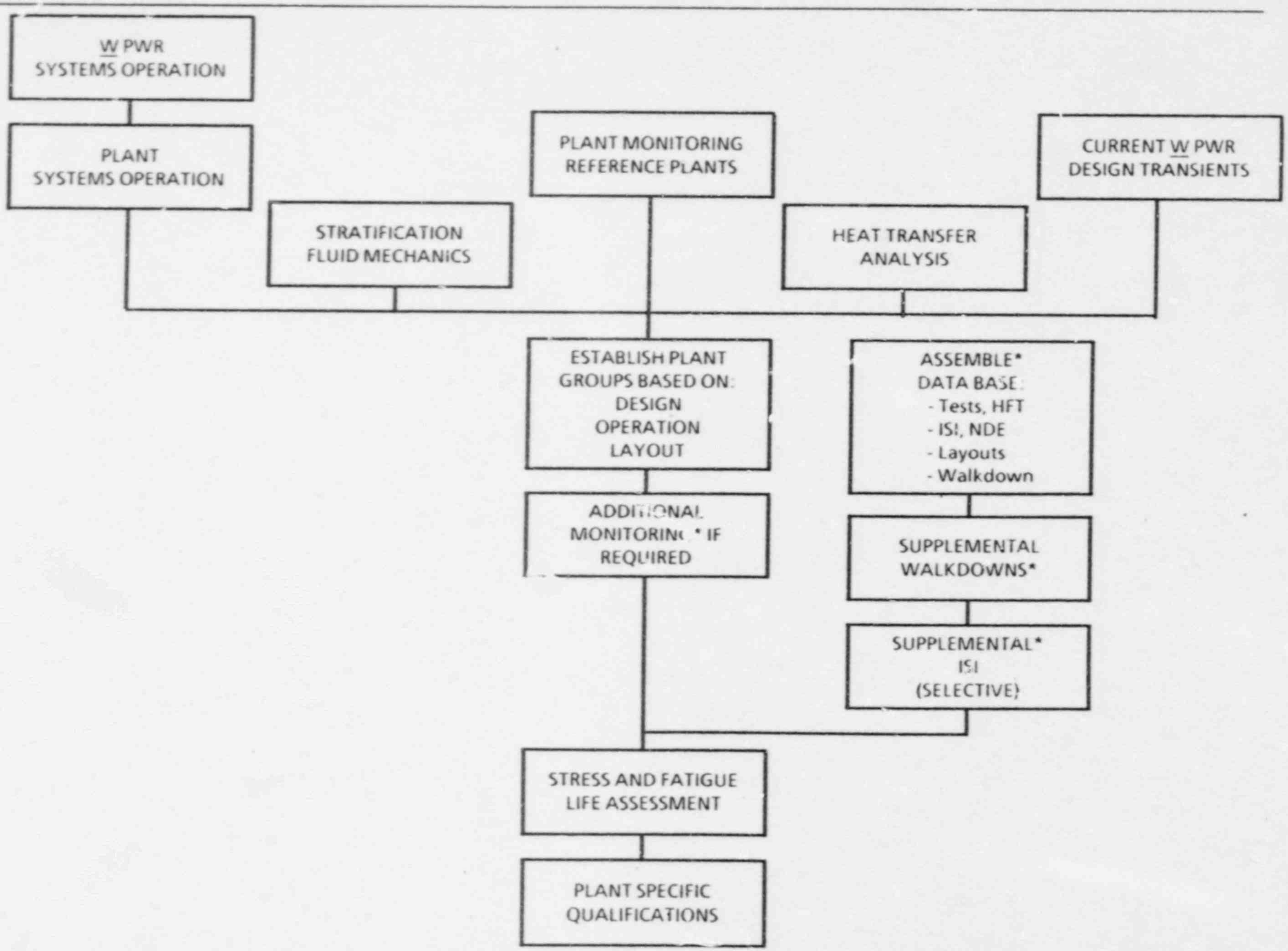
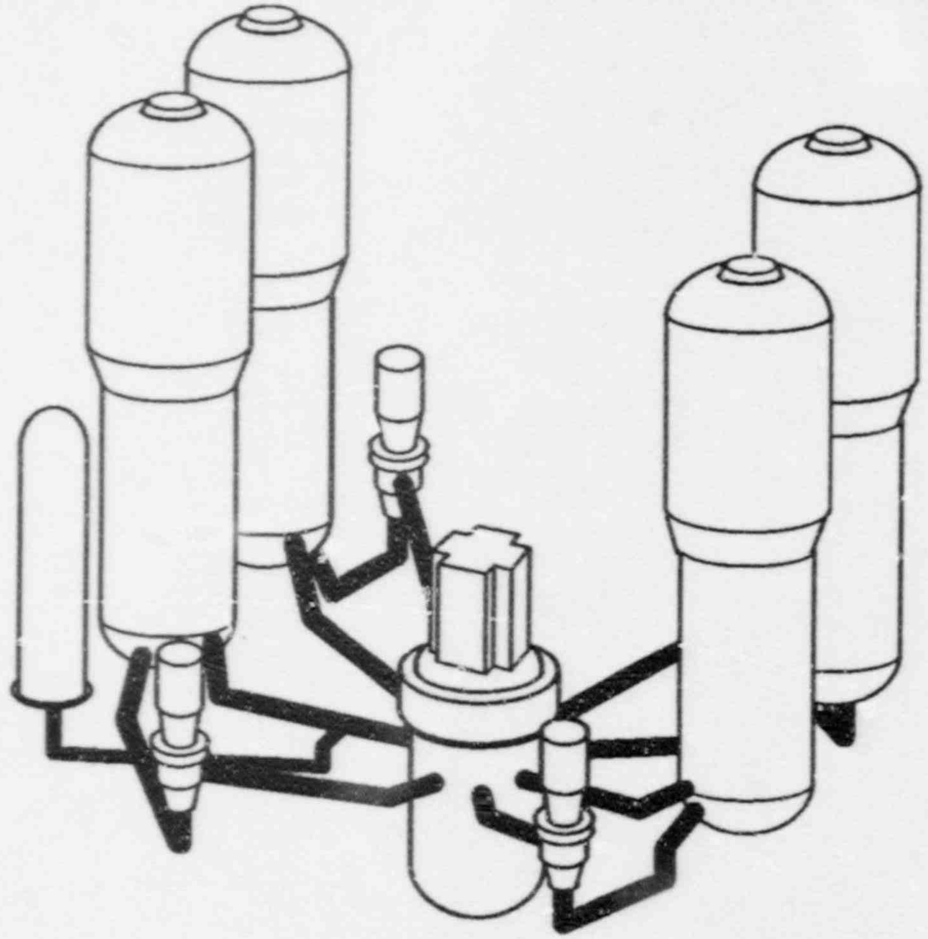
# WESTINGHOUSE PWR'S
# SURGE LINE STRATIFICATION – WOG

