Palo Verde Nuclear Generating Station

# CALCULATION REVISION/TITLE SHEET

| CALCULATION NO. | REV. | CLASS: | AFFECTED SHEET NO(S) |
|---|---|---|---|
| 13-MC-ZZ-643 | 0 | Q [X] QAG [ ] NQR [ ] | SEE BELOW |

| CALCULATION TITLE | ISSUED |
|---|---|
| AUXILIARY SPRAY LINE THERMAL STRATIFICATION | 11-13-92 |

| AFFECTED CHANGES | REFERENCE(S) | UNITS AFFECTED |
|---|---|---|
| N/A | NRC IE Bulletin 88-08 | [X] UNIT 1<br>[X] UNIT 2<br>[X] UNIT 3<br>[ ] COMMON |

REASON FOR CHANGE

As a result of the referenced IE Bulletin, APS monitored the Auxiliary Spray line to evaluate the potential for thermal stratification in the piping between Check Valve CH-431 and the tee connection to the Main Spray line above the Pressurizer vessel. This calculation evaluates the effects of the measured top to bottom delta-T values.

DESCRIPTION OF CHANGE

ORIGINAL ISSUE

DCC FILE COPY

| Preparer | Dwg. Check | Mech. | Civil | Elec. | I & C | Technical Review | Other (Specify Org.) | Other (Specify Org.) | RS | NEM |
|---|---|---|---|---|---|---|---|---|---|---|
| [signature] | N/A | N/A | N/A | N/A | N/A | [signature] | N/A | N/A | [signature] for H.R. Miyahara | N/A |
| 11-13-92 | | | | | | 11-13-92 | | | 11/13/92 | |
| Date | Date | Date | Date | Date | Date | Date | Date | Date | Date | Date |

PV214-12EC (9/91) CROSS DISCIPLINE REVIEW

Procedure 81DP-4CC04

9310080261 931001
PDR ADOCK 05000528
Q PDR

ANPP

# CALCULATION SHEET

CALC. TITLE AUXILIARY SPRAY LINE THERMAL STRATIFICATION CALC. NO 13-MC-ZZ-643

SUBJECT STRATIFIED THERMAL ANALYSIS OF THE 2-INCH DIA. PIPE SHEET NO. 1

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. indi-cator |
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## 1.0 BACKGROUND

This analysis is done to verify the structural integrity of the 2-inch diameter Auxiliary Spray Line for a recently found thermal stratified temperature distribution. The variation of temperatures found in the Auxiliary Spray pipe occurs in the immediate line where it attaches to the 4-inch vertical Pressurizer Spray line just above the Pressurizer Spray Nozzle. This temperature condition exists out to the first valve, (V-431). Temperature data was obtained by field measurements at three locations, see Fig. (2). The Auxiliary Spray line is part of the Chemical Volume Control System.

The mathematical piping model developed for this analysis, Fig. (3A, 3B), consists of a portions of the Pressurizer Spray and Auxiliary Spray lines and are investigated for thermal and mechanical loads that occur during normal and shutdown operations.

## 2.0 LOAD CONDITIONS

### 2.1 NORMAL OPERATION

During normal operations the Pressurizer Spray water is supplied by the cold legs of the Reactor Coolant System Loop 1A and 1B. These two supplies permit the spray flow into the pressurizer with less than four (4) Reactor Coolant Pumps working. The differential pressure caused by the coolant flow through the reactor vessel provides the head necessary for spray flow this pressure head of approximately 57-psi. Under these normal operating conditions, with the Reactor Coolant Pumps operating, the spray flow rate is controlled by the two modulating, (regulating), diaphragm-operated spray control valves. When on auto mode, these valves start to open at 2275-psia, and are fully open at 2300-psia. When these valves are closed each, (2), spray valve has a manual bypass valve which is adjusted to allow a small bypass flow rate of about 1.5-gpm at temperature. The bypass flow is maintained for the following reasons;

* The bypass flow keeps the piping, valves and spray nozzle near operating temperature to minimize thermal shock to piping system and nozzle when the spray valves are opened to admit more spray water.

* The bypass flow also helps to circulate the pressurizer water with the Reactor Coolant Loops water to maintain uniform temperature and chemistry control in the pressurizer.

a) Pressurizer Spray Line has cyclic water flows from the reactor coolant system introduced into the pressurizer to control its temperature and water volume. Between cyclic flows a bypass flow is maintained in the line to keep the piping system and pressurizer nozzle near temperature to preclude thermal shock.

b)The Auxiliary Pressurizer Spray line sits with valve V-431 closed so only the attaching pipe segment is at or near the temperature of the spray line and/or pressurizer. It is within this pipe segment

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and at this time in operations that PVNGS Mechanical Engineering Group determined different temperature readings between the top and bottom of the small 2-inch line, indicating thermal stratification.

## 2.2 NORMAL SHUTDOWN OPERATION

During normal shutdown of the reactor system, the Pressurizer Spray Line is in use until the Reactor Coolant System water temperature is lowered to about 440 $^{\circ}F$. At this time the RC pumps are shut off and the Auxiliary Spray line then starts with a low flow to cool and collapse the bubble

## 2.3 NORMAL STARTUP OPERATIONS

Under start-up operations the Auxiliary Spray Line is not used since after flushing the RC Pumps are used to assist heat up of the Reactor Coolant System and is available for the Pressurizer are not in operation, (i.e., Low Pressure), and the differential pressure across the Reactor Vessel is insufficient to maintain spray flow or bypass flow. Under this circumstance the spray flow is supplied from the Chemical and Volume Control System into two alternate spray valves. This condition occurs during normal cool down of the system. The thermal conditions are estimated using the Specified Transient for the Pressurizer Spray Nozzle.

Operational Pressure in the Pressurizer Spray Line will vary between 2250 and 2300-psia. The pressure in the Aux Line is taken from the shell side of the Regenerative Heat Exchanger pressure out-put minus pipe losses is less than 2450-psia at a temperature less than 550 degrees F.

## MATERIALS

The applicable materials are from the Code: ASME B&PV Code, Section III, Class 1.

* 1-inch Dia. Pipe, Sch. 160, (Seamless), Stainless Steel, ASME SA-376 or SA-312, Gr. TP304
* 1-inch Dia. Socket Fittings, 6000 lb. Stainless Steel, ASME SA-182, Gr. F304

*2-inch Dia. Pipe, Sch. 160, (Seamless), Stainless Steel, ASME SA-376 or SA-312, Gr. TP304

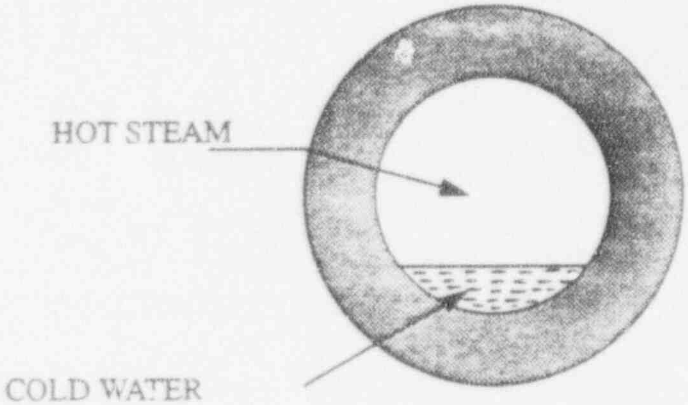


FIGURE - 1

The temperature differences shown in the above figure is attributed to probable valve leakage of colder water, (operational temperature 220 $^oF$ ), from the Chemical Volume Control System), passing the check valve, V-431, as well as, circulation of hot steam by a convection cycle from the 4-inch diameter Pressurizer Spray line. The 2-inch Auxiliary Spray Pipe pass the closed valve is approximately at a pressure that is the same as the Regenerative Heat Exchanger Shell Side Pressure, (2450-psi) minus pipe losses. Whereas the steam in the 4-inch diameter pressurizer spray line is near 550 $^oF$ with a pressure equal to the RCS, 2275 to 2300-psi.

This form of stratified flow, in the Aux. Spray pipe run up to its first valve, suggests that there is no "high cycle" mixing zone existing at the temperature interface boundary. Rather there will be a stable <u>low cycle</u> axial and tangential stress condition due to only the temperature differences at the top and bottom of the pipe and their values will be dependant on the interface level with a non-significant mixing zone. The stress condition in the pipe wall will be roughly proportional to $(T_H - T_C)$.

* 2-inch Dia. Socket Fittings, 6000 lb. Stainless Steel, ASME SA-182, Gr. F304

* 4-inch Dia. Pipe, Sch. 160, (Seamless), Stainless Steel, ASME SA-376 or SA-312, Gr. TP304

## GEOMETRY

| Pipe Size | Inside Dia. (In.) | Outside Dia. (In.) | Thickness (In.) | Section Modulus ($In.^3$) | Moment Inertia ($In.^4$) | Radius Gyration (In.) | Weight (lb/ft) |
|---|---|---|---|---|---|---|---|
| 1-in. Sch. 160 | 0.815 | 1.315 | 0.250 | 0.1903 | 0.1252 | 0.387 | 2.844 |
| 2-in. Sch. 160 | 1.689 | 2.375 | 0.343 | 0.979 | 1.163 | 0.729 | 7.444 |
| 4-in. Sch. 160 | 3.438 | 4.500 | 0.531 | 5.90 | 13.27 | 1.416 | 22.51 |

NOTE: Corrosion Allowance = 0.00

## STRESS VALUES (PSI)

| Stress Type | Temperature 100 °[illegible] | [illegible] °F | 300 °F | 400 °F | 500 [illegible] | 600 °F |
|---|---|---|---|---|---|---|
| ASME, SA-376 or SA-31[illegible] [illegible]304; Nominal Composition 18Cr-8Ni | | | | | | |
| $S_y$ | 30.0 | 25.0 | 22.5 | 20.7 | 19.4 | 18.2 |
| $S_u$ | 75.0 | 71.0 | 66.0 | 64.4 | 63.5 | 63.5 |
| Allow. $S_m$ | 20.0 | 20.0 | 20.0 | 18.7 | 17.5 | 16.4 |
| Allow. S | 18.8 | 17.8 | 16.6 | 16.2 | 15.9 | 15.9 |
| Mod. of $E10^6$ (psi) | 28.3 | 27.6 | 27.0 | 26.5 | 25.8 | 25.3 |
| Nominal Coefficient of Thermal Expansion ($\alpha$): | | | | | | |
| $\alpha \times 10^{-6}$ (in/in/°F) | 8.55 | 8.79 | 9.00 | 9.19 | 9.37 | 9.53 |

Reflective Insulation

4-inch diameter pipe has a 2-inch insulation thickness having a Density of 0.0206 lb/in 3 or 7 lb/ft

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## 3.0 REFERENCES


1) Chem. Vol. Control Sys. Auxiliary Spray Draw. No. 13 - P - CHF - 107, Rev. 16

2) BPC, Reactor Coolant System - Pressurizer Spray Line Iso. Sketch Sheet 13 p RCF - 102, Rev.5, Prob. RC-502, Sheets 11A and 11B.

3) Letter 281-00896-MAR/KMS, dated July 31, 1992 from M. A. Radspinner to File, "CATS Item 41011, IEB 88-08 Thermal Stresses in Piping Connected to the RCS"

4) Letter 161-04571-WFC/JMQ, dated January 15, 1992 from W.F. Conway, APS to NRC, "Response to NRC request for Additional Information on NRC Bulletin 88-08"

5) Calculation No. 13-MC-ZZ-588, Rev. 4, dated 12-15-89. "CVCS Auxiliary Spray Line Class 1 Piping."

6) Calculation No. 13-MC-ZZ-045,Rev. 0, dated 12-9-87. "Class 1 Analysis of Pressurizer Spray Piping to Incorporate the Test Data."

7) "Reduction and Assessment of Surge Line and Auxiliary Spray Line Temperature and Displacement Data," September 1991, prepared by Fatigue Evaluation Services, ABB Combustion Engineering Nuclear Power.

8) 1989 ASME Boiler and Pressure Vessel Code, Section III, Division 1.

9) ANSYS - Engineering Analysis System Computer Code, Revision 4.4A, 1989.

10) Calculation No. 13-MC-CH-531, Rev. 5, dated 2-18-92. "CVCS Auxiliary Spray Line Class 2 Piping Analysis."

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## 4.0 AUXILIARY SPRAY LINE TRANSIENT DEFINITIONS

PIPING SYSTEM DESCRIPTION

The function of the Auxiliary Spray Line is to provide the operator with an auxiliary pressurizer spray to control the Reactor Coolant System, RCS, pressure during the final stages of reactor shutdown by allowing cooling of the pressurizer. The Aux. Spray Line is part of the Chemical Volume Control System, CVCS, and is located between the charge line (Loop 2A) and the pressurizer, (RCE-X02). It is a 2-inch Schedule 160 pipe size. The upstream end connects to the charge line where it takes the fluid, (reactor coolant) from this charge line. Note that the section of the charge it connects to is a portion after the regenerative heat exchanger outlet nozzle. The down stream end connects to the 4-inch main spray line, and the main spray line immediately connects to the pressurizer inlet nozzle.

NORMAL START-UP OPERATIONS

The pressure in the line rises from atmospheric pressure to 2250 psig. After equilibrium of the system is attained the flow in the line drops back to zero flow, while the temperature and the pressure in the pipe system remain at 125 F and 2250 psig.

NORMAL OPERATIONS

During Normal Operations of the plant systems such as at full power, step power changes and ramp power changes, there is no flow in the Auxiliary Spray Line. In the system heat-up Operating Condition, circulation starts in the loop with coolant flow and temperature of 44.0 GPM and 120 F.

UPSET OPERATIONS

In normal operations of the plant system an upset condition is assumed where the Auxiliary Spray Line may inadvertently function at full power. For this event the coolant pressure is maintained at 2250 psig and the fluid temperature rises from an initial temperature of 125 F to 460 F in a short time and the flow reaches to 61.6 GPM.

NORMAL SHUTDOWN OPERATIONS

During normal shutdown or reactor cooling, the flow in this pipe system increases from zero flow to 61.6 GPM and the temperature of the fluid increases from 1255 F to 225 F. However, the pressure in the line remains the same, 2250 psig. After the pressurizer is cooled the flow will slowly be reduced to zero, the fluid temperature will be reduced to 70 F and pressure will be reduced to atmospheric pressure.

THERMAL STRATIFICATION

As a part of APS response to NRC, Reference (4), NED assessed Unit 3 Auxiliary Pressurizer Spray System temperature data. This data was recorded to evaluate the potential for thermal stratification in the Auxiliary Spray Line. The data reduction performed by ABB-CE focused primarily on plant heat-up and cooldown operations.In Reference (4) APS concluded that the Auxiliary Spray Line did not exhibit thermal stratification due to leakage as described in IE Bulletin 88-08. However the line did exhibit a top-to-bottom temperature differential of up to 115 F in the portion of the pipe system between Valve V-431 and

the 4"x4"x2" Tee connection to the main spray line immediately above its connection to the pressurizer inlet nozzle. This temperature difference is considered to be the result either convective cooling or insulation effects. No evidence of cyclic stratification with striping was observed and this condition will only occur when there is zero fluid flow in the Auxiliary Spray Line.