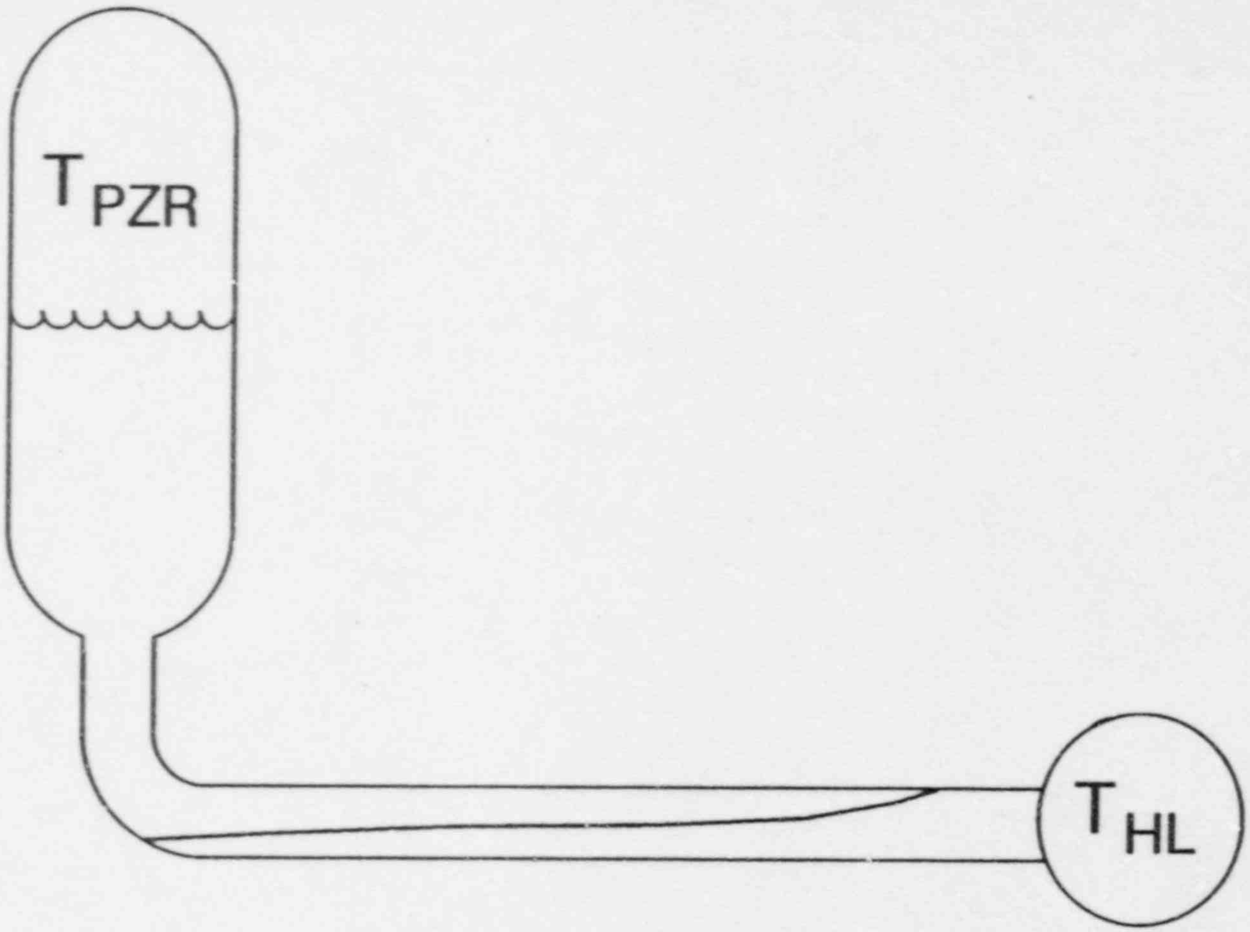


# PRESSURIZER SURGE LINE



1320 D25829.001

# Surge Line Stratification

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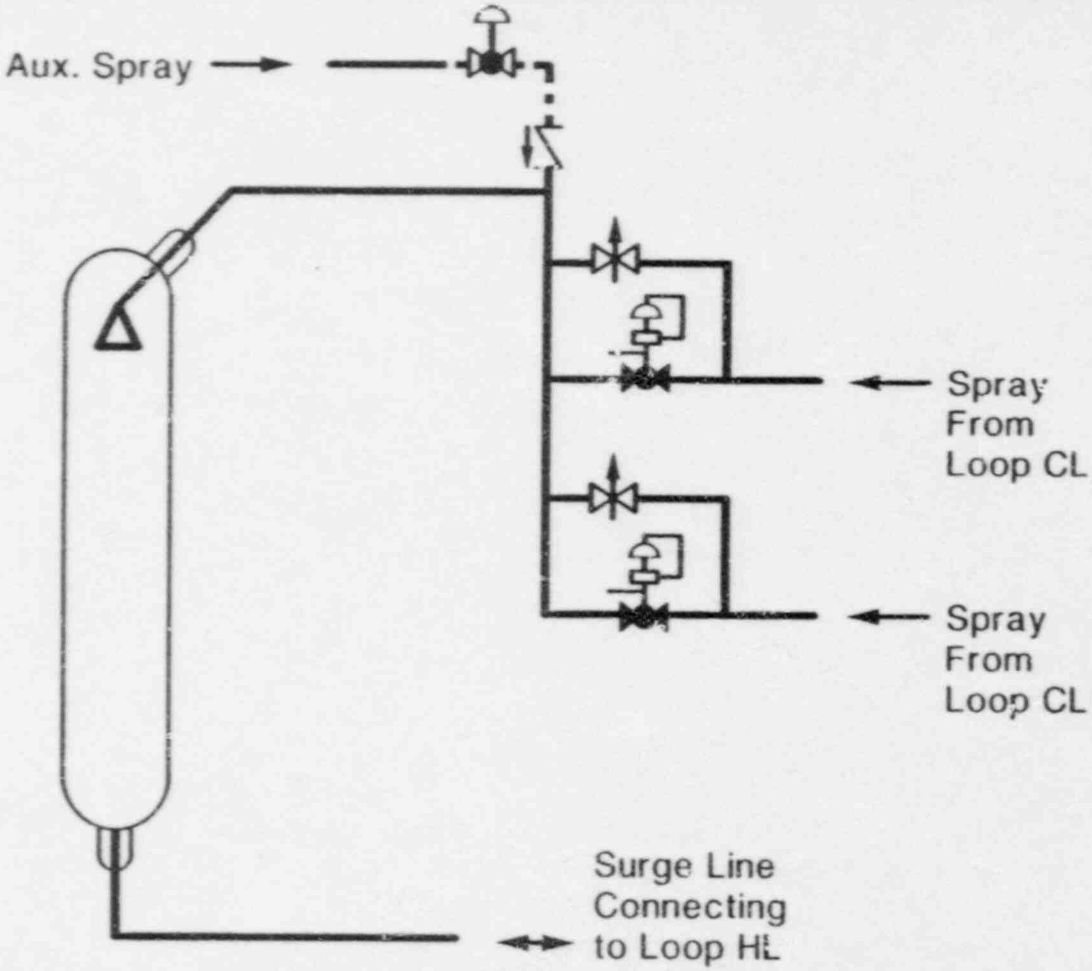
# RCS Pressurizer

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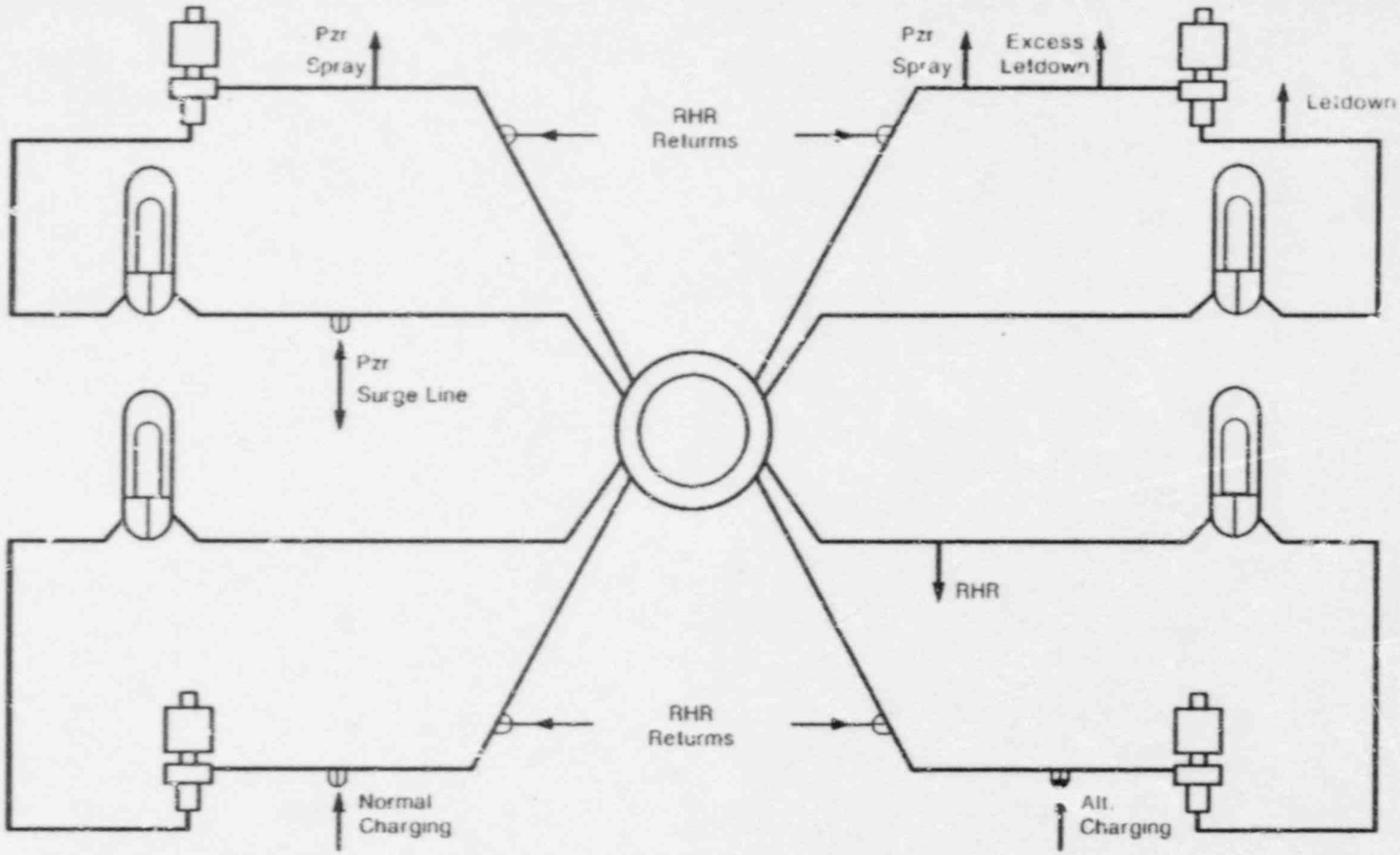
# RCS Loop

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# PRESSURIZER

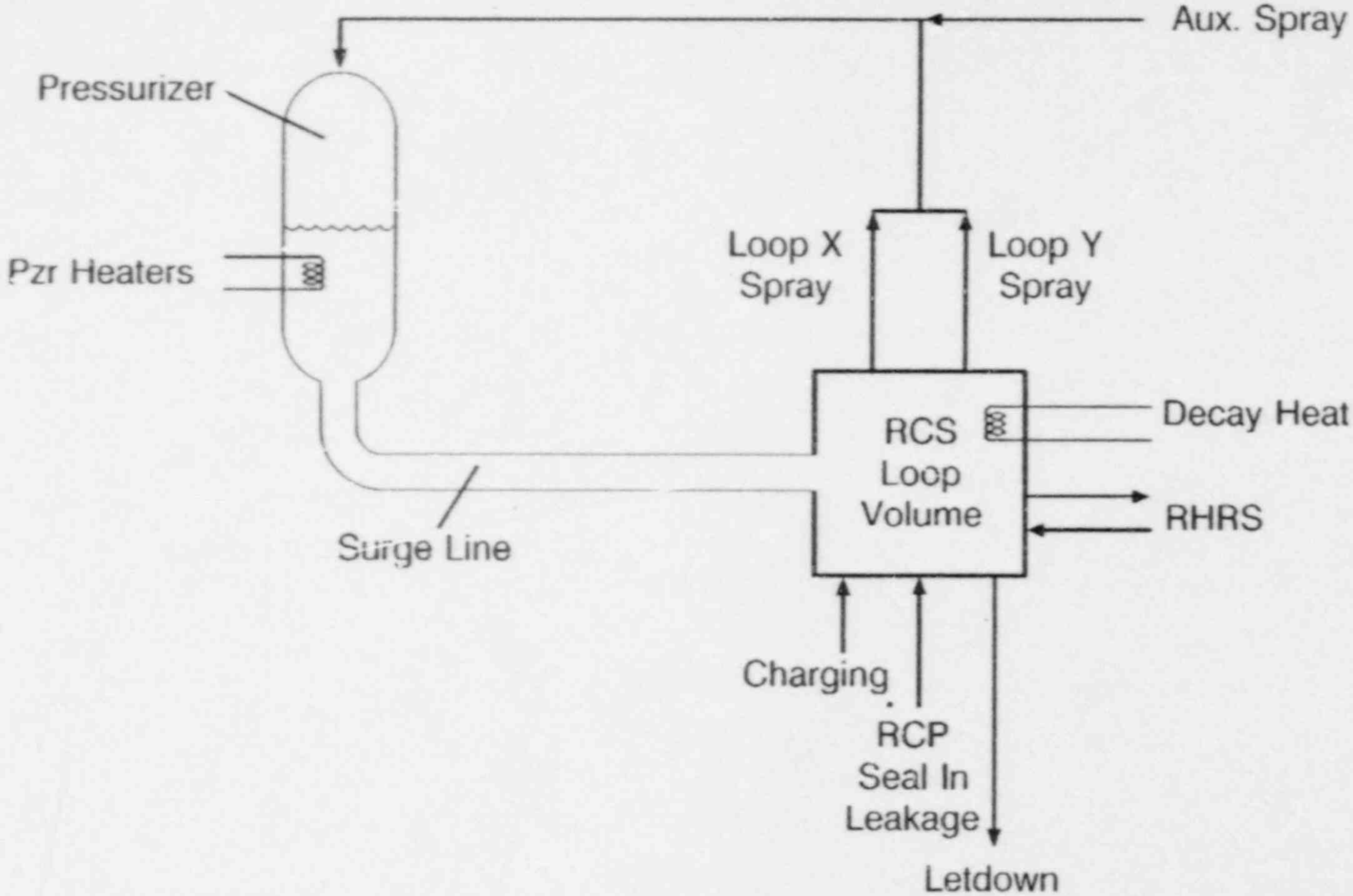
---

PROVIDES A POINT IN THE RCS WHERE LIQUID AND VAPOR CAN BE MAINTAINED IN EQUILIBRIUM UNDER SATURATED CONDITIONS FOR PRESSURE CONTROL PURPOSES.

FUNCTIONS:

- TO PROVIDE A MEANS FOR ATTAINING OPERATING PRESSURE DURING PLANT HEATUP.
- TO MAINTAIN THE REQUIRED RCS PRESSURE DURING STEADY STATE OPERATION.
- TO LIMIT PRESSURE CHANGES DURING NORMAL PLANT OPERATION TO WITHIN AN ALLOWABLE RANGE.
- TO PREVENT ~~TO~~ THE RCS PRESSURE FROM EXCEEDING ITS DESIGN VALUE.