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# CALCULATION SHEET

CALC. TITLE AUXILIARY SPRAY LINE THERMAL STRATIFICATION CALC. NO 13-MC-ZZ-643

SUBJECT STRATIFIED THERMAL ANALYSIS OF THE 2-INCH DIA. PIPE SHEET NO. 9

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## 5.0 CALCULATIONS

### 5.1 EFFECT ON CALC. NO. 13-MC-ZZ-588 USAGE FACTOR

Calculations were performed by using ANSYS Version 4.4A computer code because this code allows the input of the variable pipe wall temperatures experienced during stratification. The input is shown in Section 6.0 based on Histograms per Calculation No. 13-MC-ZZ-045. Although the monitored temperatures were in the range of 400 F at top to about 285 F on bottom of pipe, the thermal load cases were input with the Main Spray operating temperature on the top less 115 F for the bottom temperature. This was done for conservatism as the higher temperature values yield a larger differential expansion top to bottom due to their larger mean coefficients. The stratified section is Section I as described on the following sheets and shown on the sketch on sheet 40.

The results of the load case runs for expansion stress are shown in Table 1 on sheet 32. The input and stress summaries for each individual load case output are shown in Attachments 1 and 2. The maximum stresses in the output are in terms of maximum stress intensity which is conservative compared to the bending stress as it is equal to twice the maximum shear stress and includes the effects of internal pressure. Maximum stress occurs at Data Point 41 in Upset - Inadvertent Aux.Spray initiation File inp16.o and is equal to 13633 psi. Although this is not a stratified case as the Aux. Spray is on, it yields the enveloped value because the upward bowing of the Aux. Spray line during stratification relieves the bending stress resulting in lower stress levels during these cases. This can be seen by comparison of results of stratified cases to non-stratified cases.

The stratified load conditions affect only Primary Plus Secondary Stress Intensity Range, Eqtn. (10) and Peak Stress Intensity Range, Eqtn. (11) for calculating Usage Factors. 13633 psi is substituted for the second term in both equations which can be done since K2C2 indices equal 1.0x1.8=1.8 and this has been input as an SIF in the ANSYS input. The through wall temperature gradient terms in both equations can be taken from the existing stress calculation, Calc. No., 13-MC-ZZ-588. This is true because these terms for the stratified flow condition are enveloped by the thermal shock or ramp temperature changes on which the existing calculation is based. The delta-T changes during stratified flow are much lower (115 F max.) and are low cycle occurring at a slower rate of change as described previously in Section 2.2 of this calc. Also, a 2 dimensional Thermal Transient Stress calculation was done as part of Calculation 13-MC-ZZ-045, Rev. 0 (SNUMB No. X0175, Dated 9/30/87) for the 4" Main Spray under a delta-T of 160 F and the transient stresses were found to be minimal (less than 1000 psi).

Equation (10) can therefore be conservatively calculated by simply adding 13633 to the existing maximum in the stratified section I which is 35954 psi per page C-7 of Calc. 13-MC-ZZ-588. This yields 13633 + 35954 = 49587 psi < 3 Sm = 53625 psi. This value is conservative since, as mentioned above, the stratified flow actually reduces the maximum stress range.

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# CALCULATION SHEET

CALC. TITLE AUXILIARY SPRAY LINE THERMAL STRATIFICATION CALC. NO 13-MC-ZZ-643

SUBJECT STRATIFIED THERMAL ANALYSIS OF THE 2-INCH DIA. PIPE SHEET NO. 10

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Equation (11), Sp, can be recalculated as follows using 13633 for the second term and using existing values for the gradient stress terms and the pressure term. If this Sp for the Aux. Spray Stratified Flow condition is assumed to occur with every cycle shown on sheet C-8 of Calc. 13-MC-ZZ-588, the Fatigue Usage Factor based on this Sp will be conservative and then added to the existing Cumulative Usage Factor to determine it's effect on plant fatigue life. This calculation is as follows.

$$Sp = \frac{1.2(1)(2250)(2.375)}{2(.343)} + 13633 + (9.41E\text{-}6)(40)(25.5E6)(1.7)(.6) + \frac{(25.5E6)(9.41E\text{-}6)}{0.7}(.85 \times 228 + 99)$$

$$= 9348 + 13633 + 9790 + 100370 = \underline{133141} \text{ psi}$$

Salt = Sp/2 = 133141/2 = 66570 psi

Nallow = 8000 cycles

$$\text{Usage Factor} = \frac{N}{\text{Nallow}} = \frac{550}{8000} = .0688$$

N=total cycles from sheet C-8 of Calc. No. 13-MC-ZZ-588
Nallow = Allow. cycles from ASME Sect. III, Fig. I-9.2.1

Cumulative Usage Factor in stratified section = C.U.F. from sheet C-7 of Calc. No. 13-MC-ZZ-588 +.0688
=.0953 +.0688 =.1641 < 1.0 Therefore acceptable

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## 5.2 EFFECT ON CALC. NO. 13-MC-ZZ-045 USAGE FACTOR

A combined analysis of Auxiliary and Main Spray piping was done in the calculation referenced above to incorporate test data given in Study 13-MS-035. This data is based on a testing program which was implemented to determine possible future thermal transients which could occur during the life of the plant. As a result, possible transients were identified which are more severe than those defined in the Class 1 report documented in Calc. No. 13-MC-ZZ-588.

Table 2 on sheet 33 shows that, for every load case, the Stratification in Section I reduces the maximum positive stress level and, therefore, does not increase the existing maximum Equation (10) stress ranges shown on sheet 21 of Calculation 13-MC-ZZ-045 (see sheet 13, Table-A).

The effect of Stratified Flow on the Cumulative Usage Factor shown on sheet 22 of Calc. 13-MC-ZZ-045 (see sheet 14) is calculated less conservatively than done in Section 5.1. The potential increase in peak stress due to Stratification is calculated for each stratified load case by subtracting the maximum stress of the stratification run from the maximum stress of the same load case run without stratification. This is shown in Table 2 on sheet 33. From this table, it is shown that a decrease of 7403 psi is the maximum change of any load case due to stratification. This value is then added to the maximum Equation (11) stress, Sp, shown in Table B (from sheet 22 of Calc. 13-MC-ZZ-045) on sheet 14 to get a new maximum peak stress, Sp'.

$Sp' = 289{,}034 + 7403 = 296{,}437$ psi.

$Sa' = \dfrac{296{,}437}{2} = 148{,}219$ psi

Per Table I-9.1 of ASME Section III Code, Allowable cycles, N' calculated as follows.

$$N' = 200\left(\frac{500}{200}\right)^{\left[\log\left(\frac{201000}{148219}\right)\right] / \left(\log\frac{201000}{148000}\right)} = 498$$

Revised Cumulative Usage Factor can then be calculated as $C.U.F.' = \frac{n}{498}$

where n is an equivalent number of actual cycles with maximum peak stress range of 289034 psi and C.U.F. of 0.732 from the existing calculation. (see table on sheet 14)

N = Allowable cycles for Sp = 289034 psi $\quad Sa = \frac{289034}{2} = 144{,}517$ psi

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Per Table I-9.1,

$$N = 500\left(\frac{1000}{500}\right)^{\left[\log\left(\frac{148000}{144517}\right)\right] / \left(\log\frac{148000}{119000}\right)} = 539$$

n = 0.733 N = 0.733 (539) = 395 cycles

C.U.F.' = $\frac{n}{498} = \frac{395}{498}$ = 0.793 < 1.0 Therefore, the new Cumulative Usage Factor, C.U.F.' is acceptable.

CONCLUSION:

The Auxiliary Spray line is able to withstand the effects of Stratified Flow, as monitored by the PVNGS monitoring program, for a 40 year life.

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## TABLE - A

SUMMARY OF STRESS INTENSITY RANGES

| | PRIMARY + SECONDARY STRESS INTENSITY RANGE | | SIMPLIFIED ELASTIC-PLASTIC STRESS INTENSITY RANGE | | |
|---|---|---|---|---|---|
| DATA POINT No. | MAX EQ. 10 STRESS, Sn (ksi) | Sn/3Sm (1) | MAX EQ. 12 THERMAL STRESS, Se (ksi) | MAX EQ. 13 STRESS W/O THERMAL (ksi) | MAX OF EQ.12/3Sm OR EQ.13/3Sm |
| 120 | 31.495 | 0.631 | --- | --- | --- |
| 122 | 19.249 | 0.385 | --- | --- | --- |
| 124 | 13.321 | 0.267 | --- | --- | --- |
| 125 | 13.215 | 0.265 | --- | --- | --- |
| 126 | 42.638 | 0.854 | 1.335 | 40.903 | --- |
| 132 | 42.992 | 0.861 | 1.689 | 39.686 | --- |
| 134 | 51.535 | 1.032 | 9.757 | 44.145 | 0.884 |
| 136 | 23.641 | 0.473 | --- | --- | --- |
| 139 | 24.243 | 0.485 | --- | --- | --- |
| 140 | 14.571 | 0.292 | --- | --- | --- |
| 144 | 21.473 | 0.430 | --- | --- | --- |
| 146 | 21.516 | 0.431 | --- | --- | --- |
| 148 | 19.945 | 0.399 | --- | --- | --- |
| 150 | 14.079 | 0.282 | --- | --- | --- |
| 152 | 34.243 | 0.686 | --- | --- | --- |
| 156 | 13.832 | 0.277 | --- | --- | --- |
| 161 | 24.272 | 0.486 | --- | --- | --- |
| 162 | 14.378 | 0.288 | --- | --- | --- |
| 166 | 21.955 | 0.440 | --- | --- | --- |
| 166A | 42.595 | 0.853 | 1.171 | 31.013 | --- |
| 172 | 22.077 | 0.442 | --- | --- | --- |
| 174 | 22.657 | 0.454 | --- | --- | --- |
| 176 | 42.442 | 0.850 | 1.018 | 31.623 | --- |
| 182 | 21.068 | 0.422 | --- | --- | --- |
| 188 | 63.664 | 1.070 | 20.354 | 38.125 | 0.763 |
| 200 | 55.736 | 1.116 | 7.770 | 46.936 | 0.940 |
| 201 | 13.708 | 0.274 | --- | --- | --- |
| 204 | 21.186 | 0.424 | --- | --- | --- |
| 206 | 13.691 | 0.274 | --- | --- | --- |
| 208 | 20.825 | 0.417 | --- | --- | --- |
| 210 | 14.145 | 0.283 | --- | --- | --- |
| 212 | 13.987 | 0.280 | --- | --- | --- |
| 214 | 23.766 | 0.476 | --- | --- | --- |
| 217 | 23.404 | 0.469 | --- | --- | --- |
| 218 | 45.805 | 0.917 | 2.774 | 44.336 | --- |
| 230 | 42.947 | 0.860 | 1.644 | 40.137 | --- |
| 236 | 42.073 | 0.842 | 0.770 | 38.960 | --- |
| 237 | 12.837 | 0.257 | --- | --- | --- |
| 238 | 12.883 | 0.258 | --- | --- | --- |
| 240 | 18.448 | 0.369 | --- | --- | --- |
| 242 | 31.636 | 0.633 | --- | --- | --- |
| 500 | 51.998 | 0.967 | --- | --- | --- |
| 502 | 51.640 | 0.961 | --- | --- | --- |

(1) Where Sn/3Sm > 0.8, Eq. 12 & 13 used for pipe break criteria.
Where Sn/3Sm > 1.0, check Eq. 12 & 13 for Code compliance, check for thermal ratchet, and determine Ke for Salt (Table E-2).

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. Indi-cator |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | D Berg | 11/13/92 | [illegible] | 11/13/92 | | | | | | ↓ |
| | | | | | | | | | | |

## TABLE - B

SUMMARY THERMAL RATCHET AND
THERMAL FATIGUE CUMULATIVE USAGE FACTORS

| DATA POINT No. | THERMAL RATCHET (1) $\Delta$T1 (F) | ALLOW $\Delta$T1 (F) | PEAK STRESS/FATIGUE ALTERNATING STRESS FACTOR, Ke | MAX EQ. 11 STRESS, Sp (ksi) | USAGE FACTOR, U |
|---|---|---|---|---|---|
| 120 | --- | --- | 1.000 | 153.652 | 0.152 |
| 122 | --- | --- | 1.000 | 79.400 | 0.008 |
| 124 | --- | --- | 1.000 | 51.167 | 0.000 |
| 125 | --- | --- | 1.000 | 51.054 | 0.000 |
| 126 | --- | --- | 1.000 | 122.244 | 0.050 |
| 132 | --- | --- | 1.000 | 122.880 | 0.051 |
| 134 | 142.7 | 330.7 | 1.106 | 142.048 | 0.116 |
| 136 | --- | | 1.000 | 89.941 | 0.014 |
| 139 | --- | | 1.000 | 92.103 | 0.015 |
| 140 | --- | | 1.000 | 52.491 | 0.000 |
| 144 | --- | | 1.000 | 82.499 | 0.009 |
| 146 | --- | | 1.000 | 66.584 | 0.002 |
| 148 | --- | | 1.000 | 73.219 | 0.005 |
| 150 | --- | | 1.000 | 47.317 | 0.000 |
| 152 | --- | | 1.000 | 112.904 | 0.059 |
| 156 | --- | | 1.000 | 47.056 | 0.000 |
| 161 | --- | | 1.000 | 100.445 | 0.701 |
| 162 | --- | | 1.000 | 47.634 | 0.000 |
| 166 | --- | | 1.000 | 75.320 | 0.006 |
| 166A | --- | --- | 1.000 | 129.118 | 0.089 |
| 172 | --- | | 1.000 | 74.202 | 0.005 |
| 174 | --- | | 1.000 | 75.308 | 0.005 |
| 176 | --- | --- | 1.000 | 128.698 | 0.085 |
| 182 | --- | | 1.000 | 121.920 | 0.126 |
| 188 | 307.7 | 849.2 | 1.234 | 157.600 | 0.732 |
| 200 | 238.3 | 608.4 | 1.386 | 180.249 | 0.871 |
| 201 | --- | --- | 1.000 | 51.458 | 0.000 |
| 204 | --- | --- | 1.000 | 82.150 | 0.009 |
| 206 | --- | --- | 1.000 | 51.539 | 0.000 |
| 208 | --- | --- | 1.000 | 79.651 | 0.008 |
| 210 | --- | --- | 1.000 | 52.040 | 0.000 |
| 212 | --- | --- | 1.000 | 51.872 | 0.000 |
| 214 | --- | --- | 1.000 | 90.388 | 0.014 |
| 217 | --- | --- | 1.000 | 89.089 | 0.013 |
| 218 | --- | --- | 1.000 | 135.648 | 0.096 |
| 230 | --- | --- | 1.000 | 122.801 | 0.051 |
| 236 | --- | --- | 1.000 | 121.226 | 0.048 |
| 237 | --- | --- | 1.000 | 50.653 | 0.000 |
| 238 | --- | --- | 1.000 | 50.703 | 0.000 |
| 240 | --- | --- | 1.000 | 77.872 | 0.006 |
| 242 | --- | --- | 1.000 | 153.793 | 0.153 |
| 500 | --- | --- | 1.000 | 289.034 | 0.733 |
| 502 | --- | --- | 1.000 | 288.455 | 0.730 |

(1) When Sn of Eq. 10 > 3Sm

## 6.0 THERMAL INPUT DATA SUMMARY

| | | | AUX / MAIN | | OPER. TEMP. / REF. TEMP. | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | AUX. SPRAY | | MAIN SPRAY | |
| FILE | LOAD CASE NAME | CYCLES | FLOW RATE | INTERN. PRESS. | SECT. I TEMP. | SEC. J,K TEMP. | SECT. A TEMP. | SEC. B-F TEMP. |
| inp 14 | NORMAL START UP | 500 | 10/0 | 2250 | 495*/70 | 495/70 | 495/70 | 495/70 |
| inp 18 | COOLDOWN (A) | 200 | 10/62 | 400/2250 | 435*/60 | 60/60 | 435/60 | 435/60 |
| inp 19 | COOLDOWN (B) | 460 | 10/62 | 400/2250 | 435*/110 | 110/110 | 435/110 | 435/70 |
| inp 20 | COOLDOWN (C) | 1840 | 10/62 | 400/2250 | 435*/160 | 160/160 | 435/160 | 435/70 |
| inp 12 | NORMAL -10% | 200,000 | 290/0 | 2250 | 570*/495 | 120/120 | 570/495 | 570/495 |
| inp 13 | NORMAL +10% | 200,000 | 290/0 | 2250 | 565*/495 | 120/120 | 565/495 | 565/495 |
| inp 15 | UPSET LD REJECT. | 85 | 220/0 | 2250 | 575*/495 | 120/120 | 575/495 | 575/495 |
| inp 16 | UPSET INAD. AUX. | 5 | 10/62 | 2250 | 460/450 | 370/160 | 495/495 | 495/495 |
| inp 17 | UPSET SPUR. EVENT | 355 | 437/62 | 2250 | 573/495 | 573/120 | 573/495 | 573/495 |

* INDICATES SECTION STRATIFIED AT DELTA-T OF 115F. (INDICATED TEMP. AT TOP. INDICATED LESS 115F AT BOTTOM.)

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE |
|---|---|---|---|---|---|---|---|---|---|
| 0 | DOUG BERG | 11/13/92 | AMIT BHATTACHARYA | 11/13/92 | | | | | |

Rev. Indicator ←

ANPP

# CALCULATION SHEET

CALC. TITLE AUXILIARY SPRAY LINE THERMAL STRATIFICATION CALC. NO 13-MC-ZZ-643

SUBJECT STRATIFIED THERMAL ANALYSIS OF THE 2-INCH DIA. PIPE SHEET NO. 16

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. Indi-cator |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | DOUG BERG | 11/13/92 | AMIT BHATTACHARYA | 11/13/92 | | | | | | ↓ |
| | | | | | | | | | | |

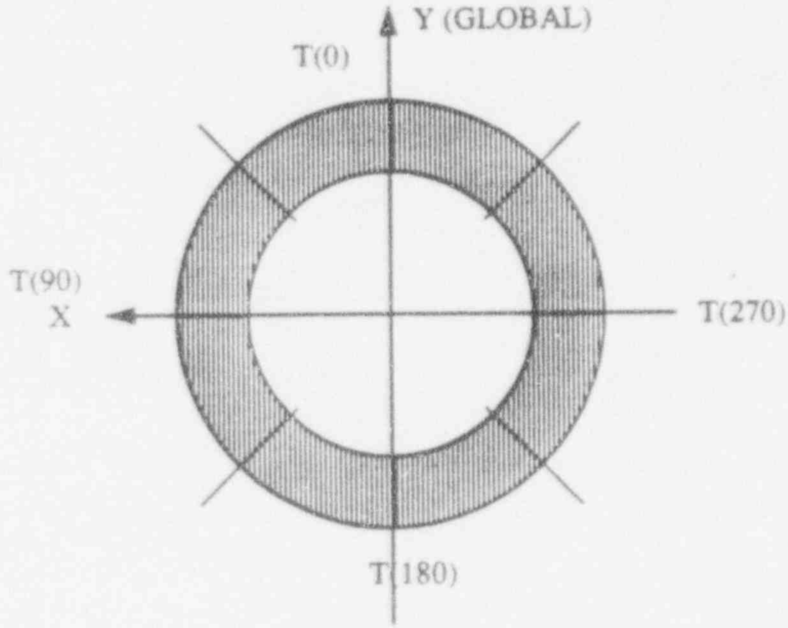



FIGURE - 2

TEMPERATURE INPUT TO ANSYS PIPE MODEL

| Plant Condition | Elem. TYPE | T(0) | T(90) | T(180) |
|---|---|---|---|---|
| Summarized on charts on following pages | STIF20 (Plastic Pipe) | Sect. 1 Temp. | $\frac{T(0) - T(180)}{2}$ | Sect. 1 Temp. - 115 F |

inp12

PIPE TEMPERATURES FOR TRANSIENT HISTOGRAMS – AUXILIARY SPRAY PIPE SYSTEM

NORMAL -10% POWER CHANGE OPERATIONS: During -10% Power Change maneuvering operations of the plant there is no flow in the auxiliary spray line. At this time thermal stratification in pipe section exists for this operation in the pipe section I, CH-E-009-BCAA-2".

Number of Cycles: 200,000

| Pipe Section | A | B | C | D | E | F | I | J | K |
|---|---|---|---|---|---|---|---|---|---|
| Reference Temp. F | 495 | 495 | 495 | 495 | 495 | 495 | 495 | 120 | 120 |
| System Temp. F | 570 | 570 | 570 | 570 | 570 | 570 | 570 | 120 | 120 |
| Delta Temp. F | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 0 | 0 |

THERMAL STRATIFICATION IS TO BE INCLUDED IN PIPE SECTION I

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Pressure psig | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 |
| Flow GPM | 290 | 290 | 290 | 290 | 290 | 290 | 0 | 0 | 0 |

**INPUT FILE = inp12**

**REFERENCE - HISTOGRAM I**

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE |
|---|---|---|---|---|---|---|---|---|---|
| 0 | DOUG BERG | 11/13/92 | AMIT BHATTACHARYA | 11/13/92 | | | | | |

inp13

PIPE TEMPERATURES FOR TRANSIENT HISTOGRAMS – AUXILIARY SPRAY PIPE SYSTEM

NORMAL +10% POWER CHANGE OPERATIONS: During +10% Power Change maneuvering operations of the plant there is no flow in the auxiliary spray line. At this time thermal stratification in pipe section exists for this operation in the pipe section I, CH-E-009-BCAA-2".

Number of Cycles: 200,000

| Pipe Section | A | B | C | D | E | F | I | J | K |
|---|---|---|---|---|---|---|---|---|---|
| Reference Temp. F | 495 | 495 | 495 | 495 | 495 | 495 | 495 | 120 | 120 |
| System Temp. F | 565 | 565 | 565 | 565 | 565 | 565 | 565 | 120 | 120 |
| Delta Temp. F | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 0 | 0 |

THERMAL STRATIFICATION IS TO BE INCLUDED IN PIPE SECTION I

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Pressure psig | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 |
| Flow GPM | 290 | 290 | 290 | 290 | 290 | 290 | 0 | 0 | 0 |

**INPUT FILE = inp13**

**REFERENCE - HISTOGRAM II**

Rev. Indicator ←

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. Indi-cator |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | DOUG BERG | 11/13/92 | AMIT BHATTACHARYA | 11/13/92 | | | | | | ↓ |
| | | | | | | | | | | |

inp14

PIPE TEMPERATURES FOR TRANSIENT HISTOGRAMS – AUXILIARY SPRAY PIPE SYSTEM

NORMAL START UP OPERATIONS: During normal start up operations of the plant there is no flow in the auxiliary spray line. At this time thermal stratification in pipe section could exist at the end of this operation in the pipe section I, CH-E-009-BCAA-2".

Number of Cycles: 500

| Pipe Section | A | B | C | D | E | F | I | J | K |
|---|---|---|---|---|---|---|---|---|---|
| Reference Temp. F | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 |
| System Temp. F | 495 | 495 | 495 | 495 | 495 | 495 | 495 | 495 | 495 |
| Delta Temp. F | 425 | 425 | 425 | 425 | 425 | 425 | 425 | 425 | 425 |

THERMAL STRATIFICATION IS TO BE INCLUDED IN PIPE SECTION I

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Pressure psig | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 |
| Flow GPM | 10 | 10 | 10 | 10 | 10 | 10 | 0 | 0 | 0 |

**INPUT FILE = inp14**

**REFERENCE - HISTOGRAM III**

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. Indicator |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | DOUG BERG | 11/13/92 | AMIT BHATTACHARYA | 11/13/92 | | | | | | ← |

inp15

PIPE TEMPERATURES FOR TRANSIENT HISTOGRAMS – AUXILIARY SPRAY PIPE SYSTEM

UPSET-LOAD REJECTION AT 100% OPERATIONS (NO REACTOR TRIP): During -100% Power Load Rejection Change Operations of the plant there is no flow in the auxiliary spray line. At this time thermal stratification in pipe section exists for this operation in the pipe section I, CH-E-009-BCAA-2".

Number of Cycles: 85

| Pipe Section | A | B | C | D | E | F | I | J | K |
|---|---|---|---|---|---|---|---|---|---|
| Reference Temp. F | 495 | 495 | 495 | 495 | 495 | 495 | 495 | 120 | 120 |
| System Temp. F | 575 | 575 | 575 | 575 | 575 | 575 | 575 | 120 | 120 |
| Delta Temp. F | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 0 | 0 |

THERMAL STRATIFICATION IS TO BE INCLUDED IN PIPE SECTION I

| Pipe Section | A | B | C | D | E | F | I | J | K |
|---|---|---|---|---|---|---|---|---|---|
| Pressure psig | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 |
| Flow GPM | 220 | 220 | 220 | 220 | 220 | 220 | 0 | 0 | 0 |

**INPUT FILE = inp15**

**REFERENCE - HISTOGRAM IV**

inp16

PIPE TEMPERATURES FOR TRANSIENT HISTOGRAMS – AUXILIARY SPRAY PIPE SYSTEM

UPSET- INADVERTENT INITIATION OF AUX AT 100% POWER: During this Upset event there is flow in the auxiliary spray line. No thermal stratification exists in Pipe Section I for this operations.

Number of Cycles: 5

TDN 6-28-93

| Pipe Section | A | B | C | D | E | F | I | J | K |
|---|---|---|---|---|---|---|---|---|---|
| Reference Temp. F | 495 | 495 | 495 | 495 | 495 | 495 | ~~450~~ 250 | 160 | 160 |
| System Temp. F | ? | 495 | 495 | 495 | 495 | 495 | 460 | 370 | 370 |
| Delta Temp. F | ? | 0 | 0 | 0 | 0 | 0 | 210 | 210 | 210 |

NO THERMAL STRATIFICATION IS TO BE INCLUDED IN PIPE SECTION I

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Pressure psig | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 |
| Flow GPM | 10 | 10 | 10 | 10 | 10 | 10 | 62 | 62 | 62 |

**INPUT FILE = inp16**

**REFERENCE - HISTOGRAM V**

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE |
|---|---|---|---|---|---|---|---|---|---|
| 0 | DOUG BERG | 11/12/92 | AMIT BHATTACHARYA | 11/13/92 | | | | | |

Rev. Indicator

inp17

PIPE TEMPERATURES FOR TRANSIENT HISTOGRAMS - AUXILIARY SPRAY PIPE SYSTEM

UPSET- SPURIOUS UPSET EVENTS: During Spurious Upset Events Of The Main Spray Line there is flow in the auxiliary spray line. No thermal stratification exists in Pipe Section I for these operations.

Number of Cycles: 355

| Pipe Section | A | B | C | D | E | F | I | J | K |
|---|---|---|---|---|---|---|---|---|---|
| Reference Temp. F | 495 | 495 | 495 | 495 | 495 | 495 | 495 | 120 | 120 |
| System Temp.F | 573 | 573 | 573 | 573 | 573 | 573 | ? | ? | ? |
| Delta Temp. F | 78 | 78 | 78 | 78 | 78 | 78 | ? | ? | ( |

NO THERMAL STRATIFICATION IS TO BE INCLUDED IN PIPE SECTION I

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Pressure psig | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 | 2250 |
| Flow GPM | 437 | 437 | 375 | 375 | 375 | 375 | 62 | 62 | 62 |

**INPUT FILE = inp17**

**REFERENCE - HISTOGRAM VI**

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE |
|---|---|---|---|---|---|---|---|---|---|
| 0 | DOUG BERG | 1/13/92 | AMIT BHATTACHARYA | 1/13/92 | | | | | |

inp18

PIPE TEMPERATURES FOR TRANSIENT HISTOGRAMS – AUXILIARY SPRAY PIPE SYSTEM

NORMAL PLANT COOLDOWN (A): During Normal Plant Cooldown Operations there is intermittent flow in the auxiliary spray line. At this time the auxiliary spray pipe has a flow condition of 62 GPM for two, (2), minutes and shuts down for twenty, (20), minutes to zero flow. Stratification in pipe section is conservatively assumed to exist for this operation in the pipe section I, CH-E-009-BCAA-2". There is a possibility that the regenerative heat exchanger is not operating so various temperatures are assumed and accounted for by PLANT COOLDOWN (A), (B), and (C) Conditions

Number of Cycles: COOLDOWN CONDITION (A) – 40 cycles x 5cycles per Cooldown= 200 cycles

| Pipe Section | A | B | C | D | E | F | I | J | K |
|---|---|---|---|---|---|---|---|---|---|
| Reference Temp. F | 60 | 70 | 70 | 70 | 70 | 70 | 60 | 60 | 60 |
| System Temp. F | 435 | 435 | 435 | 435 | 435 | 435 | 435 | 60 | 60 |
| Delta Temp. F | 375 | 365 | 365 | 365 | 365 | 365 | 375 | 0 | 0 |
| THERMAL STRATIFICATION IS TO BE INCLUDED IN PIPE SECTION I | | | | | | | | | |
| Pressure psig | 400 | 400 | 400 | 400 | 400 | 400 | 2250 | 2250 | 2250 |
| Flow GPM | 72/10 | 10 | 10 | 10 | 10 | 10 | 62/0 | 62/0 | 62/0 |