# RCS Mass and Energy Interfaces

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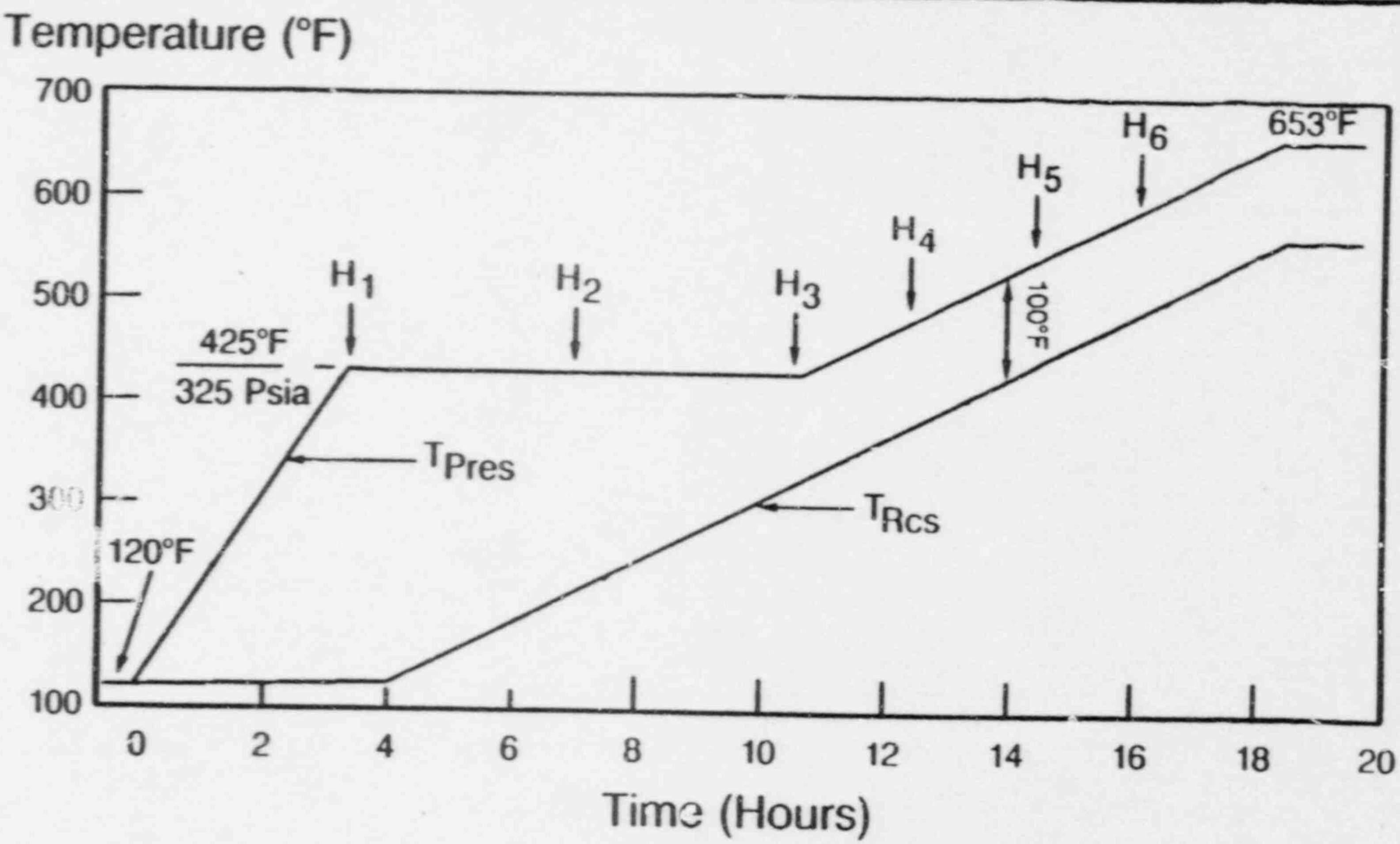
# Steam Bubble Mode Heatup

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# STEAM BUBBLE MODE HEATUP

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ORIGIN OF LARGE PZR - HOT LEG TEMPERATURE DIFFERENTIAL

THE LARGE DIFFERENTIAL TEMPERATURE RESULTS FROM THE REQUIREMENT THAT A STEAM BUBBLE BE PRESENT IN THE PRESSURIZER BEFORE THE RCP'S ARE STARTED.

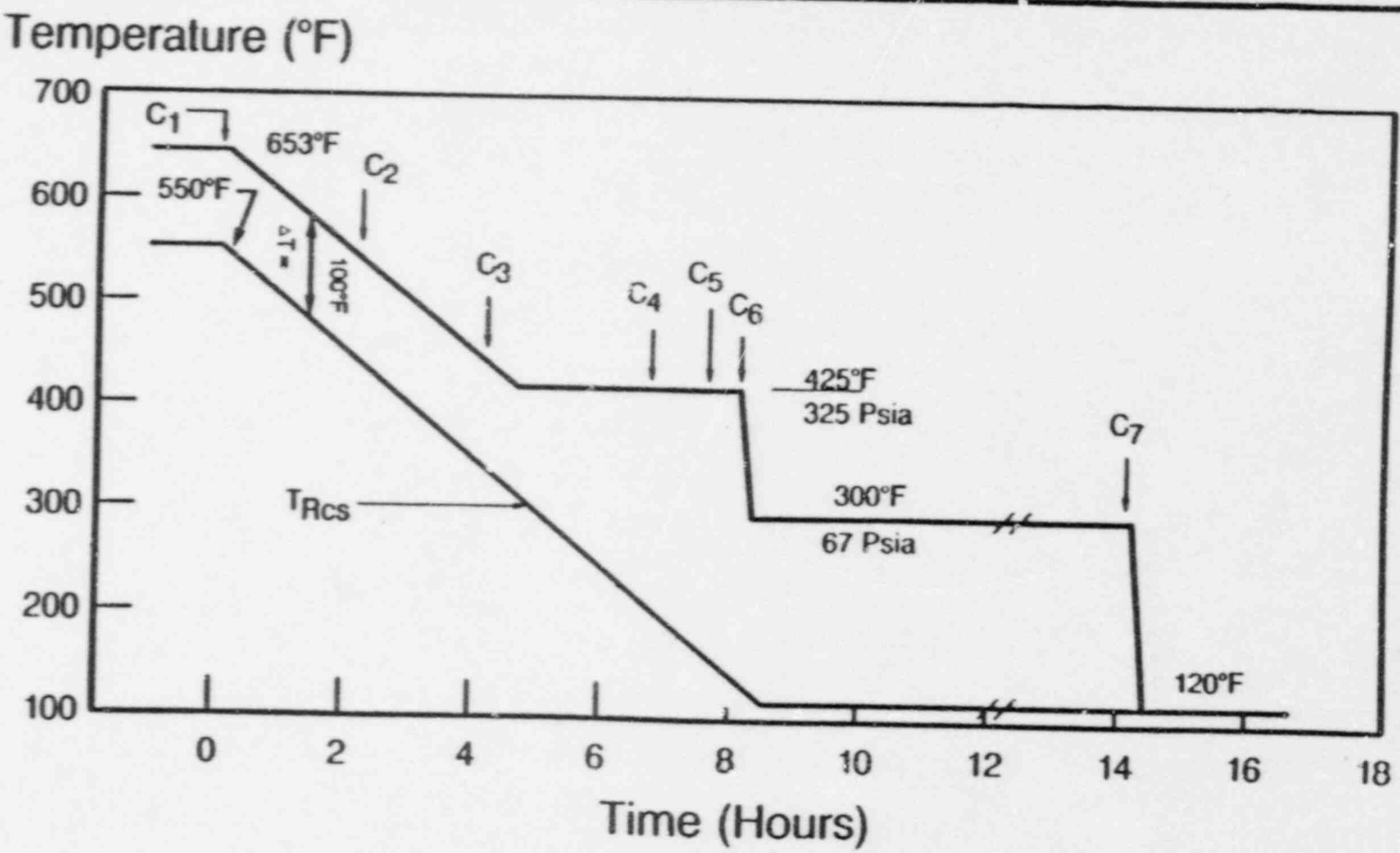
PROCEDURE:

- THE RCS IS PRESSURIZED TO 325 PSIA, THE PRESSURE REQUIRED FOR RCP OPERATION.

- THE PRESSURIZER COOLANT IS THEN HEATED WITH PRESSURIZER HEATERS TO 425°F, THE SATURATION TEMPERATURE, AND A STEAM BUBBLE DRAWN.

- THE RCP'S ARE THEN STARTED TO BEGIN HEATING UP THE RCS COOLANT. AT THIS TIME THE PZR - HOT LEG TEMPERATURE DIFFERENTIAL IS APPROXIMATELY 320°F.

# Steam Bubble Mode Cooldown




D013 D26914.023

# COOLDOWN

ACCOMPLISHED IN TWO PHASES, USING STEAM SYSTEM DOWN TO 350°F AND 400 PSIG AND THEN RHRS.

FOR BOTH STEAM BUBBLE AND WATER SOLID MODES, PZR IS COOLED DOWN TO 425°F WITH PRESSURE AT 325 PSIA.

## STEAM BUBBLE MODE

- WHEN RCS REACHES 160°F, OPERATING RCP IS SHUTOFF.
- SHUTDOWN STEAM BUBBLE CONDITIONS ACHIEVED WITH AUXILIARY SPRAY.

## WATER SOLID MODE

- CHARGING FLOW IS INCREASED AND PRESSURIZER SPRAY OPERATED TO FILL PRESSURIZER AND COLLAPSE BUBBLE.

## 3A. SUMMARY: SYSTEM OPERATION

- MAXIMUM dT OF 320$^{o}$F FOR CPSES

- SIGNIFICANT dT ONLY OCCURS DURING CERTAIN MODES OF OPERATION

- DURING POWER OPERATION dT LESS THAN 50$^{o}$F

- OPERATIONS OF CPSES AND REFERENCE PLANT ARE VERY SIMILAR

# Outline

- Criterion to establish stratification
- Spatial variations in stratified flow
- Thermal striping potential associated with stratification

## TABLE 4-II

### IMPORTANT DIMENSIONLESS GROUPS FOR SIMILITUDE IN HYDRODYNAMIC TESTING

| Parameter | Symbol | Definition | Significance |
|---|---|---|---|
| 1. Weisbach friction factor | $f$ | $D\Delta P/2\rho V^2 L$ | Pressure force/inertia force |
| 2. Cavitation number | $b$ | $(P_s - P_v)/\rho V^2$ | Pressure difference/inertia force |
| 3. Reynolds number | Re | $\rho VD/\mu$ | Inertia force/viscous force |
| 4. Strouhal number | Sr | $\eta D/V$ | Vortex shedding frequency/inertia force |
| 5. Weber number | We | $\rho DV^2/\sigma$ | Inertia force/surface-tension force |
| 6. Froude number | Fr | $V^2/gD$ | Inertia force/gravity force |
| 7. Richardson number (Modified Froude number) | Ri | $\Delta\rho gD/\rho V^2$ | Buoyancy force/inertia force |
| 8. Euler number | Eu | $\Delta P/\rho V^2$ | Pressure force/inertia force |
| 9. Prandtl number | Pr | $\mu C/k$ | Momentum diffusivity/thermal diffusivity |
| 10. Peclet number | Pe | $\rho VDC/k$ (Re × Pr) | Convective heat transfer/conductive heat transfer |
| 11. Grashof number | Gr | $L^3\rho^2 g\beta\Delta T/\mu^2$ | Buoyancy force/viscous force |
| 12. Rayleigh number | Ra | $L^3\rho^2 Cg\beta\Delta T/\mu k$ (Gr × Pr) | — |

NOMENCLATURE:

$C$ = specific heat
$\rho$ = density
$\sigma$ = surface tension
$k$ = thermal conductivity
$\beta$ = volumetric expansion coefficient
$\Delta T$ = fluid temperature change
$\eta$ = vortex shedding frequency
$g$ = acceleration of gravity
$P$ = pressure
$P_s$ = static fluid pressure
$P_v$ = fluid vapor pressure
$L, D$ = characteristic dimensions
$V$ = fluid velocity
$\mu$ = viscosity

# Stratification Potential Based on Richardson Number

- Stratification potential exists if $Ri > 1$
- Example: 90 GPM in 14" schedule 140 pipe with 300°F hot-to-cold temperature difference gives

$$Ri = \frac{\Delta \rho g D}{V^2} = \frac{g \beta \Delta T D}{V^2} \cong 60$$

OR if ~ 700 GPM

$Ri = 1$

OR if $\Delta T \sim 5°F$

$Ri = 1$

1340 D26914.003

## Spatial Variations in Stratified Flow

- o Limited heat exchange between hot and cold fluid layers; earlier example would only attenuate $\Delta T$ by 10% after 70 feet (using standard semi-inifinite body solution).

- o Stratified flow could persist in the stratified state for long periods after flow stops.

- o Based on observations from small and large diameter Westinghouse tests, flow in $90^{\circ}$ elbow would be expected to have pattern shown by attached figure.

- o Hot-to-cold interface can be steep as shown by attached data from Westinghouse tests.