**INPUT FILE = inp18**

**REFERENCE - HISTOGRAM VII**

Rev. Indicator ←

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE |
|---|---|---|---|---|---|---|---|---|---|
| 0 | DORIS BERG | 11/13/92 | AMIT BHATTACHARYA | 11/13/92 | | | | | |

**inp19**

PIPE TEMPERATURES FOR TRANSIENT HISTOGRAMS – AUXILIARY SPRAY PIPE SYSTEM

NORMAL PLANT COOLDOWN (B): During Normal Plant Cooldown Operations there is intermittent flow in the auxiliary spray line. At this time the auxiliary spray pipe has a flow condition of 62 GPM for two, (2), minutes and shuts down for twenty, (20), minutes to zero flow. Stratification in pipe section is conservatively assumed to exist for this operation in the pipe section I, CH-E-009-BCAA-2". There is a possibility that the regenerative heat exchanger is not operating so various temperatures are assumed and accounted for by PLANT COOLDOWN (A), (B), and (C) Conditions

Number of Cycles: COOLDOWN CONDITION (B) – 92 cycles x 5cycles per Cooldown= 460 cycles

| Pipe Section | A | B | C | D | E | F | I | J | K |
|---|---|---|---|---|---|---|---|---|---|
| Reference Temp. F | 110 | 70 | 70 | 70 | 70 | 70 | 110 | 110 | 110 |
| System Temp. F | 435 | 435 | 435 | 435 | 435 | 435 | 435 | 110 | 110 |
| Delta Temp. F | 325 | 365 | 365 | 365 | 365 | 365 | 375 | 0 | 0 |

THERMAL STRATIFICATION IS TO BE INCLUDED IN PIPE SECTION I

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Pressure psig | 400 | 400 | 400 | 400 | 400 | 400 | 2250 | 2250 | 2250 |
| Flow GPM | 72/10 | 10 | 10 | 10 | 10 | 10 | 62/0 | 62/0 | 62/0 |

**INPUT FILE = inp19**

**REFERENCE - HISTOGRAM VII**

Rev. Indicator ←

inp20

PIPE TEMPERATURES FOR TRANSIENT HISTOGRAMS – AUXILIARY SPRAY PIPE SYSTEM

NORMAL PLANT COOLDOWN (C): During Normal Plant Cooldown Operations there is intermittent flow in the auxiliary spray line. At this time the auxiliary spray pipe has a flow condition of 62 GPM for two, (2), minutes and shuts down for twenty, (20), minutes to zero flow. Stratification in pipe section is conservatively assumed to exist for this operation in the pipe section I, CH-E-009-BCAA-2". There is a possibility that the regenerative heat exchanger is not operating so various temperatures are assumed and accounted for by PLANT COOLDOWN (A), (B), and (C) Conditions

Number of Cycles: COOLDOWN CONDITION (C) – 368 cycles x 5cycles per Cooldown= 1840cycles

| Pipe Section | A | B | C | D | E | F | I | J | K |
|---|---|---|---|---|---|---|---|---|---|
| Reference Temp. F | 160 | 70 | 70 | 70 | 70 | 70 | 160 | 160 | 160 |
| System Temp. F | 435 | 435 | 435 | 435 | 435 | 435 | 435 | 160 | 160 |
| Delta Temp. F | 275 | 365 | 365 | 365 | 365 | 365 | 275 | 0 | 0 |

THERMAL STRATIFICATION IS TO BE INCLUDED IN PIPE SECTION I

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Pressure psig | 400 | 400 | 400 | 400 | 400 | 400 | 2250 | 2250 | 2250 |
| Flow GPM | 72/10 | 10 | 10 | 10 | 10 | 10 | 62/0 | 62/0 | 62/0 |

**INPUT FILE = inp20**

**REFERENCE - HISTOGRAM VII**

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE |
|---|---|---|---|---|---|---|---|---|---|
| 0 | DOUG BERG | 11/3/92 | AMIT BHATTACHARYA | 11/3/92 | | | | | |

Rev. Indicator

ANPP

# CALCULATION SHEET

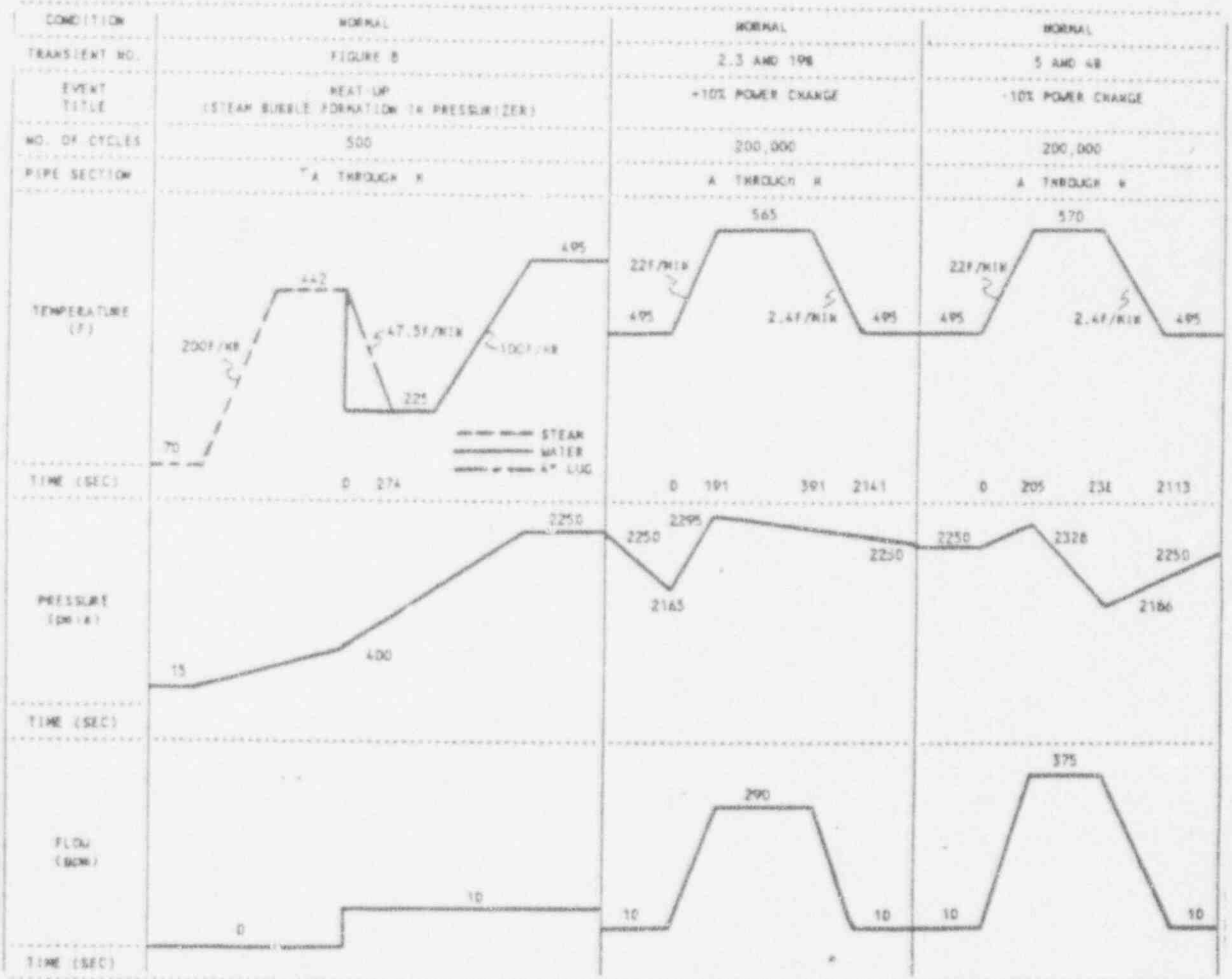
CALC. TITLE AUXILIARY SPRAY LINE THERMAL STRATIFICATION CALC. NO 13-MC-ZZ-643

SUBJECT STRATIFIED THERMAL ANALYSIS OF THE 2-INCH DIA. PIPE SHEET NO. 26

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. Indicator ↓ |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | DOUG BERG | 11/13/92 | AMIT BHATTACHARYA | 11/13/92 | | | | | | |
| | | | | | | | | | | |

## HISTOGRAMS

HISTOGRAM NO. ⟶ III II I



ANPP

# CALCULATION SHEET

CALC. TITLE AUXILIARY SPRAY LINE THERMAL STRATIFICATION CALC. NO 13-MC-ZZ-643

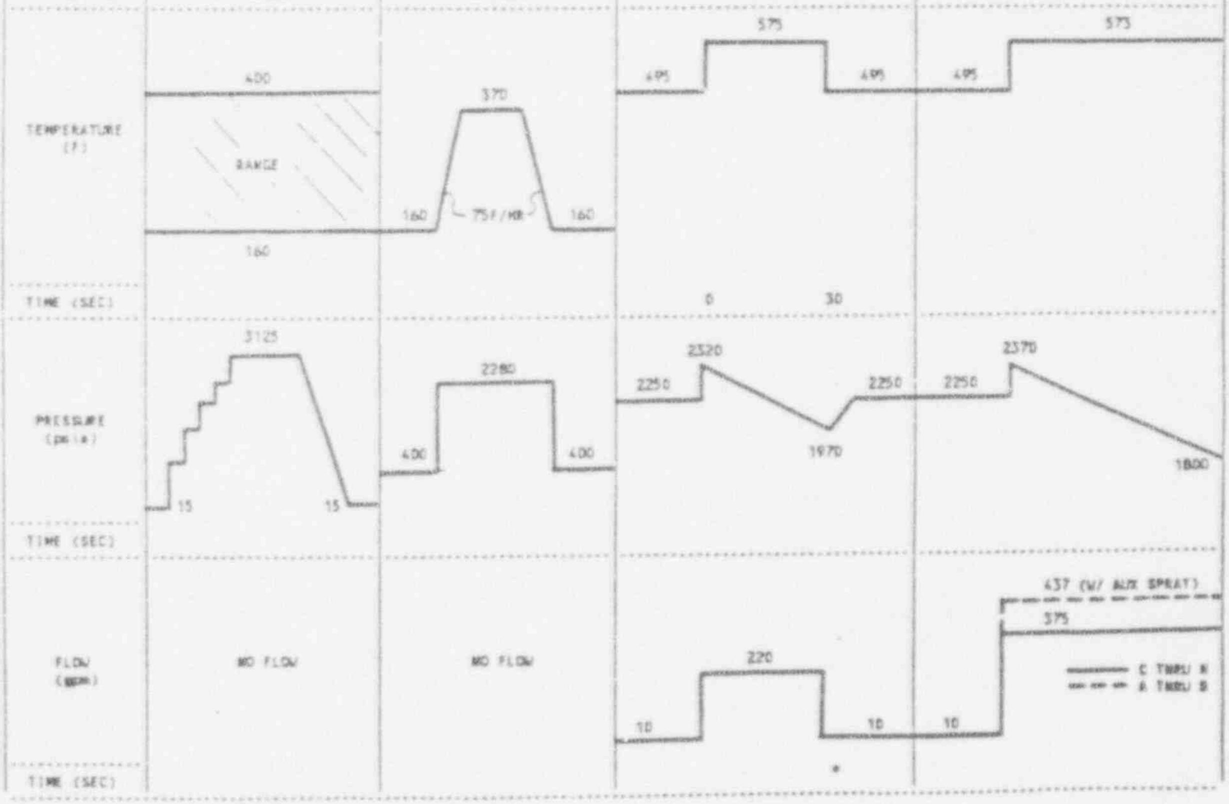
SUBJECT STRATIFIED THERMAL ANALYSIS OF THE 2-INCH DIA. PIPE SHEET NO. 27

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. Indi-cator ↓ |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | DOUG BERG | 11/13/92 | AMIT BHATTACHARYA | 11/13/92 | | | | | | |
| | | | | | | | | | | |

## HISTOGRAMS

HISTOGRAM NO. ⟶

| | | | IV | VI |
|---|---|---|---|---|
| CONDITION | TEST | TEST | UPSET | UPSET |
| TRANSIENT NO. | 21K | 22K | 12B | 10, 11, 17, 31 & 9B |
| EVENT TITLE | HYDRO TEST | LEAK TEST | LOAD REJECTION AT 100 % POWER NO REACTOR TRIP | SPURIOUS UPSET EVENTS |
| NO. OF CYCLES | 20 | 400 | 85 | 355 |
| PIPE SECTION | A THROUGH H | A THROUGH H | A THROUGH H | A THROUGH H |




NOTE: Test conditions not run due to no flow in either Aux. or Main Spray systems.

ANPP

# CALCULATION SHEET

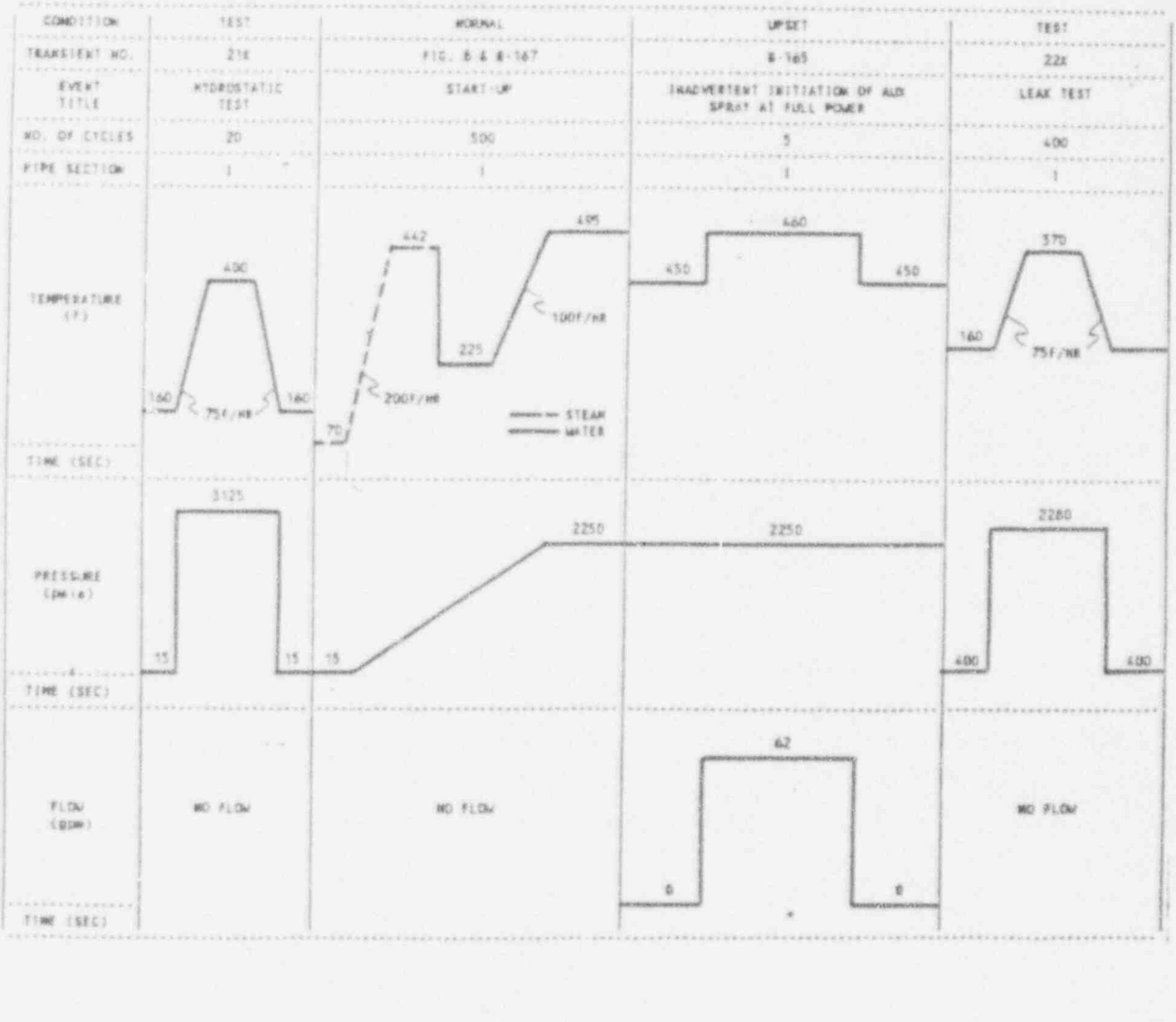
CALC. TITLE AUXILIARY SPRAY LINE THERMAL STRATIFICATION CALC. NO 13-MC-ZZ-643

SUBJECT STRATIFIED THERMAL ANALYSIS OF THE 2-INCH DIA. PIPE SHEET NO. 28

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. Indi-cator ↓ |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | DOUG BERG | 11/13/92 | AMIT BHATTACHARYA | 11/13/92 | | | | | | |
| | | | | | | | | | | |

## HISTOGRAMS

HISTOGRAM NO ⟶ III V




NOTE: Test conditions not run due to no flow in either Aux. or Main Spray systems.

ANPP

# CALCULATION SHEET

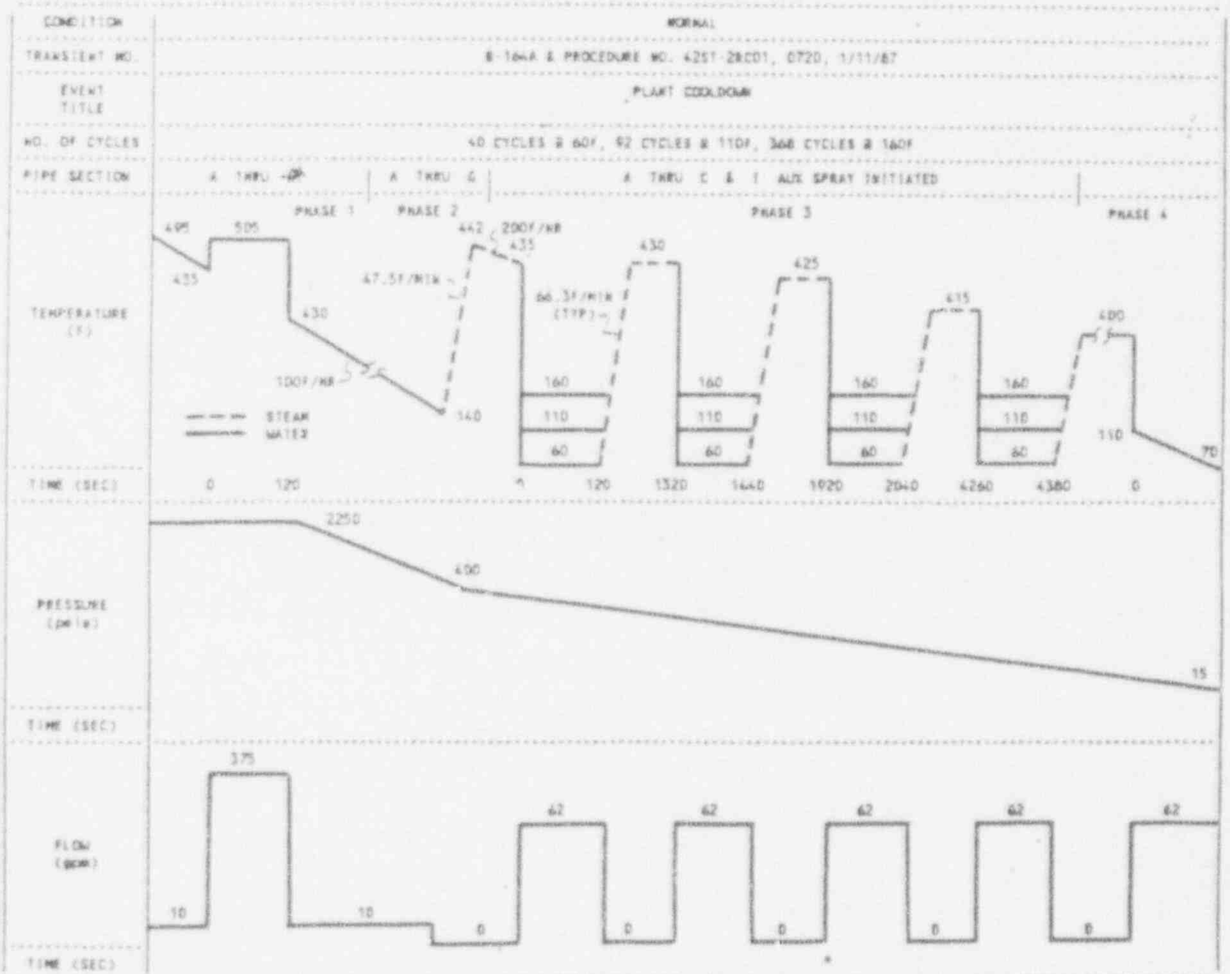
CALC. TITLE AUXILIARY SPRAY LINE THERMAL STRATIFICATION CALC. NO 13-MC-ZZ-643

SUBJECT STRATIFIED THERMAL ANALYSIS OF THE 2-INCH DIA. PIPE SHEET NO. 29

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. Indi-cator ↓ |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | DOUG BERG | 11/18/92 | AMIT BHATTACHARYA | 12/3/92 | | | | | | |
| | | | | | | | | | | |

## HISTOGRAMS

HISTOGRAM NO. ⟶ VII



ANPP

# CALCULATION SHEET

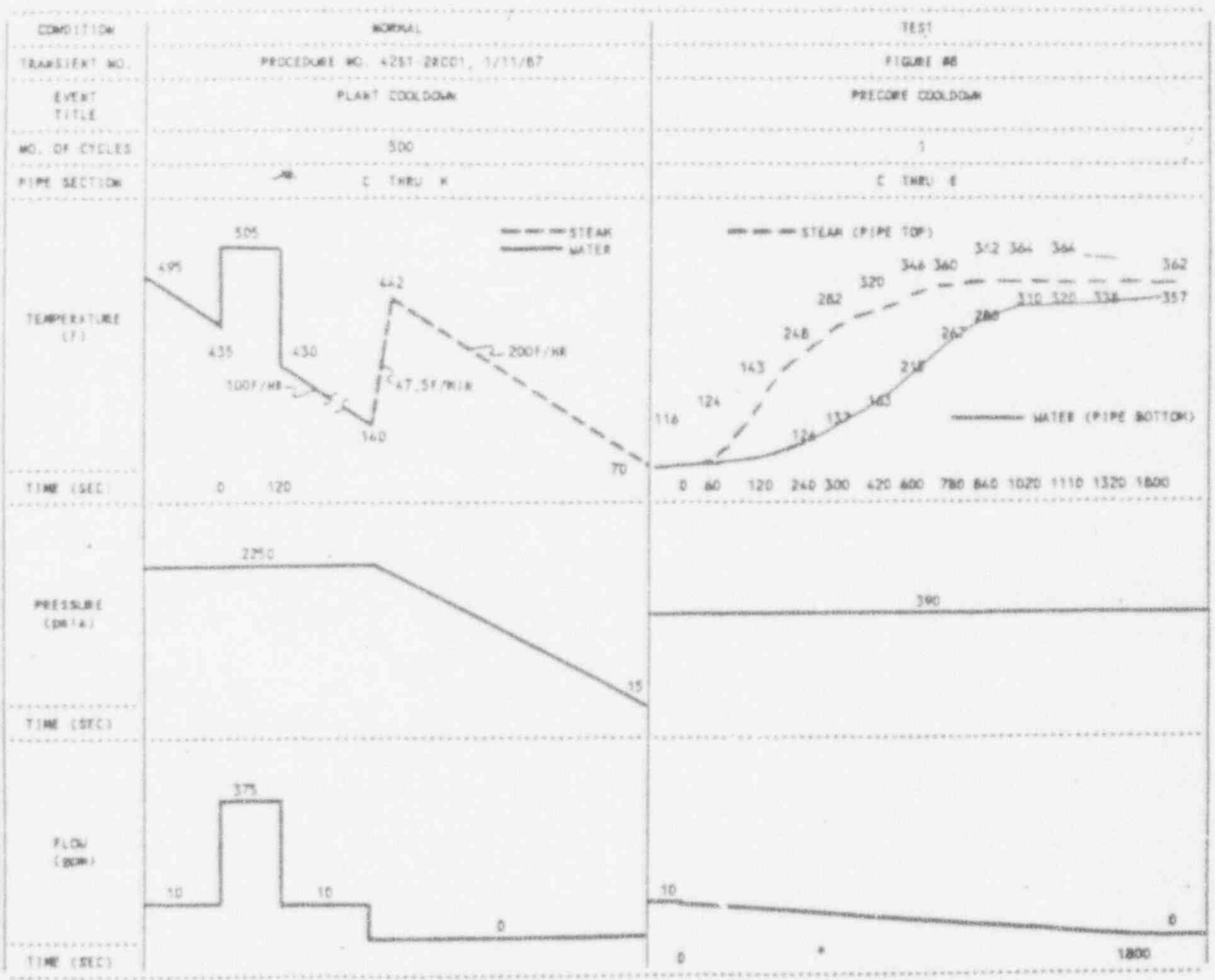
CALC. TITLE AUXILIARY SPRAY LINE THERMAL STRATIFICATION CALC. NO 13-MC-ZZ-643

SUBJECT STRATIFIED THERMAL ANALYSIS OF THE 2-INCH DIA. PIPE SHEET NO. 30

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. Indicator |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | DOUG BERG | 11/13/92 | AMIT BHATTACHARYA | 11/13/92 | | | | | | ↓ |
| | | | | | | | | | | |

## HISTOGRAMS

HISTOGRAM NO. → VII




NOTE: Precore Cooldown was not run due to only one cycle event which has insignificant effect on the usage factor.

ANPP

# CALCULATION SHEET

CALC. TITLE AUXILIARY SPRAY LINE THERMAL STRATIFICATION CALC. NO 13-MC-ZZ-643

SUBJECT STRATIFIED THERMAL ANALYSIS OF THE 2-INCH DIA. PIPE SHEET NO. 31

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. Indi-cator |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | DOUG BERG | 11/13/92 | AMIT BHATTACHARYA | 11/13/92 | | | | | | ↓ |
| | | | | | | | | | | |

## 7.0 STRESS RESULTS SUMMARIES

ANPP

# CALCULATION SHEET

CALC. TITLE AUXILIARY SPRAY LINE THERMAL STRATIFICATION CALC. NO 13-MC-ZZ-643

SUBJECT STRATIFIED THERMAL ANALYSIS OF THE 2-INCH DIA. PIPE SHEET NO. 32

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. Indicator |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | DOUG BERG | 11/13/92 | AMIT BHATTACHARYA | 11/13/92 | | | | | | ↓ |
| | | | | | | | | | | |

## TABLE 1

### STRESS SUMMARY FOR EFFECT ON CLASS 1 CALC. NO. 13-MC-ZZ-588

| LOAD CASE | MAX. STRESS INTENSITY, S.I. psi | NODE POINT |
|---|---|---|
| inp12 | 9228.3 | 52 |
| inp13 | 9225 | 52 |
| inp14 | 6411.6 | 6 |
| inp15 | 9201.4 | 52 |
| inp16 | 13633.0 | 41 |
| inp17 | 10716.0 | 41 |
| inp18 | 9148.8 | 52 |
| inp19 | 9153.7 | 52 |
| inp20 | 9158.7 | 52 |

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. Indicator |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | DOUG BERG | 11/13/92 | AMIT BHATTACHARYA | 11/13/92 | | | | | | ↓ |
| | | | | | | | | | | |

# TABLE 2

## STRESS SUMMARY FOR EFFECT ON POTENTIAL TRANSIENT CALC. NO. 13-MC-ZZ-045

| STRATIFIED LOAD CASE | NON-STRATIFIED(1) LOAD CASE | MAX. CHANGE IN S.I.(2) psi | NODE POINT |
|---|---|---|---|
| inp12 | inp5 | 9228.3 - 16604 = -7376 | 52 |
| inp13 | inp5 | 9225.0 - 16604 = -7379 | 52 |
| inp14 | inp4 | 6411.6 - 11066 = -4654 | 6 |
| inp15 | inp5 | 9201.4 - 16604 = -7403 | 52 |
| N/A | inp16 (3) | 13633 - 13633 = 0 | 41 |
| N/A | inp17 (3) | 10716 - 10716 = 0 | 41 |
| inp18 | inp8 | 9148.8 - 16406 = -7257 | 52 |
| inp19 | inp8 | 9153.7 - 16406 = -7252 | 52 |
| inp20 | inp8 | 9158.7 - 16406 = -7247 | 52 |

With Stratification ↑ (first value) ↑ Without Stratification (second value)

NOTES:

(1) Non-stratified load case was run with uniform temperature in Section I the same as in Section A.

(2) Max. change in stress intensity, S.I. is calculated as the max. stress intensity in the Stratified case minus the max. stress intensity in the Non-stratified case.

(3) No Stratification exists in this load condition and, therefore, there will be no change in existing stresses.

(4) Same geometry and input model are used for both stratified and non-stratified load cases per Figures 3A, 3B and 5 for ANSYS 4.4A analysis.

# TABLE 3

## VALIDITY CHECK OF ANSYS RUN BY COMPARISON TO EXISTING ME101 RUN

| LOAD CASE ME101 | LOAD CASE ANSYS | ME101 MAX (1) STRESS psi | ANSYS 4.4A MAX (2) STRESS psi |
|---|---|---|---|
| THRM02 | inp4 | 5617 x 1.9 = 10672 psi | $16604 - \frac{2250 \times 2.375}{4 \times 0.343} =$ 12709 psi |
| THRM01 | inp5 | 3977 x 1.9 = 7556 psi | $11066 - \frac{2250 \times 2.375}{4 \times 0.343} =$ 7171 psi |
| THRM02 | inp8 | 5617 x 1.9 = 10672 psi | $16406 - \frac{2250 \times 2.375}{4 \times 0.343} =$ 12511 psi |

NOTES:

(1) Reference run is SNUM #NE194 from Calc. No. 13-MC-ZZ-045. Values are multiplied by the butt weld SIF of 1.9 for comparison with ANSYS since this SIF was omitted from ME101.