# Thermal Striping Associated with Stratification

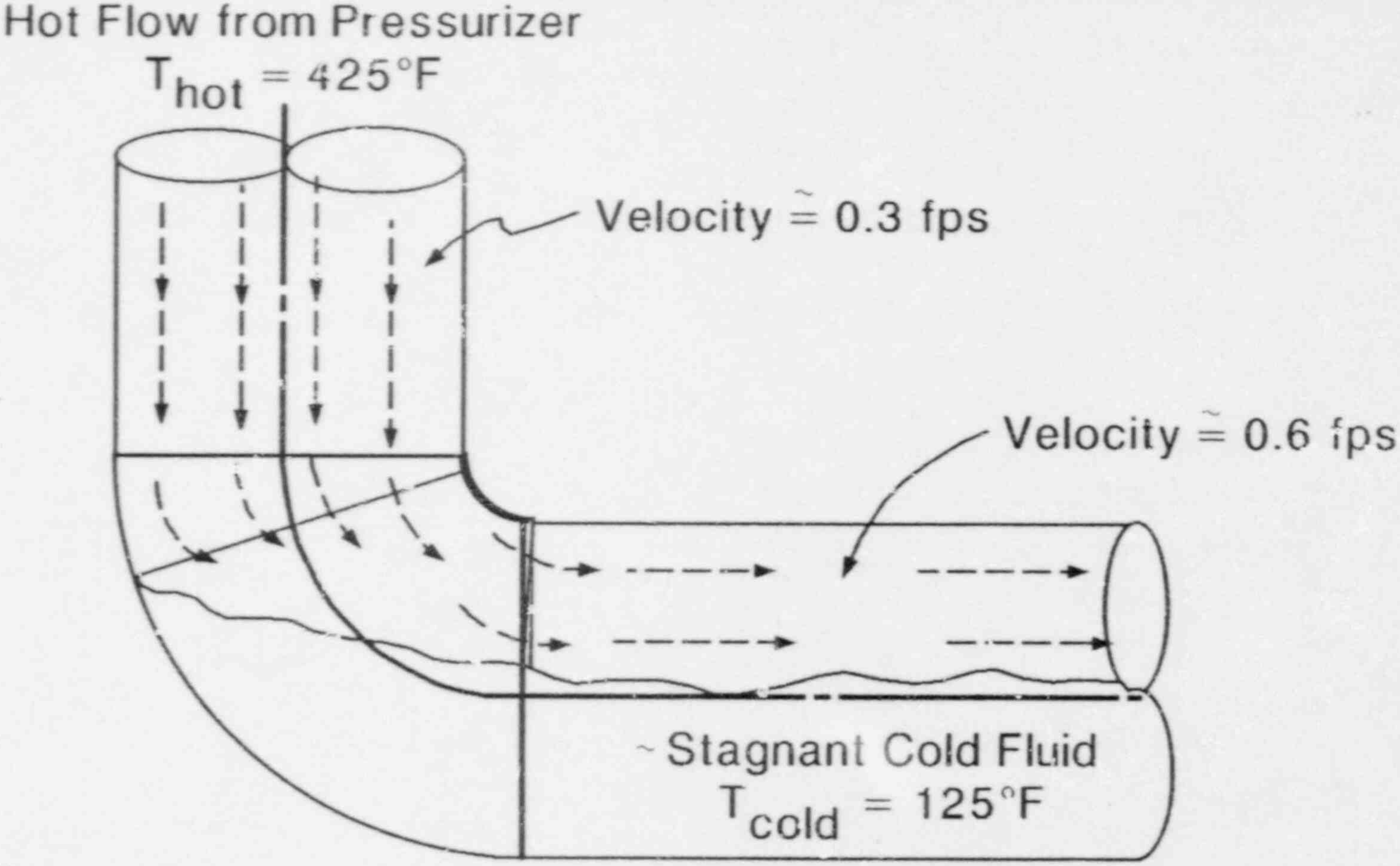
- Hot-to-cold interfacial surface oscillation in range of 0.1 to 10 hertz (Westinghouse tests + Japanese tests).
- Heat transfer coefficient, BTU/ HR-FT$^2$ -°F, in range (for earlier example).

  $263 \leq H_{MAX} < 1052$

  Based on boundary layer development arguments (fully developed, classical entrance region or limited Bergles data for vibrating plates).

10 D26914.006

# Estimate of Flow Stratification Pattern in Elbow Under Pressurizer




1340 D26914.008

3B. SUMMARY: STRATIFICATION

- STRATIFICATION CAN BE PREDICTED
- THERMAL HYDRAULIC PARAMETERS (ΔT, D AND v) SIMILAR FOR CPSES AND REFERENCE PLANT.
- EXISTING TEST DATA GENERALLY APPLICABLE TO SURGE LINE.

# TU ELECTRIC

# IPO-001A/IPO-005A HEATUP/COOLDOWN PROCEDURES

COMANCHE PEAK
STEAM ELECTRIC
STATION

RALPH FLORES

IPC-001A

PLANT HEATUP PROCEDURE

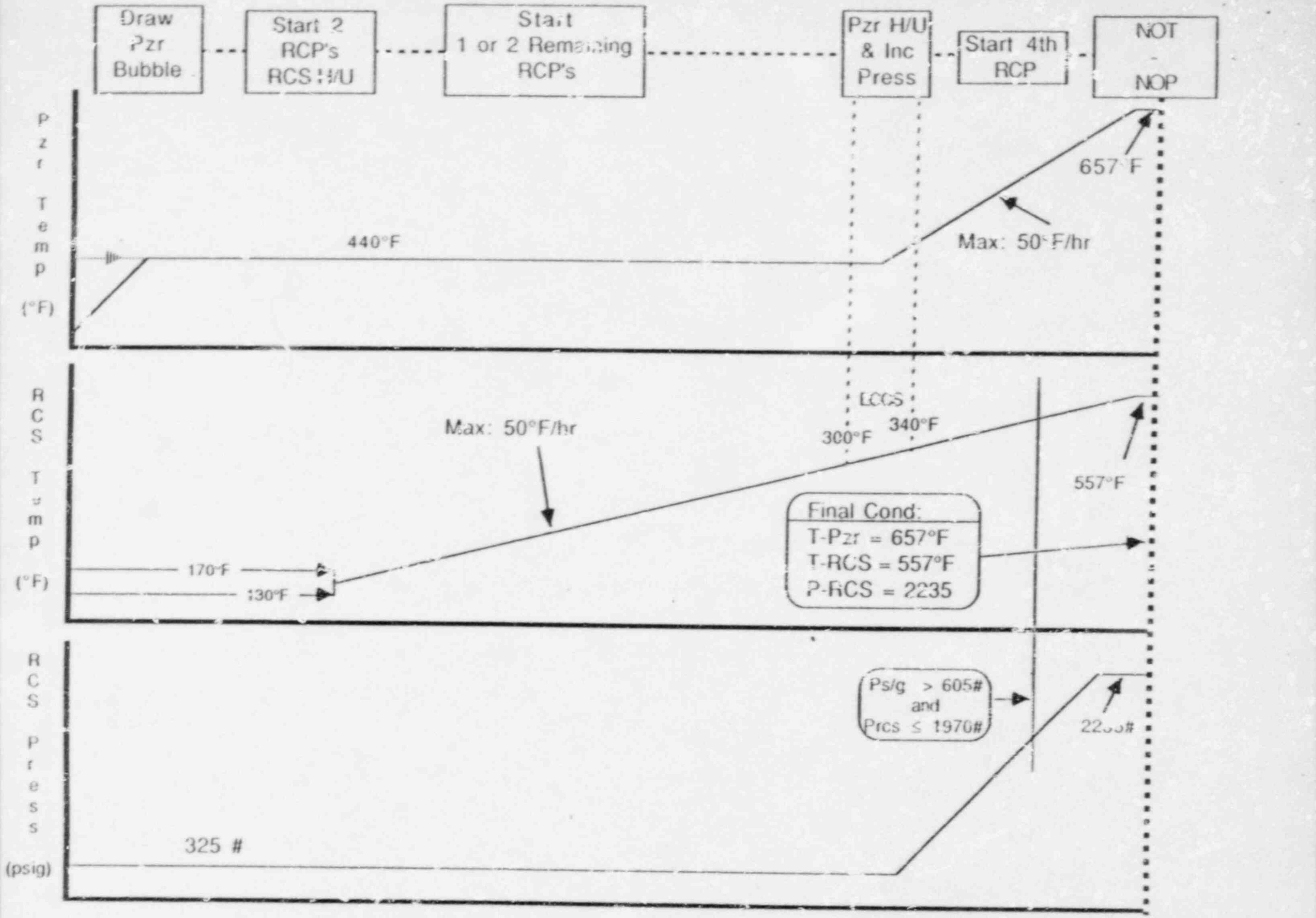
MAJOR EVOLUTIONS PERTAINING TO HEATUP

INITIAL CONDITIONS

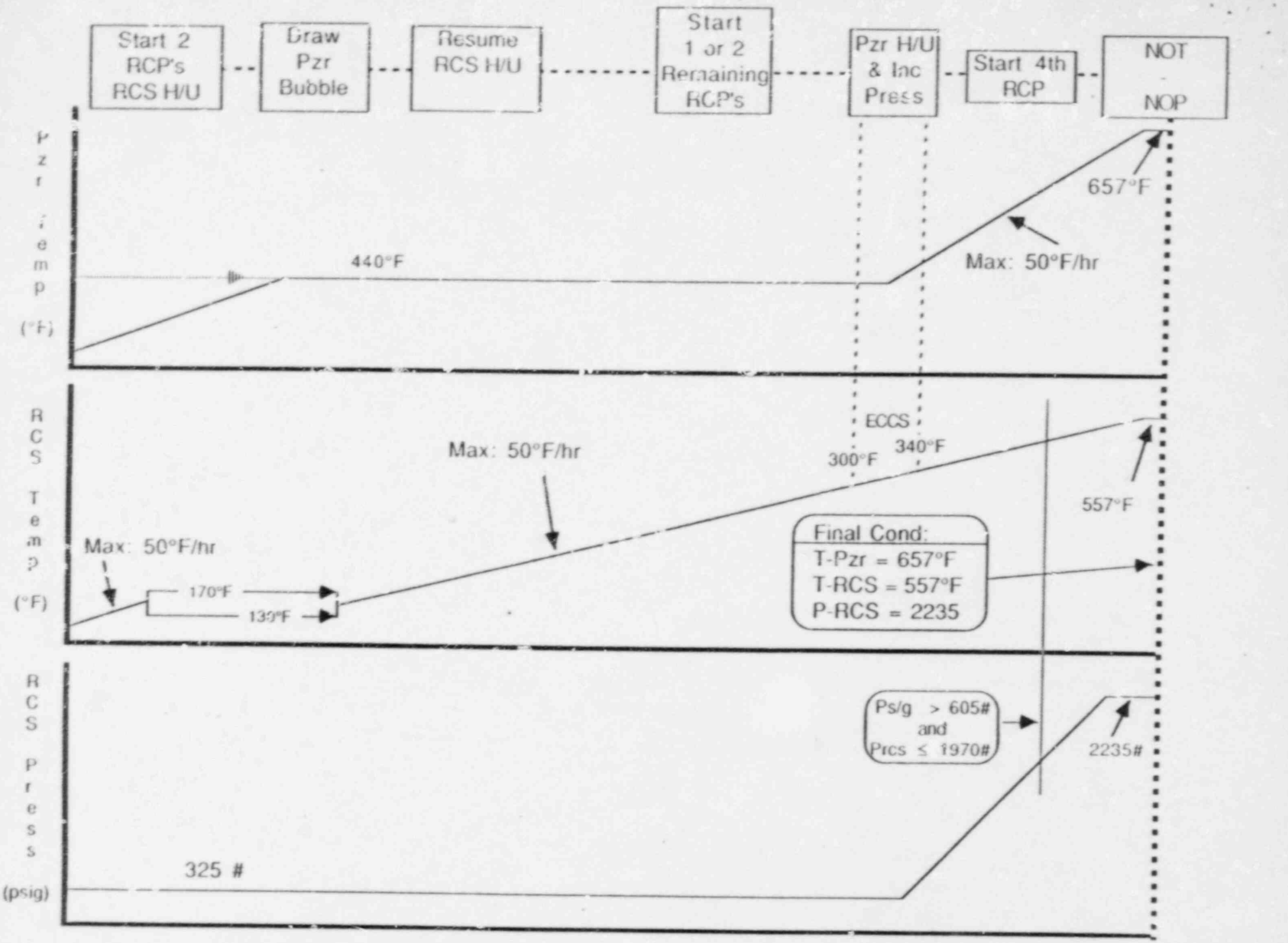
- RCS TI [illegible] °F, 170°F
- RCS PR [illegible] 5 PSIG
- PRZR TE [illegible] 0°F, 170°F

PROCEDURAL GUIDANCE

- START NO 1 AND 4 REACTOR COOLANT PUMPS INITIATING PLANT HEATUP. (ONLY IF RCS TEMP ≤ .30°F)
- INITIATE PRESSURIZER HEATUP.
- DRAW PRESSURIZER BUBBLE.
- CHEMISTRY PARAMETERS IN SPEC.
- START NO 1 AND 4 REACTOR COOLANT PUMPS TO INITIATE RCS HEATUP. IF NOT PREVIOUSLY DONE.
- RHR OUT OF SERVICE.
- START NO 2 AND 3 REACTOR COOLANT PUMPS TO ASSIST IN RCS HEATUP.
- INITIATE PRESSURIZER HEATUP AND PRESSURE INCREASE.
- START REMAINING REACTOR COOLANT IF NOT PREVIOUSELY DONE.