(2) Reference runs have same run number as ANSYS load case. Pressure stress included in ANSYS run has been subtracted for comparison with ME101.

CONCLUSION:

ANSYS stresses are more conservative by comparison to ME101 stresses per the table above. However, ANSYS stresses above are actually based on Stress Intensity as compared to ME101 stresses which are based on Bending Stress. Stress Intensity is higher because it is the maximum principal stress range in the direction of zero shear due to loading in all directions. Bending Stress is only the longitudinal stress due to the bending moment.

Therefore, the ANSYS calculated stresses have been judged to be comparable to the existing ME101 stresses and the ANSYS model used for this analysis is valid.

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. Indi-cator ↓ |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | DOUG BERG | 11/13/92 | AMIT BHATTACHARYA | 11/13/92 | | | | | | |
| | | | | | | | | | | |

# 8.0 PIPING MODELS & SKETCHES

ANPP

# CALCULATION SHEET

CALC. TITLE AUXILIARY SPRAY LINE THERMAL STRATIFICATION CALC. NO 13-MC-ZZ-643

SUBJECT STRATIFIED THERMAL ANALYSIS OF THE 2-INCH DIA. PIPE SHEET NO. 36

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. Indicator |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | [signature] | 11/13/92 | [signature] | 11/13/92 | | | | | | ↓ |
| | | | | | | | | | | |

## ANSYS 4.4A INPUT MODEL

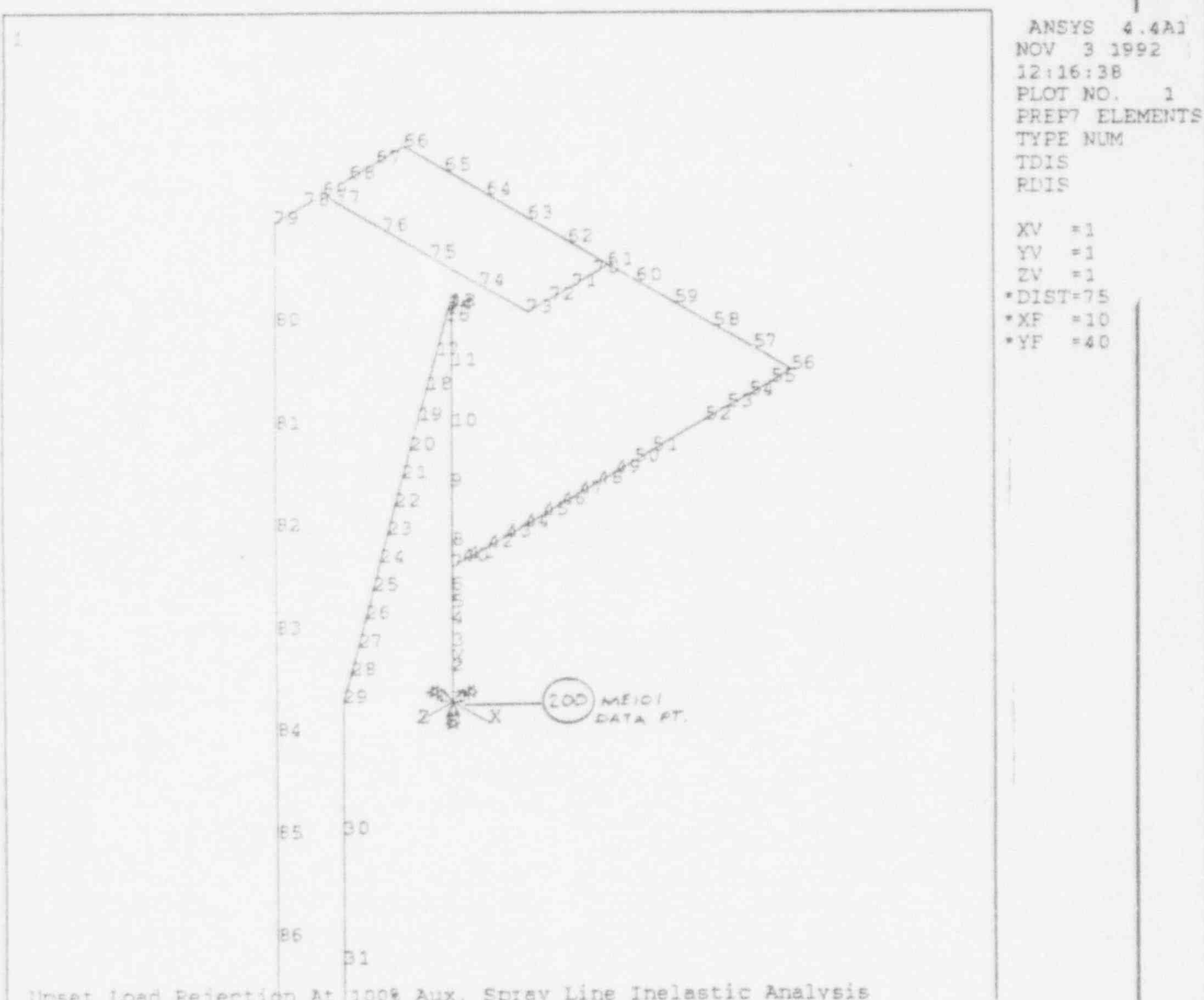



FIGURE - 3A

ANPP

# CALCULATION SHEET

CALC. TITLE AUXILIARY SPRAY LINE THERMAL STRATIFICATION CALC. NO 13-MC-ZZ-643

SUBJECT STRATIFIED THERMAL ANALYSIS OF THE 2-INCH DIA. PIPE SHEET NO. 37

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. Indicator ↓ |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | D Bee | 11/13/92 | [signature] | 11/13/92 | | | | | | |
| | | | | | | | | | | |

## ANSYS 4.4A INPUT MODEL

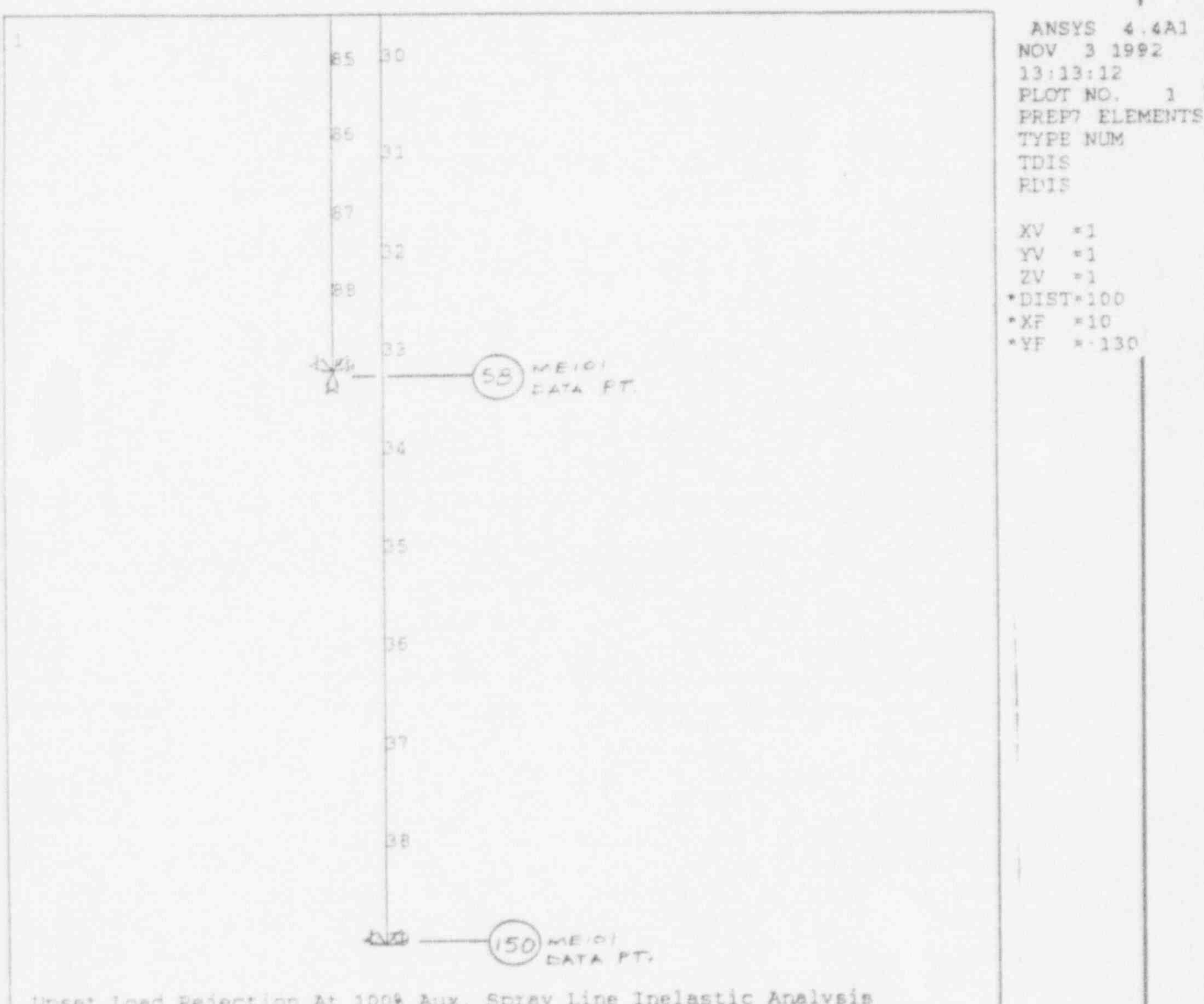



FIGURE - 3B

ANPP

# CALCULATION SHEET

CALC. TITLE AUXILIARY SPRAY LINE THERMAL STRATIFICATION CALC. NO 13-MC-ZZ-643

SUBJECT STRATIFIED THERMAL ANALYSIS OF THE 2-INCH DIA. PIPE SHEET NO. 38

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. Indi-cator |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | [signature] | 11/13/92 | [signature] | 11/13/92 | | | | | | ↓ |
| | | | | | | | | | | |

## ORIGINAL STRESS SKETCHES

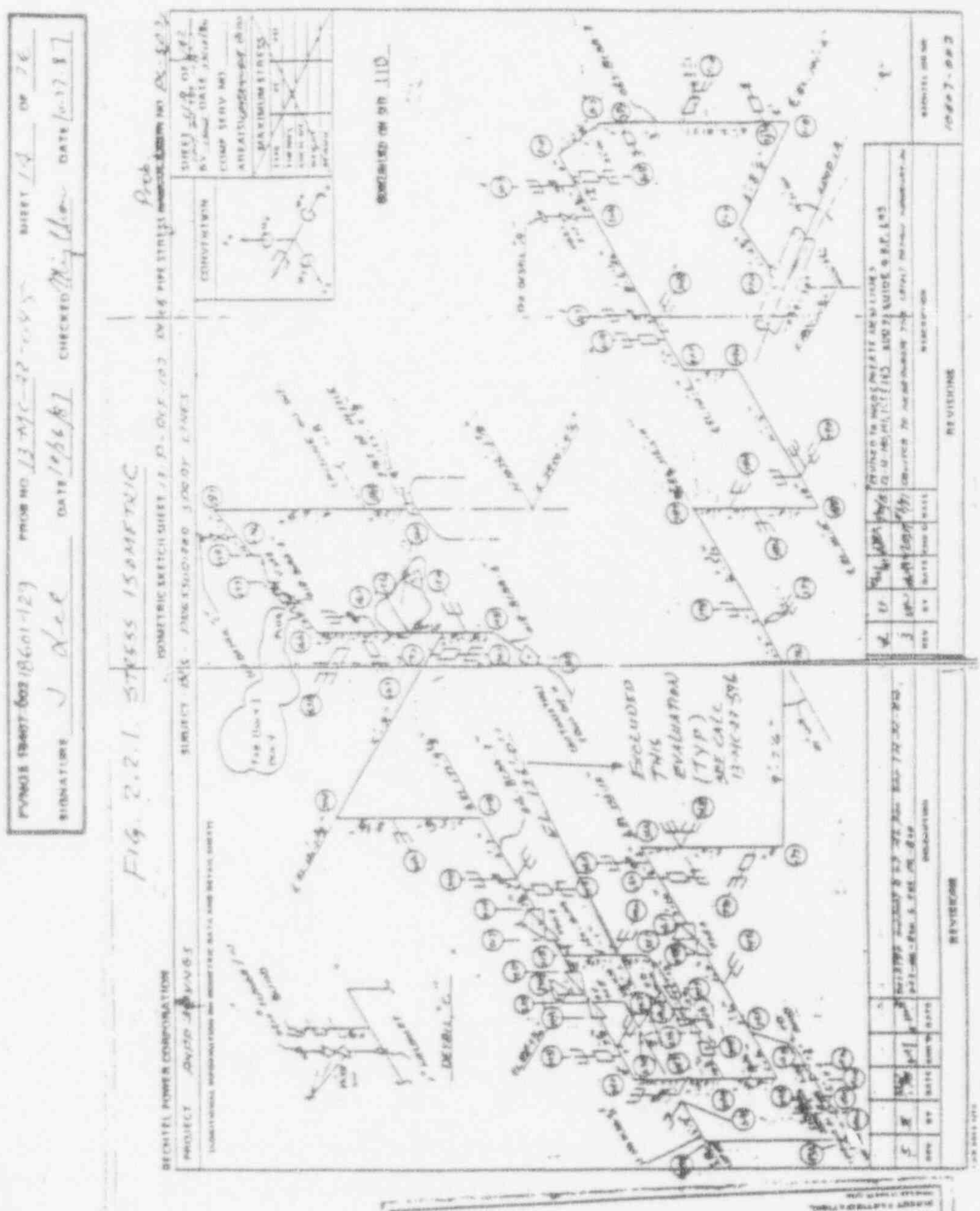


FIGURE - 4A

# CALCULATION SHEET

ANPP

CALC. TITLE AUXILIARY SPRAY LINE THERMAL STRATIFICATION CALC. NO 13-MC-ZZ-643

SUBJECT STRATIFIED THERMAL ANALYSIS OF THE 2-INCH DIA. PIPE SHEET NO. 39

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. Indicator |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | [signature] | 11/13/92 | [signature] | 11/13/92 | | | | | | ↓ |
| | | | | | | | | | | |

## ORIGINAL STRESS SKETCHES

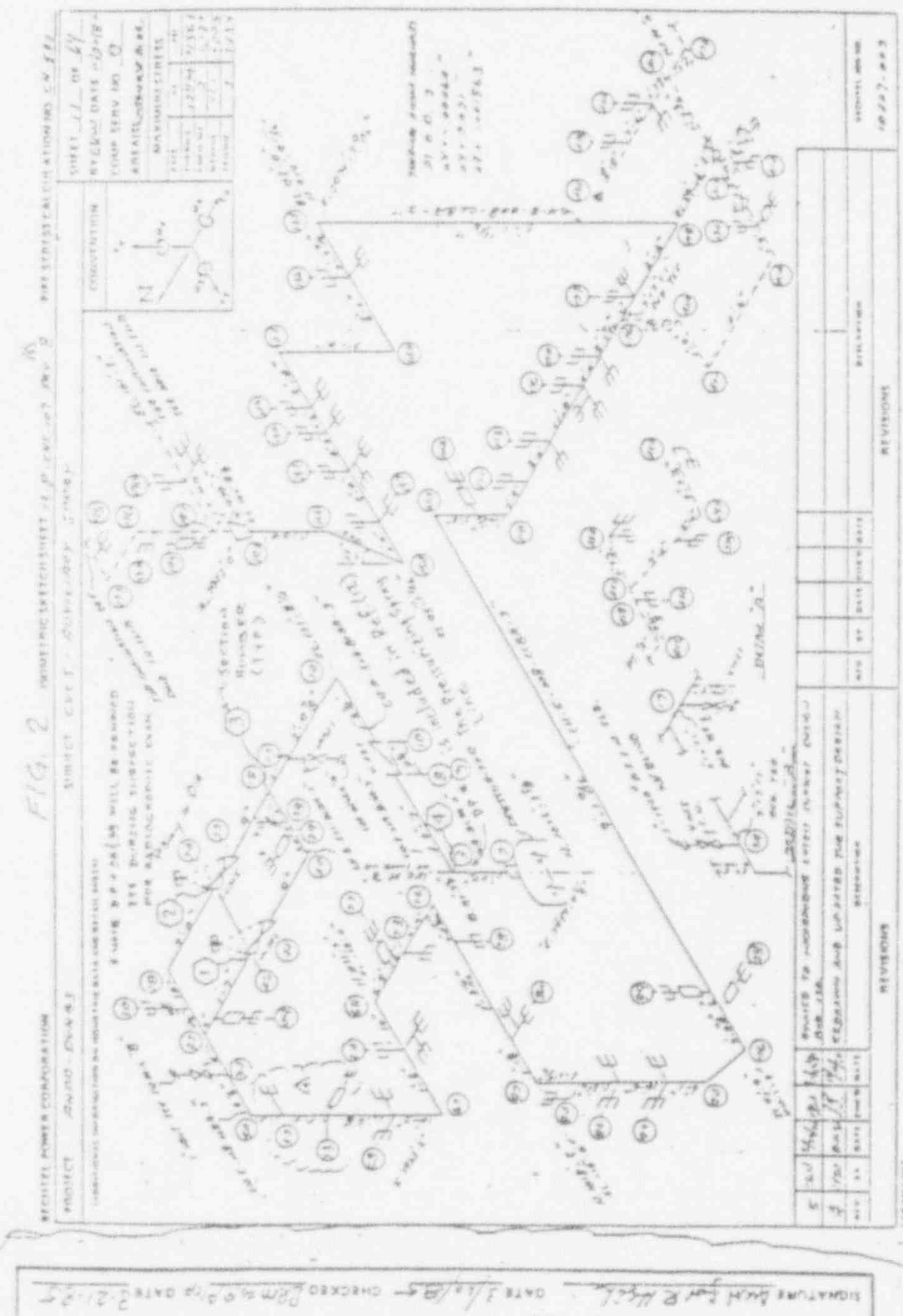


FIGURE - 4B

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. indicator |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | [signature] | 11/13/92 | [signature] | 11/13/92 | | | | | | ↓ |
| | | | | | | | | | | |

## CALC. 13-MC-ZZ-045 SKETCH

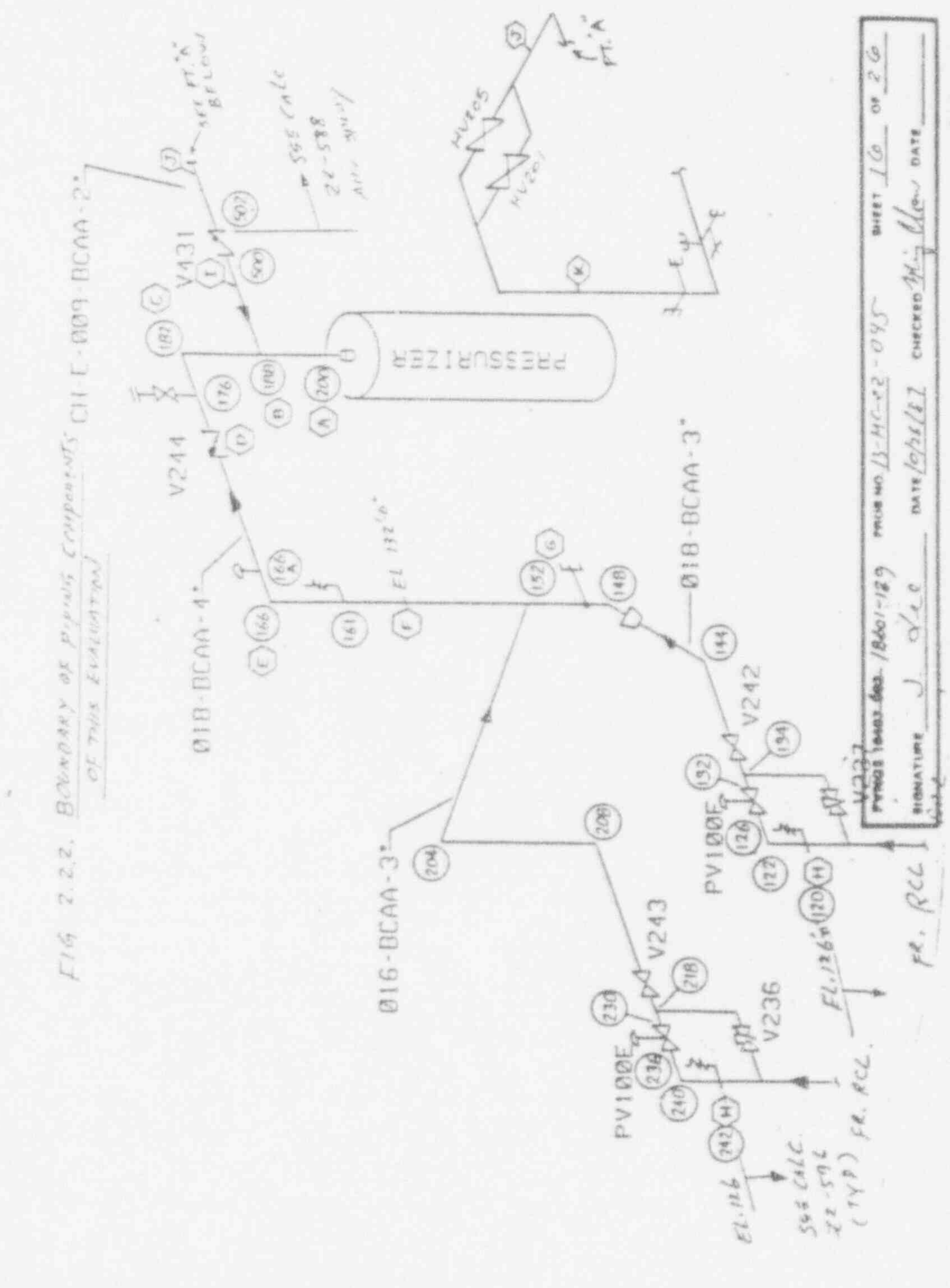



FIGURE - 5

ANPP

# CALCULATION SHEET

CALC. TITLE AUXILIARY SPRAY LINE THERMAL STRATIFICATION CALC. NO 13-MC-ZZ-643

SUBJECT STRATIFIED THERMAL ANALYSIS OF THE 2-INCH DIA. PIPE SHEET NO. 1 of 13

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. Indi-cator ↓ |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | DOUG BERG | 4/13/92 | AMIT BHATTACHARYA | 4/13/92 | | | | | | |
| | | | | | | | | | | |

## ATTACHMENT 1

## ANSYS 4.4A STRESS SUMMARIES

ATT. 1
SHT. 2 OF 13



```
    88    3266.3      -1150.0       5662.8      -9.2009       2400.7      0.28170E-24  5662.8
    5133.7            0.        0.74999E-04
1           ANSYS - ENGINEERING ANALYSIS SYSTEM  REVISION 4.4       A166   ARIZONA PUBLIC
  MAY 1,1990
     ANSYS(R)  COPYRIGHT(C) 1971, 1978, 1982, 1983, 1985, 1987, 1989, 1990   SWANSON ANAL
YSIS SYSTEMS, INC. AS UNPUBLISHED WORK.
     PROPRIETARY DATA - UNAUTHORIZED USE, DISTRIBUTION OR DUPLICATION IS PROHIBITED.  ALL
 RIGHTS RESERVED.
     FOR SUPPORT CALL BOB WESOLOWSKI    PHONE (602) 250-3428    TWX

 Normal -10% Change 570-435  Strat. Aux. Spray Line Inelastic Analysis            17.1500
 OCT 15,1992 CP=     72.100

        ***** POST1 ELEMENT STRESS LISTING *****

 LOAD STEP     4  ITERATION=     5  SECTION=  1
 TIME=         0.          LOAD CASE=  1

 ELEM       STRA          STRR          STRH          STRX          STRD          STRT          STRP
      STIN          RATY          AEST
    89    2833.5      -1150.0       5662.8      -9.2009       2400.7          0.        5662.8
    5000.0            0.        0.58026E-04

 MINIMUMS
 ELEMENT      55            52            51            70            51            56            51
        2             1            55
 VALUE     -1444.1      -1150.0       1644.9      -584.68       491.41      -2606.0       1644.9
    2136.7            0.       -0.10972E-03

 MAXIMUMS
 ELEMENT      80             1             3            56             8            71             3
       52             6            80
 VALUE      6728.6      -1125.0       7283.9       2303.6       3154.7       553.57       7283.9
    9228.3        0.38741       0.21078E-03

 ***** ROUTINE COMPLETED *****  CP =          72.130

 ***** END OF INPUT ENCOUNTERED ON FILE18

 PREP7 AFWRITE OR SFWRITE WARNING MESSAGES =  12
 NUMBER OF SOLUTION PHASE WARNING MESSAGES =   0

 ***** RUN COMPLETED *****  CP=        72.1500   TIME=   17.1500
```

Normal +10% Change Aux. Spray Line Inelastic Analysis 9.3444
OCT 16,1992 CP= 75.490

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 4 ITERATION= 5 SECTION= 1
TIME= 0. LOAD CASE= 1

| ELEM | STRA | STRR | STRH | STRX | STRD | STRT | STRP |
|---|---|---|---|---|---|---|---|
| STIN | RATY | AEST | | | | | |
| 89 | 2833.3 | -1150.0 | 5662.8 | -9.1970 | 2400.7 | 0. | 5662.8 |
| 5000.0 | 0. | 0.58017E-04 | | | | | |

MINIMUMS

| | STRA | STRR | STRH | STRX | STRD | STRT | STRP |
|---|---|---|---|---|---|---|---|
| ELEMENT | 55 | 52 | 51 | 71 | 51 | 56 | 51 |
| | 2 | 1 | 55 | | | | |
| VALUE | -1442.2 | -1150.0 | 1644.9 | -584.38 | 491.40 | -2604.7 | 1644.9 |
| | 2137.0 | 0. | -0.10965E-03 | | | | |

MAXIMUMS

| | STRA | STRR | STRH | STRX | STRD | STRT | STRP |
|---|---|---|---|---|---|---|---|
| ELEMENT | 80 | 1 | 3 | 56 | 9 | 71 | 3 |
| | 52 | 6 | 80 | | | | |
| VALUE | 6726.5 | -1125.0 | 7283.9 | 2302.4 | 3154.7 | 553.27 | 7283.9 |
| | 9225.0 | 0.38741 | 0.21069E-03 | | | | |

***** ROUTINE COMPLETED ***** CP = 75.510

***** END OF INPUT ENCOUNTERED ON FILE18

PREP7 AFWRITE OR SFWRITE WARNING MESSAGES = 12
NUMBER OF SOLUTION PHASE WARNING MESSAGES = 0

***** RUN COMPLETED ***** CP= 75.5400 TIME= 9.3444

ATT-1
SHT. 4 OF 13



1 ANSYS - ENGINEERING ANALYSIS SYSTEM REVISION 4.4 , A166 ARIZONA PUBLIC
MAY 1,1990


FOR SUPPORT CALL BOB WESOLOWSKI PHONE (602) 250-3428 TWX

Normal Start Up Aux. Spray Line Inelastic Analysis 7.4039
OCT 16,1992 CP= 71.400

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 4 ITERATION= 5 SECTION= 1
TIME= 0. LOAD CASE= 1

```
 ELEM      STRA        STRR        STRH        STRX        STRD        STRT        STRP
     STIN        RATY        AEST
   89    2643.1     -1150.0      5662.8      1.5320          0.          0.          0.
       0.          0.          0.

MINIMUMS
ELEMENT     51          52          51          71           1          48           1
       1           1          50
VALUE   -1016.5     -1150.0      1644.9     -444.72          0.     -965.72          0.
       0.          0.     -0.37715E-04

MAXIMUMS
ELEMENT     80           1           3          56           7           1           6
       6           6           7
VALUE    5063.3     -1125.0      7283.9      1658.3      3154.7          0.      7283.9
    6411.6     0.38754     0.49598E-04
```

***** ROUTINE COMPLETED ***** CP = 71.420

***** END OF INPUT ENCOUNTERED ON FILE18

PREP7 AFWRITE OR SFWRITE WARNING MESSAGES = 12
NUMBER OF SOLUTION PHASE WARNING MESSAGES = 0

***** RUN COMPLETED ***** CP= 71.4400 TIME= 7.4042

Upset Load Rejection At 100% Aux. Spray Line Inelastic Analysis 10.9747
OCT 16,1992 CP= 72.120

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 4 ITERATION= 5 SECTION= 1
TIME= 0. LOAD CASE= 1

| ELEM | STRA | STRR | STRH | STRX | STRD | STRT | STRP |
|---|---|---|---|---|---|---|---|
| STIN | RATY | AEST | | | | | |
| 89 | 2833.3 | -1150.0 | 5662.8 | -9.3351 | 2400.9 | -0.28133E-24 | 5662.8 |
| 5000.1 | 0. | 0.58018E-04 | | | | | |