Draw Pzr Bubble
Start 2 RCP's RCS H/U
Start 1 or 2 Remaining RCP's
Pzr H/U & Inc Press
Start 4th RCP
NOT - NOP
Pzr Temp (°F)
440°F
Max: 50°F/hr
657°F
RCS Temp (°F)
170°F
130°F
Max: 50°F/hr
ECCS
300°F
340°F
557°F
Final Cond:
T-Pzr = 657°F
T-RCS = 557°F
P-RCS = 2235
RCS Press (psig)
325 #
Psig > 605#
and
Prcs ≤ 1970#



Start 2 RCP's RCS H/U
Draw Pzr Bubble
Resume RCS H/U
Start 1 or 2 Remaining RCP's
Pzr H/U & Inc Press
Start 4th RCP
NOT - NOP
Pzr Temp (°F)
440°F
657°F
Max: 50°F/hr
RCS Temp (°F)
ECCS
300°F
340°F
Max: 50°F/hr
557°F
Max: 50°F/hr
170°F
130°F
Final Cond:
T-Pzr = 657°F
T-RCS = 557°F
P-RCS = 2235
RCS Press (psig)
Ps/g > 605# and Prcs ≤ 1970#
2235#
325 #

IPO-001A

PLANT HEATUP PROCEDURE

| | INITIAL CONDITIONS | BUBBLE 50°F/HR | RCP START 50°F/HR | PRZR H/U 50°F/HR | FINAL CONDITION |
|---|---|---|---|---|---|
| RCS TEMP | BETWEEN 130-170 | BETWEEN 130-170 | HEATUP 130-300 | HEATUP 300-557 | |
| TIME DURATION | N/A | N/A | 4 HRS | 6 HRS | 557 |
| PRESSURIZER | BETWEEN 130-170 | HEATUP 130 to 440 | 440 | 440 to 657 | |
| TIME DURATION | N/A | 7 HRS | N/A | 5 HRS | 657 |
| PRESSURIZER PRESSURE | 325 | 325 | 325 | PRESSURIZE 325 to 2235 | |
| TIME DURATION | N/A | 7 HRS | N/A | 5 HRS | 2235 |
| DELTA T (PRZR,RCS) | 0 | 0 to 310 | 310 to 140 | 140 to 100 | |
| TIME DURATION | | 7 HRS | 4 HRS | 6 HRS | |

IPO-005A

PLANT COOLDOWN PROCEDURE

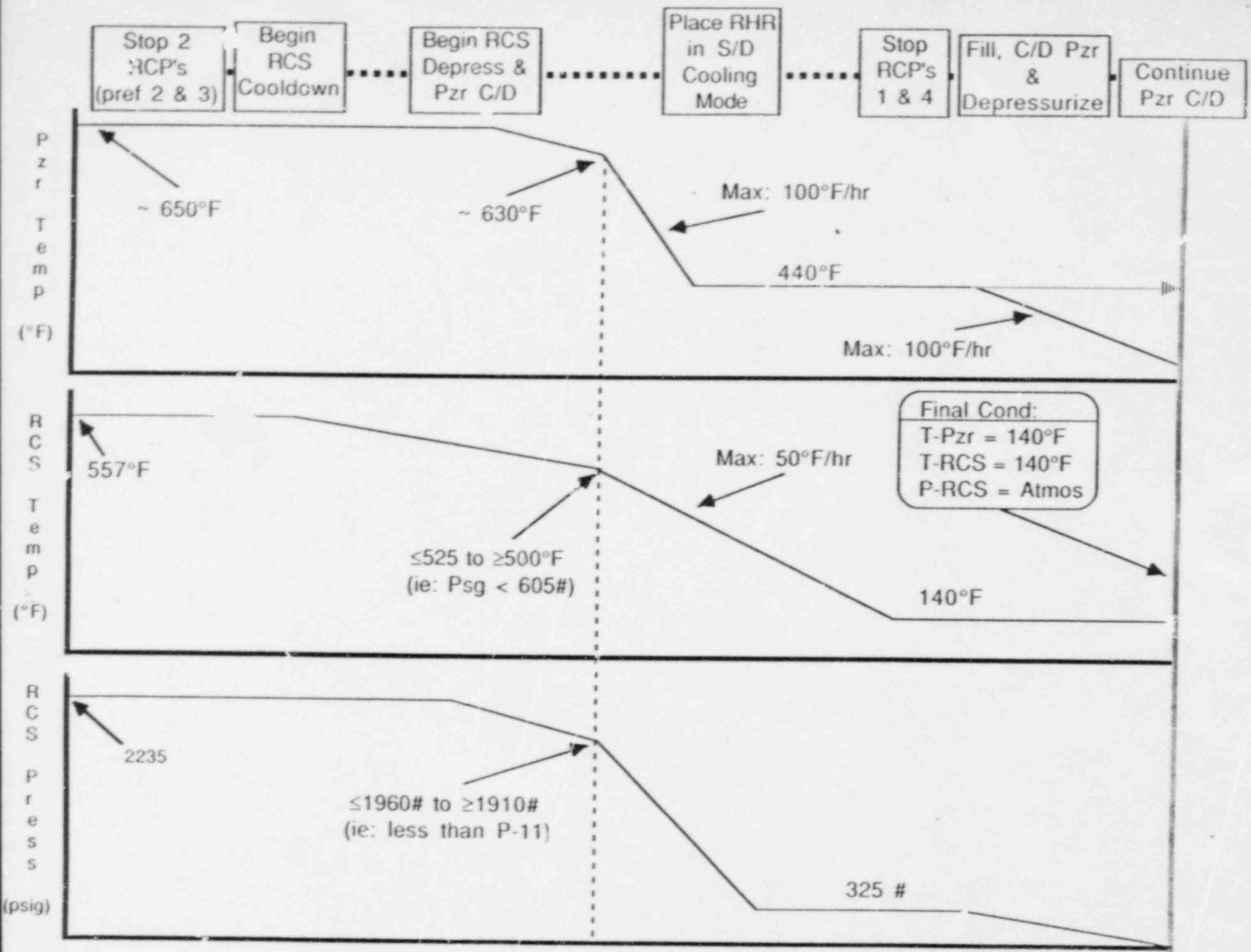
MAJOR EVOLUTIONS PERTAINING TO COOLDOWN

INITIAL CONDITIONS

- RCS TEMP 557°F
- RCS PRESS 2235 PSIG
- PRZR TEMP 657°F

PROCEDURAL GUIDANCE

- STOP NO. 2 AND 3 REACTOR COOLANT PUMPS TO INITIATE RCS COOLDOWN.
- INITIATE RCS DEPRESSURIZATION AND PRESSURIZER COOLDOWN.
- INITIATE RHR COOLING.
- STOP NO. 1 AND 4 REACTOR COOLANT PUMPS.
- FILL, COOLDOWN AND DEPRESSURIZE PRESSURIZER.
- CONTINUE PRESSURIZER COOLDOWN.



Stop 2
RCP's
(pref 2 & 3)
Begin
RCS
Cooldown
Begin RCS
Depress &
Pzr C/D
Place RHR
in S/D
Cooling
Mode
Stop
RCP's
1 & 4
Fill, C/D Pzr
&
Depressurize
Continue
Pzr C/D
Pzr Temp (°F)
~ 650°F
~ 630°F
Max: 100°F/hr
440°F
Max: 100°F/hr
RCS Temp (°F)
557°F
≤525 to ≥500°F
(ie: Psg < 605#)
Max: 50°F/hr
140°F
Final Cond:
T-Pzr = 140°F
T-RCS = 140°F
P-RCS = Atmos
RCS Press (psig)
2235
≤1960# to ≥1910#
(ie: less than P-11)
325 #

IPO-005A

PLANT COOLDOWN PROCEDURE

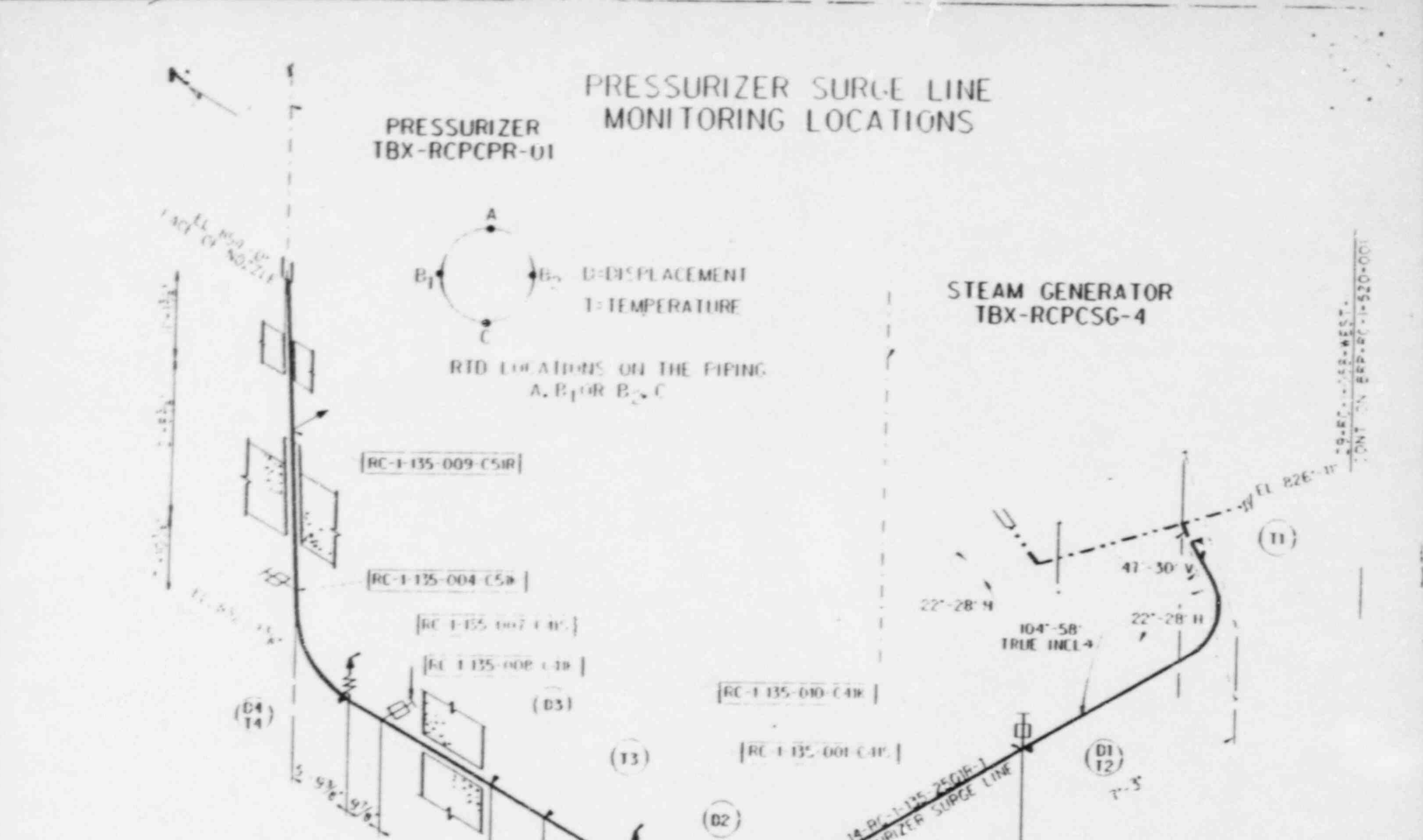
| | INITIAL CONDITIONS | BEGIN RCS COOLDOWN 50°F/HR | BEGIN RCS DEPRESS & 100°F/HR | RHR IN SERVICE | FILL, C/D PRZR & DEPRESSURIZE | FINAL CONDITIONS |
|---|---|---|---|---|---|---|
| RCS TEMP | 557 | COOLDOWN 557 to 530 | COOLDOWN 530 to 500 | COOLDOWN 500 to 300 | COOLDOWN 300 to 140 | |
| TIME DURATION | N/A | 1 HR | 1 HR | 5 HRS | 4 HRS | 140 |
| PRESSURIZER TEMP | 657 | 657 | COOLDOWN 657 to 630 | COOLDOWN 630 to 440 | COOLDOWN 440 to 140 | |
| TIME DURATION | N/A | N/A | 1 HR | 3 HRS | 4 HRS | 140 |
| PRESSURIZER | 2235 | 2235 | DEPRESSURIZE 2235 to 1960 | DEPRESSURIZE 1960 to 350 | DEPRESSURIZE 325 to 50 | |
| TIME DURATION | N/A | N/A | 1 HR | 3 HRS | 4 HRS | ATMOS. |
| DELTA T (PRZR, RCS) | 100 | 127 | 130 | 130 | 300 to 0 | |
| TIME DURATION | | 1 HR | 1 HR | 5 HRS | 5 HRS | |

PROCEDURAL CONTROLS

FOR TEMPERATURE

AND PRESSURE LIMITS

- PROCEDURAL STEP SEQUENCING (BUBBLE CHARTS)
- PRECAUTIONS
  - SUBCOOLING MINIMUM
  - 320 DELTA T LIMIT
  - COOLDOWN/HEATUP LIMITS (ADMINISTRATIVE)
  - SUBCOOLING DELTA T LIMIT (RCS, PRZR)
  - LOGGING TEMPERATURES
  - TECH SPEC CURVES



PRESSURIZER SURGE LINE
MONITORING LOCATIONS
PRESSURIZER
TBX-RCPCPR-01
STEAM GENERATOR
TBX-RCPCSG-4
A
C
D=DISPLACEMENT
T=TEMPERATURE
RTD LOCATIONS ON THE PIPING
RC-1-135-009-C5IR
RC-1-135-004-C5IR
RC-1-135-010-C4IR
(D4 T4)
(D3)
(T3)
(D2)
(D1 T2)
(T1)
22"-28" H
47"-30" V
104"-58"
TRUE INCL
SLOPE
PRESSURIZER SURGE LINE
EL 826'-11"

# PRESSURIZER SURGE LINE MONITORING PARAMETERS

- LOCATIONS/DIRECTIONS
  - LOCATIONS D1 THROUGH D4 AND T1 THROUGH T4 ($\pm$6")
  - LATERAL AND VERTICAL READINGS AT ALL LOCATIONS

- RECORDING INTERVALS
  - EVERY 10 MINUTES DURING HEATUP
  - EVERY 60 MINUTES AT EACH TEMPERATURE PLATEAU

- RECORDING SYSTEM CAPABILITIES
  - 10 SECOND INTERVALS FOR A PERIOD OF 10 MINUTES
  - PROVIDE LABELED PLOTS OF TEMPERATURES AND DISPLACEMENTS AS A FUNCTION OF TIME
  - AVERAGE ALL TEMPERATURE READINGS AT EACH MEASUREMENT TIME

80901-3

ENCLOSURE 4

# *DUQUESNE LIGHT COMPANY*

# *BEAVER VALLEY UNIT 2*

# *PRESSURIZER SURGE LINE STRATIFICATION*

*S. K. MUKHERJEE*
*NUCLEAR ENGINEERING DEPARTMENT*

BACKGROUND

- ORIGINAL CONFIGURATION OF SURGE LINE (PRE HFT)
  - TANDEM 6 KIP MECH. SNUBBERS INSTALLED
  - WHIP RESTRAINTS REMOVED PER WHIPJET PROGRAM
  - 2 VARIABLE SPRING HANGERS INSTALLED
  - 1 PERMANENT RTD INSTALLED
  - OPERATING LIMITS - MAX TEMP. DIFF. 300°F

- STRATIFICATION FIRST BECAUSE APPARENT DURING HFT
  - UNUSUAL MOVEMENT OF SNUBBERS NOTED
  - ADDITIONAL INSTRUMENTATION INSTALLED TO REMOTELY MONITOR DISPLACEMENT DURING FUTURE TESTING

- DURING PREOP AND POWER ASCENSION TESTING FURTHER DISPLACEMENT OF A CYCLIC NATURE WERE OBSERVED
  - MAX. RECORDED DISPLACEMENT WAS ~ 3.0 INCHES VERSUS .4 IN. CALCULATED DISPLACEMENT
  - MAX. DISPLACEMENT OCCURRED DURING HEAT UP AND COOL DOWN

- FROM EVALUATION OF DATA CONCLUDED THAT HIGH DISPLACEMENTS WERE A RESULT OF FLUID THERMAL STRATIFICATION

DATA COLLECTION

- - PIPING DISPLACEMENTS APPEARED TO VARY AS A FUNCTION OF TEMPERATURE DIFFERENTIAL BETWEEN THE PRESSURIZER AND THE RCS HOT LEG
- - ADDITIONAL INSTRUMENTATION INSTALLED TO REMOTELY MONITOR TEMPERATURE
- - CONTINUED PLANT TESTING WITH CONTINUOUS MONITORING OF DISPLACEMENTS AND TEMPERATURE

ACTIONS

- - IMPOSED HEAT UP/COOL DOWN LIMITATION OF $\Delta T \leq 200^{\circ}F$ BETWEEN PRESSURIZER AND RCS HOT LEG
- - REMOVED SNUBBER TRAPEZE ON SURGE LINE UTILIZING ASME CODE CASE N-411
- - ANALYSIS CONDUCTED TO QUANTIFY EFFECTS OF STRATIFICATION

## SPECIFIC ANALYSIS

- - SIMPLIFIED 'ANSYS' MODEL OF SURGE LINE GENERATED

  - MODEL COMPRISED OF ELASTIC BEAM ELEMENTS

  - FIRST BENCH MARKED 'ANSYS' MODEL TO ORIGINAL 'NUPIPE' MODEL

  - ALL THERMAL CONDITIONS APPLICABLE TO SURGE LINE WERE REVIEWED TO DETERMINE THE PRESENCE OF THERMAL STRATIFICATION AND POTENTIAL EFFECTS ON THE EXISTING PIPING ANALYSIS

  - THESE THERMAL CONDITIONS INCLUDED

    - NORMAL POWER OPERATION

    - HEAT UP AND COOL DOWN

    - MAXIMUM STRATIFICATION FOLLOWING PLANT EXCURSION/TRIP

- - 'ANSYS' MODEL INCORPORATED ACTUAL RECORDED IN-PLANT TEMPERATURE DATA DURING THE ABOVE THERMAL CONDITIONS TO QUANTIFY THERMAL STRATIFICATION EFFECTS

- - RESULTS OF 'ANSYS' MODEL (FORCES, MOMENTS) FOR EACH APPLICABLE THERMAL CONDITION WAS RE-EVALUATED BY THE ORIGINAL 'NUPIPE' MODEL

- - NUPIPE MODEL THEREFORE COMBINED THE EFFECTS OF THERMAL STRATIFICATION WITH ALL OTHER LOADING CONDITIONS

## WHIPJET REVIEW

- EFFECT OF REVISED ANALYSIS ON SURGE LINE EVALUATED
  - LEAKAGE SIZE FLAW RECALCULATED
  - STABILITY EVALUATION CONDUCTED
  - FATIGUE CRACK GROWTH RATE ANALYSIS REVIEWED
- MAINTAINED MARGINS PER NUREG 1061 VOL. 3

BV-1 SURGE LINE REVIEW

- GEOMETRY CLOSELY APPROXIMATES BV-2
  - THIS INCLUDES PIPE ROUTING, SIZE, ENTRANCE INTO HOT LEG AND SLOPE
- SUPPORTING ARRANGEMENT SIMILAR TO BV-2
  - NO RUPTURE RESTRAINTS ON SURGE LINE
  - PIPING SUPPORTED BY TWO VARIABLE SPRING HANGERS
- OPERATIONAL RESTRICTIONS IMPOSED DURING HEATUP/ COOLDOWN SIMILAR TO BV-2
- PIPING LOADS DUE TO STRATIFICATION FROM BV-2 ANALYSIS BEING EVALUATED

CONCLUSIONS

- STRATIFICATION EFFECTS WERE QUALIFIED AND INCORPORATED INTO THE ANALYSIS

- ANALYSIS SHOWS THAT CODE ACCEPTABILITY MAINTAINED UNDER ALL CASES

- WHIPJET REANALYSIS OF SURGE LINE DEMONSTRATES PIPE LBB CAPABILITY UNDER REVISED LOADING

- OPERATIONAL RESTRICTIONS OF $\Delta T \leq 200°F$ IMPOSED DURING HEATUP AND COOLDOWN ON BOTH BV-1 AND BV-2

- SIMILARITY OF BOTH UNITS SHOWS BV-2 STRATIFICATION EFFECTS/LOADS CAN BE APPLIED TO BV-1

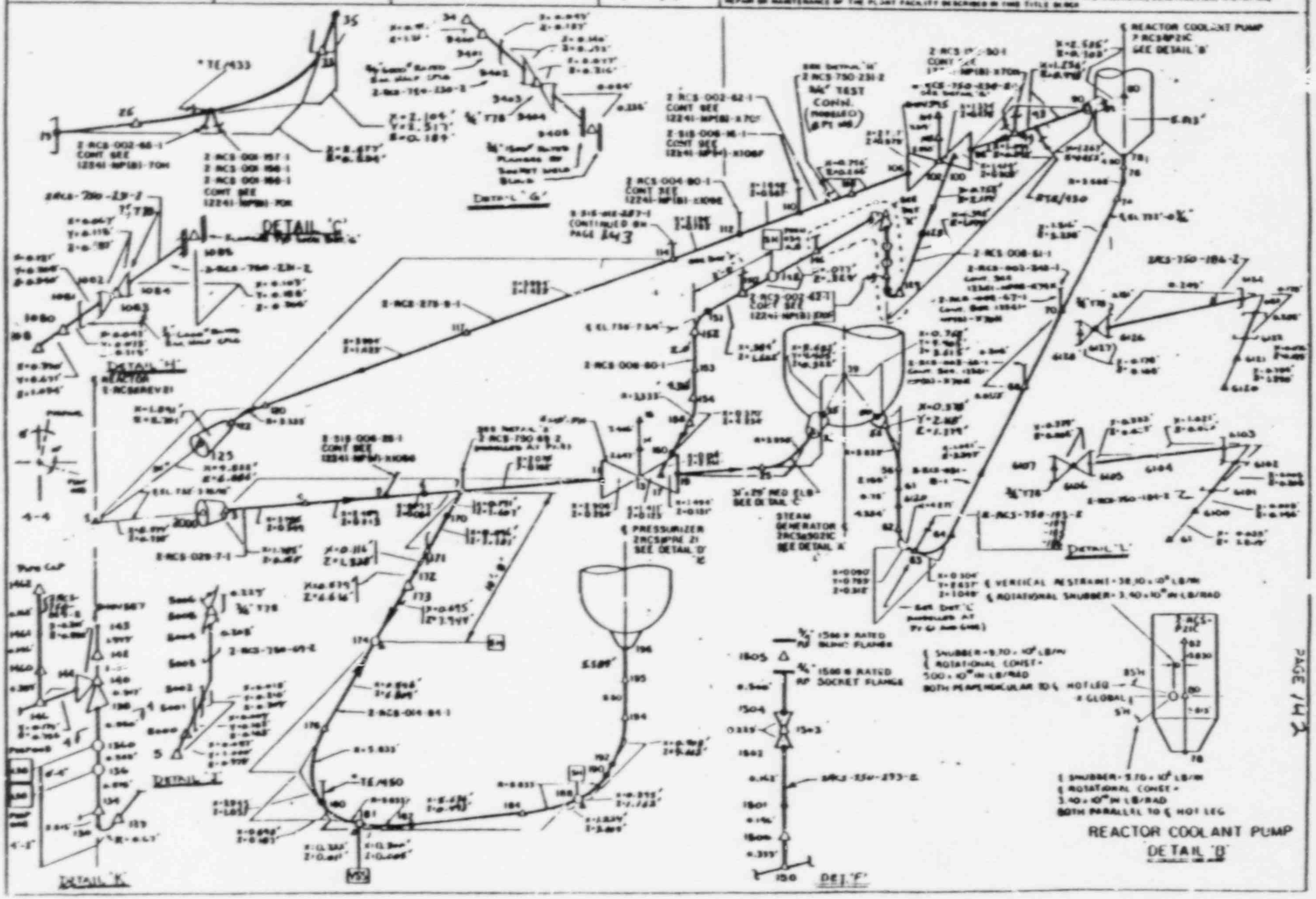
STONE & WEBSTER ENGINEERING CORPORATION
PIPE STRESS SKETCH

CLIENT: DUQUESNE LIGHT CO. LOCATION: B.V.2
SYSTEM: REACTOR COOLANT PIPING - LOOP 21 REACTOR CONTAINMENT
CALCULATION No. 12241-NP(B)-370C-X

THE INFORMATION ON THIS DRAWING MAY NOT BE COPIED OR USED FOR OTHER THAN THE LICENSING, CONSTRUCTION, OPERATION, REPAIR OR MAINTENANCE OF THE PLANT FACILITY DESCRIBED IN THIS TITLE BLOCK

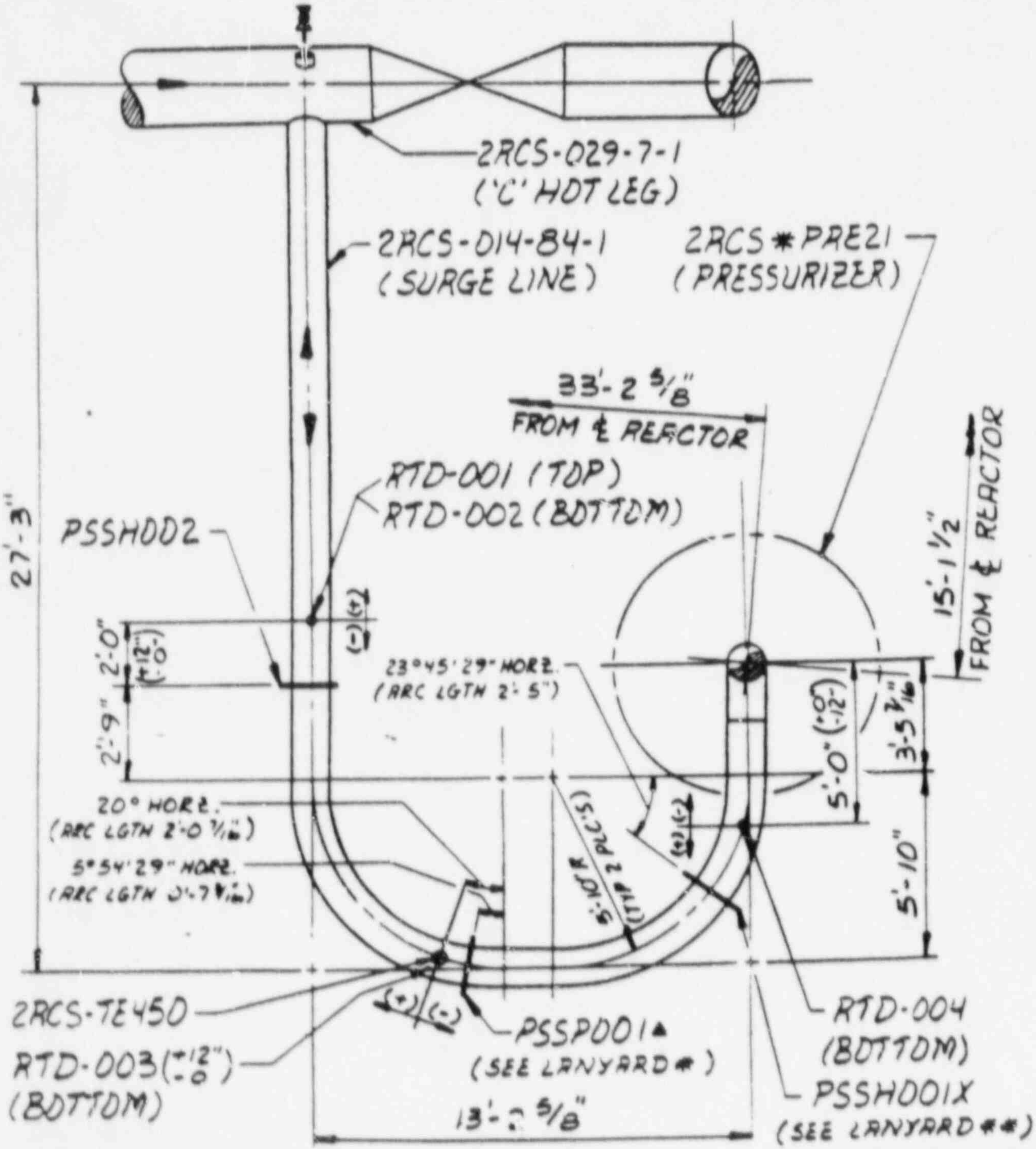
CS - CONSTANT SUPPORT
VS - VERTICAL SUPPORT
VC - VERTICAL CONSTRAINT
LC - LATERAL CONSTRAINT
AC - AXIAL CONSTRAINT
NS - NORTH-SOUTH CONSTRAINT
EW - EAST-WEST CONSTRAINT

SH - SPRING HANGER (VARIABLE)
RH - ROD HANGER
VSS - VERTICAL SHOCK SUPPRESSOR
LSS - LATERAL SHOCK SUPPRESSOR
ASS - AXIAL SHOCK SUPPRESSOR
NSS - NORTH-SOUTH SHOCK SUPPRESSOR
ESS - EAST-WEST SHOCK SUPPRESSOR



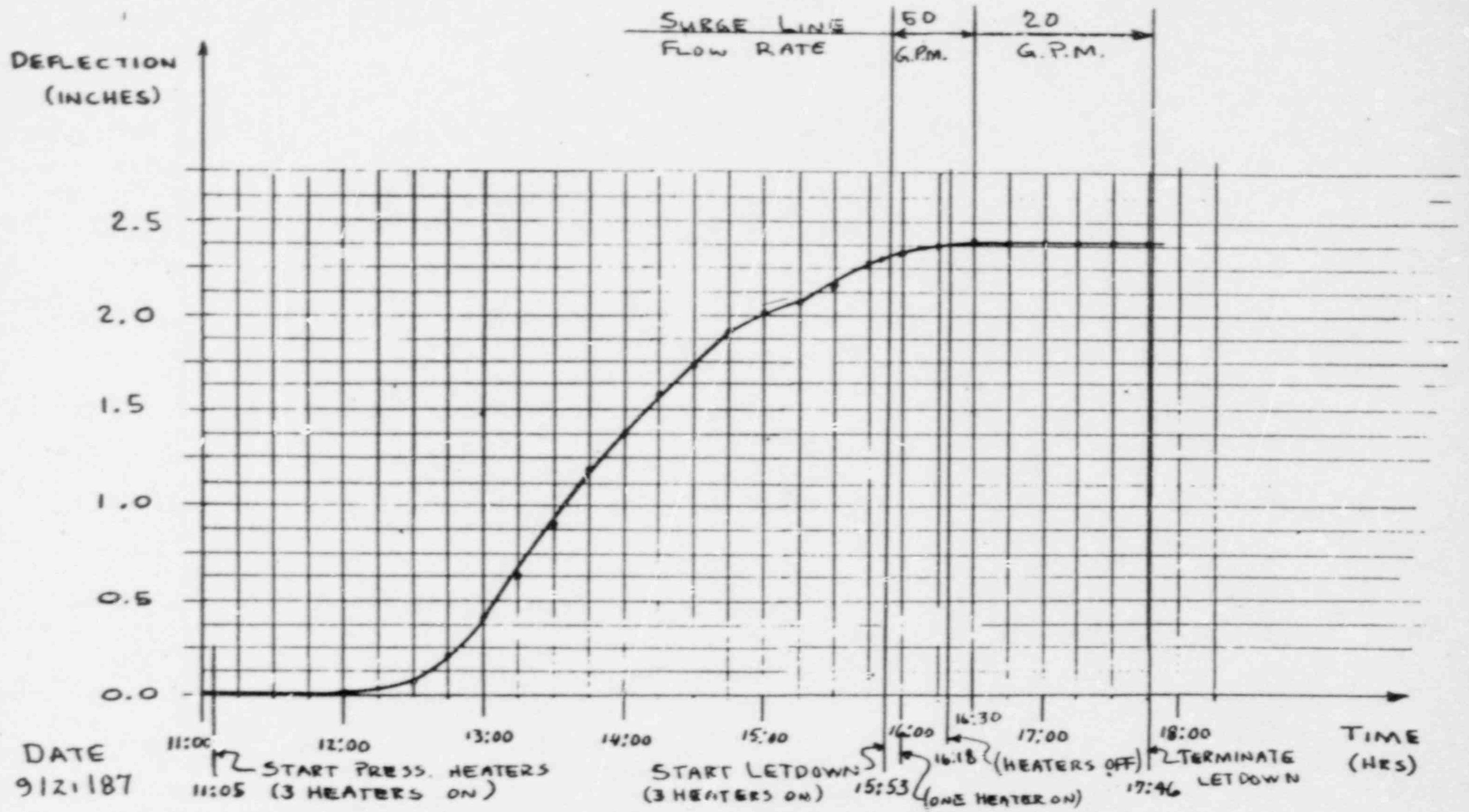
* { LANYARD RCS-TE01-076P Y - VERTICAL DEFLECTION MONITOR ▲▲
LANYARD RCS-TE02-077P L - LATERAL DEFLECTION MONITOR
LANYARD RCS-TE03-078P A - AXIAL DEFLECTION MONITOR }

** LANYARD RCS-TE04-079P Y - VERTICAL DEFLECTION MONITOR

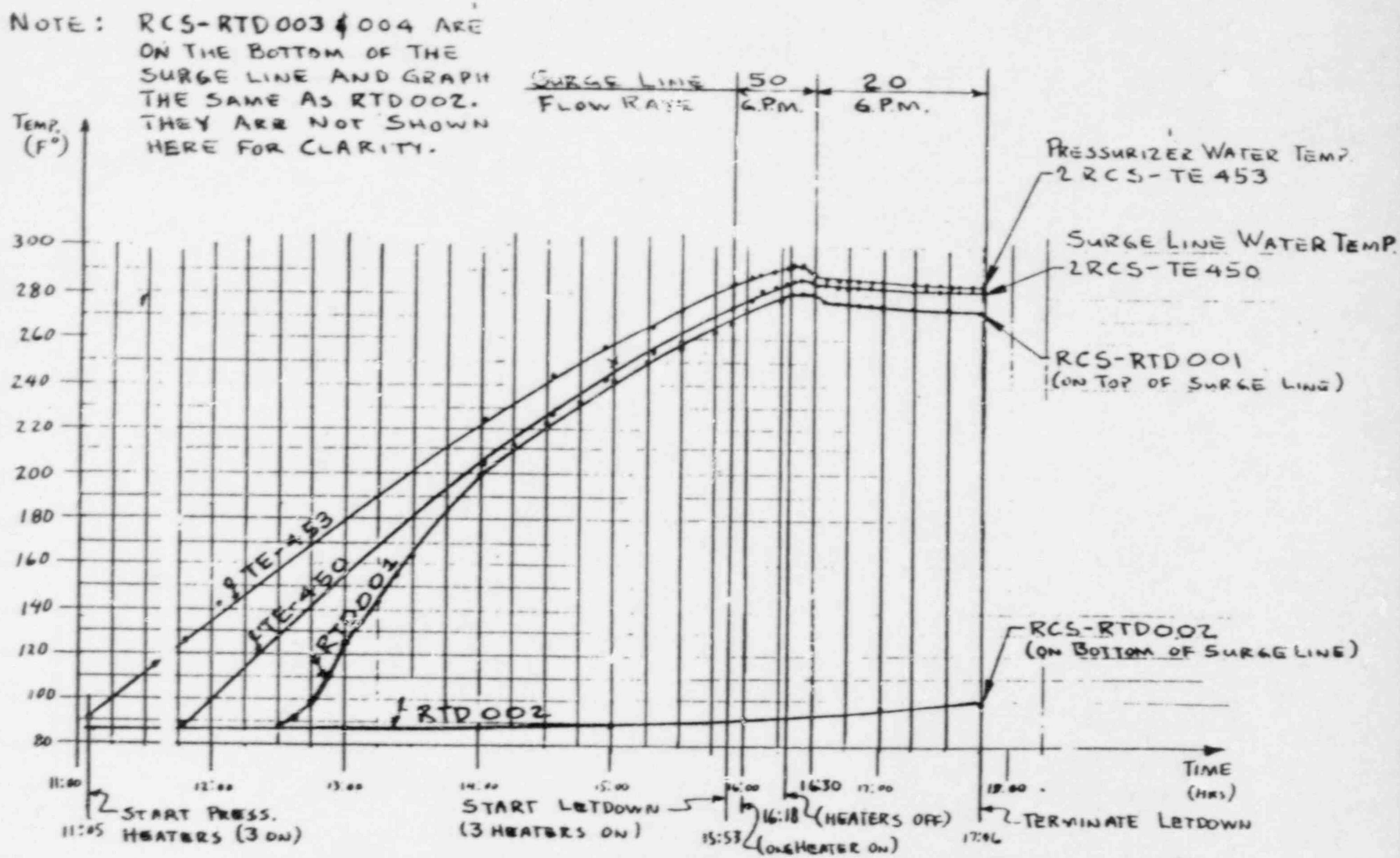



▲ SNUBBER PSSP001 DELETED PER E1DCR Nº DCP-1015-02
SHOWN FOR REFERENCE ONLY

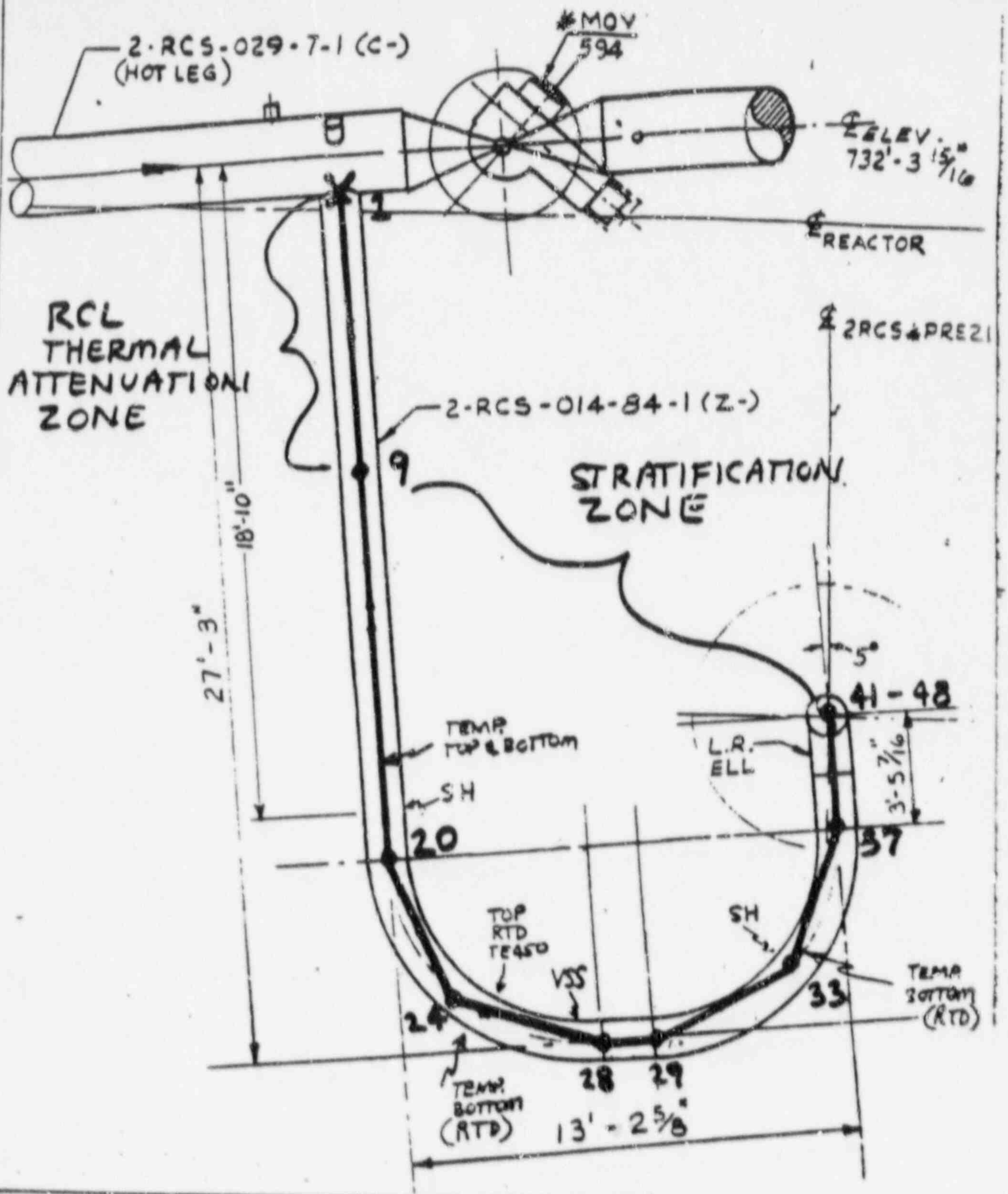
▲▲ LANYARD RCS-TE01-076P IS ALSO IDENTIFIED AS <u>LAN. 43</u>



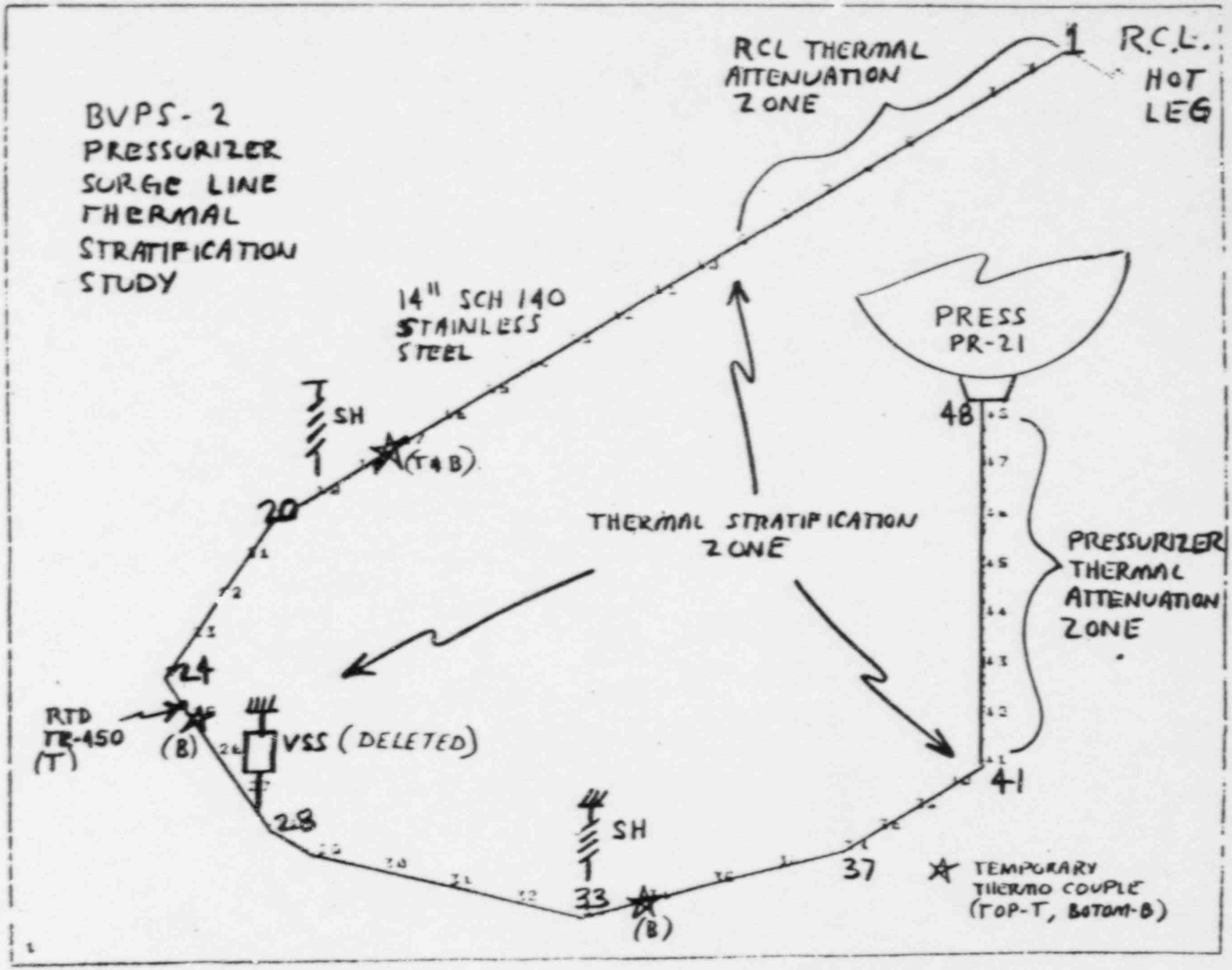

PIPE DEFLECTION AT LANYARD № 76




PRESSURIZER AND SURGE LINE TEMPERATURE




| | | | |
|---|---|---|---|
| CHECKED | | TITLE: PRESSURIZER SURGE LINE | SCALE: 1/4" = 1'-0" |
| CORRECT | | BEAVER VALLEY UNIT 2 | DATE: |
| APPROVED | | | SKETCH NUMBER |
| REVISIONS | ② | ③ ④ ⑤ | |




BVS THERMAL STRATIFICATION STUDY OF SURGE LINE