MINIMUMS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ELEMENT | 55 | 52 | 51 | 70 | 51 | 60 | 51 |
| 2 | 1 | 55 | | | | | |
| VALUE | -1430.3 | -1150.0 | 1644.9 | -583.31 | 491.37 | -2599.6 | 1644.9 |
| 2137.1 | 0. | -0.10918E-03 | | | | | |

MAXIMUMS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ELEMENT | 80 | 1 | 3 | 60 | 9 | 72 | 3 |
| 52 | 6 | 80 | | | | | |
| VALUE | 6724.9 | -1125.0 | 7283.9 | 2298.3 | 3154.7 | 551.88 | 7283.9 |
| 9201.4 | 0.38741 | 0.21063E-03 | | | | | |

***** ROUTINE COMPLETED ***** CP = 72.140

***** END OF INPUT ENCOUNTERED ON FILE18

PREP7 AFWRITE OR SFWRITE WARNING MESSAGES = 12
NUMBER OF SOLUTION PHASE WARNING MESSAGES = 0

***** RUN COMPLETED ***** CP= 72.1700 TIME= 10.9750

```
         STIN          RATY          AEST
     89    2700.3      -1150.0       5662.8      -20.730      2408.1        0.       5662.8
     5002.6          0.     0.52804E-04

 MINIMUMS
 ELEMENT     56          52           51           71           51           78          51
       2           1           56
 VALUE    -210.66     -1150.0      1644.9      -326.33       487.34     -2795.0      1644.9
     2213.1          0.     -0.61353E-04

 MAXIMUMS
 ELEMENT     39          43            3           79           33           70           3
      41          39          39
 VALUE     7142.3     -1125.0      7283.9       2295.8      3154.7       272.83      7283.9
     13633.      0.44309     0.22815E-03

 ***** ROUTINE COMPLETED *****  CP =         59.940

 ***** END OF INPUT ENCOUNTERED ON FILE18

 PREP7 AFWRITE OR SFWRITE WARNING MESSAGES =  12
 NUMBER OF SOLUTION PHASE WARNING MESSAGES =   0

 ***** RUN COMPLETED *****  CP=       59.9800   TIME=   13.0089
```

ATT-1
SHT 7 OF 13

```
 LOAD STEP      4  ITERATION=     5  SECTION=  1
 TIME=        0.           LOAD CASE=  1

 ELEM       STRA          STRR          STRH          STRX          STRD          STRT          STRP
     STIN          RATY          AEST
    89    2591.3      -1150.0       5662.8      -14.785       2393.2          0.          5662.8
    4974.5          0.       0.48529E-04

MINIMUMS
ELEMENT     56            52            51            71            51            78            51
      2             1             56
VALUE      351.60      -1150.0       1644.9      -245.87       487.52      -1950.8       1644.9
    2148.7          0.     -0.39304E-04

MAXIMUMS
ELEMENT     39             1             3            79            29            71             3
     41            39            39
VALUE      5865.3      -1125.0       7283.9       1600.1       3154.7       211.47       7283.9
    10716.      0.38917      0.17807E-03

***** ROUTINE COMPLETED *****  CP =        58.020

***** END OF INPUT ENCOUNTERED ON FILE18

PREP7 AFWRITE OR SFWRITE WARNING MESSAGES =  12
NUMBER OF SOLUTION PHASE WARNING MESSAGES =   0

***** RUN COMPLETED *****  CP=       58.0300   TIME=   13.2314
```

ATT -1
SHT 8 of 13

```
     5546.8           0.      0.10834E-03
     87   3687.6      -1150.0       5662.8      -9.2796      2400.5    -0.58785E-24  5662.8
     5315.9           0.      0.91518E-04
     88   3258.5      -1150.0       5662.8      -9.2796      2400.5     0.28170E-24  5662.8
     5131.7           0.      0.74694E-04
1          ANSYS - ENGINEERING ANALYSIS SYSTEM  REVISION 4.4      A166   ARIZONA PUBLIC
  MAY 1,1990
```


FOR SUPPORT CALL BOB WESOLOWSKI PHONE (602) 250-3428 TWX

```
 Normal Plant Cooldown (A) - Aux. Spray Line Inelastic Analysis                 14.2925
 OCT 16,1992 CP=      72.640

          ***** POST1 ELEMENT STRESS LISTING *****

 LOAD STEP      4  ITERATION=      5  SECTION=  1
 TIME=        0.          LOAD CASE=  1

 ELEM       STRA         STRR         STRH         STRX         STRD         STRT         STRP
     STIN         RATY         AEST
    89   2829.5     -1150.0       5662.8      -9.2796      2400.5          0.        5662.8
    4999.4           0.      0.57870E-04

 MINIMUMS
 ELEMENT    55           52           51           72           51           57           51
     2            1            55
 VALUE   -1399.0     -1150.0       1644.9      -578.41      491.35      -2578.3       1644.9
    2143.3           0.     -0.10795E-03

 MAXIMUMS
 ELEMENT    80            1            3           59            7           69            3
    52            6            80
 VALUE    6690.6     -1125.0       7283.9       2279.5      3154.7       547.16       7283.9
    9148.8     0.38740     0.20928E-03


 ***** ROUTINE COMPLETED *****  CP =         72.660

 ***** END OF INPUT ENCOUNTERED ON FILE18


 PREP7 AFWRITE OR SFWRITE WARNING MESSAGES =  12
 NUMBER OF SOLUTION PHASE WARNING MESSAGES =   0


 ***** RUN COMPLETED *****  CP=       72.6900   TIME=   14.2925
```

```
     5541.3          0.     0.10811E-03
     87    3683.1     -1150.0       5662.8      -9.0821       2400.1    -0.58785E-24  5662.8
     5312.6          0.     0.91342E-04
     88    3255.4     -1150.0       5662.8      -9.0821       2400.1     0.28170E-24  5662.8
     5130.0          0.     0.74571E-04
1          ANSYS - ENGINEERING ANALYSIS SYSTEM  REVISION 4.4      A166   ARIZONA PUBLIC
 MAY 1,1990
```


FOR SUPPORT CALL BOB WESOLOWSKI PHONE (602) 250-3428 TWX

```
 Normal Plant Cooldown (B) - Aux. Spray Line Inelastic Analysis              15.4311
 OCT 16,1992 CP=      71.950

         ***** POST1 ELEMENT STRESS LISTING *****

 LOAD STEP     4  ITERATION=     5  SECTION=  1
 TIME=         0.          LOAD CASE=  1

 ELEM       STRA         STRR         STRH         STRX         STRD         STRT         STRP
     STIN        RATY        AEST
   89    2827.8     -1150.0       5662.8      -9.0821       2400.1           0.        5662.8
   4998.9          0.     0.57801E-04

MINIMUMS
ELEMENT     55           52           51           72           51           60           51
      2           1           55
VALUE    -1399.0     -1150.0       1644.9      -577.45       491.37      -2574.7       1644.9
   2146.1          0.    -0.10796E-03

MAXIMUMS
ELEMENT     80            1            3           60            7           71            3
     52            6           80
VALUE     6676.6     -1125.0       7283.9       2275.9       3154.7       546.69       7283.9
   9153.7     0.38740     0.20873E-03

***** ROUTINE COMPLETED *****  CP =        71.970

***** END OF INPUT ENCOUNTERED ON FILE18

PREP7 AFWRITE OR SFWRITE WARNING MESSAGES =  12
NUMBER OF SOLUTION PHASE WARNING MESSAGES =   0

***** RUN COMPLETED *****  CP=       72.0100   TIME=   15.4311
```

ATT - 1
SHT 10 OF 13

```
    5535.9            0.      0.10788E-03
    87    3678.6     -1150.0      5662.8     -8.8846      2399.7    -0.30653E-24  5662.8
    5309.2            0.      0.91166E-04
    88    3252.3     -1150.0      5662.8     -8.8846      2399.7    -0.58748E-24  5662.8
    5128.4            0.      0.74449E-04
1          ANSYS - ENGINEERING ANALYSIS SYSTEM  REVISION 4.4      A166   ARIZONA PUBLIC
  MAY 1,1990
    ANSYS(R)  COPYRIGHT(C) 1971, 1978, 1982, 1983, 1985, 1987, 1989, 1990   SWANSON ANAL
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 RIGHTS RESERVED.
    FOR SUPPORT CALL BOB WESOLOWSKI    PHONE (602) 250-3428    TWX

 Normal Plant Cooldown (C) - Aux. Spray Line Inelastic Analysis               15.8364
 OCT 16,1992 CP=      72.480

          ***** POST1 ELEMENT STRESS LISTING *****

 LOAD STEP     4  ITERATION=     5  SECTION=  1
 TIME=        0.          LOAD CASE=  1

 ELEM      STRA        STRR        STRH        STRX        STRD        STRT        STRP
     STIN        RATY        AEST
    89    2826.0     -1150.0      5662.8     -8.8846      2399.7         0.       5662.8
    4998.3            0.      0.57732E-04

 MINIMUMS
 ELEMENT    55          52          51          70          51          57          51
      2           1          55
 VALUE    -1399.1     -1150.0      1644.9     -576.50      491.40     -2571.1      1644.9
    2149.1            0.     -0.10796E-03

 MAXIMUMS
 ELEMENT    80           1           3          57           8          70           3
     52           6          80
 VALUE     6662.5     -1125.0      7283.9      2272.2      3154.7      546.22      7283.9
    9158.7      0.38740     0.20818E-03

 ***** ROUTINE COMPLETED *****  CP =        72.490

 ***** END OF INPUT ENCOUNTERED ON FILE18

 PREP7 AFWRITE OR SFWRITE WARNING MESSAGES =  12
 NUMBER OF SOLUTION PHASE WARNING MESSAGES =   0

 ***** RUN COMPLETED *****  CP=       72.5300   TIME=   15.8364
```

ATT-1
SHT 11 OF 13

```
     ***** POST1 ELEMENT STRESS LISTING *****

  LOAD STEP     4  ITERATION=     5  SECTION=  1
  TIME=          0.          LOAD CASE=  1

  ELEM      STRA          STRR          STRH          STRX          STRD          STRT          STRP
      STIN          RATY          AEST
    89    2605.3       -1150.0        5662.8       -15.522          0.            0.            0.
        0.            0.            0.

 MINIMUMS
 ELEMENT    56            52            51            72            1             50            1
       1             1             1
 VALUE     283.39      -1150.0        1644.9       -256.25          0.         -1884.9          0.
        0.            0.            0.

 MAXIMUMS
 ELEMENT    39            1             3             78            7             6             6
      41            39            39
 VALUE     6021.9      -1125.0        7283.9        1688.0        3154.7        100.91        7283.9
     11066.      0.39532       0.18422E-03

 ***** ROUTINE COMPLETED *****  CP =        64.7[illegible]0

 ***** END OF INPUT ENCOUNTERED ON FILE18


 PREP7 AFWRITE OR SFWRITE WARNING MESSAGES =  12
 NUMBER OF SOLUTION PHASE WARNING MESSAGES =   0


 ***** RUN COMPLETED *****  CP=        64.8200   TIME=   13.7844
```

ATT-1
SHT 12 OF 13

```
     STIN          RATY          AEST
   89    2795.4      -1150.0      5662.8     -26.480      2421.9          0.       5662.8
   5032.7            0.      0.56530E-04

 MINIMUMS
 ELEMENT    56           52           51          70          51          79          51
      2            1            56
 VALUE    -772.79     -1150.0      1644.9     -393.84      487.05     -3570.7      1644.9
   2254.8            0.     -0.83398E-04

 MAXIMUMS
 ELEMENT    39            1            3          78           8          72           3
     41           39           39
 VALUE     8404.1     -1125.0      7283.9      2934.9      3154.7      322.60      7283.9
   16604.      0.50268      0.27763E-03


 ***** ROUTINE COMPLETED *****  CP =        60.330

 ***** END OF INPUT ENCOUNTERED ON FILE18


 PREP7 AFWRITE OR SFWRITE WARNING MESSAGES =  12
 NUMBER OF SOLUTION PHASE WARNING MESSAGES =   0


 ***** RUN COMPLETED *****  CP=        60.3700   TIME=   11.1983
```

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 4 ITERATION= 5 SECTION= 1
TIME= 0. LOAD CASE= 1

| ELEM | STRA | STRR | STRH | STRX | STRD | STRT | STRP |
|---|---|---|---|---|---|---|---|
| STIN | RATY | AEST | | | | | |
| 89 | 2792.3 | -1150.0 | 5662.8 | -26.133 | 2421.2 | 0. | 5662.8 |
| 5031.1 | 0. | 0.56409E-04 | | | | | |

MINIMUMS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ELEMENT | 56 | 52 | 51 | 69 | 51 | 78 | 51 |
| | 2 | 1 | 56 | | | | |
| VALUE | -732.78 | -1150.0 | 1644.9 | -392.16 | 487.10 | -3534.2 | 1644.9 |
| | 2262.8 | 0. | -0.81829E-04 | | | | |

MAXIMUMS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ELEMENT | 39 | 1 | 3 | 79 | 8 | 69 | 3 |
| | 41 | 39 | 39 | | | | |
| VALUE | 8320.4 | -1125.0 | 7283.9 | 2904.9 | 3154.7 | 321.78 | 7283.9 |
| | 16406. | 0.49871 | 0.27435E-03 | | | | |

***** ROUTINE COMPLETED ***** CP = 59.610

***** END OF INPUT ENCOUNTERED ON FILE18

PREP7 AFWRITE OR SFWRITE WARNING MESSAGES = 12
NUMBER OF SOLUTION PHASE WARNING MESSAGES = 0

***** RUN COMPLETED ***** CP= 59.6400 TIME= 11.3753

ANPP

# CALCULATION SHEET

CALC. TITLE AUXILIARY SPRAY LINE THERMAL STRATIFICATION CALC. NO 13-MC-ZZ-643

SUBJECT STRATIFIED THERMAL ANALYSIS OF THE 2-INCH DIA. PIPE SHEET NO. 1 OF 61

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. Indi-cator ↓ |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | DOUG BERG | 11/13/92 | AMIT BHATTACHARYA | 11/13/92 | | | | | | |
| | | | | | | | | | | |

## ATTACHMENT 2

ANSYS 4.4A INPUT

IF RUNNING INTERACTIVELY, ENTER /INTER
1

*********** ANSYS INPUT DATA LISTING (FILE18) **********

```
/PREP7
/TITLE, Normal -10% Change 570-455  Strat. Aux. Spray Line Inelastic Analysis
KAN,0
KAY,9,1
MP,EX,1,25.5E6
MP,ALPX,1,9.48E-6
MP,DENS,1,0.2836
MAT,1
MP,EX,2,25.5E6
MP,ALPX,2,9.48E-6
MP,DENS,2,0.2836
NL,2,13,10
NL,2,25,18800
NL,2,31,100000
MAT,2
MPPLOT,PLAS,2
MP,EX,3,25.5E6
MP,ALPX,3,8.60E-6
MP,DENS,3,0.2836
MAT,3
ET,1,20,,4,,,,
TYPE,1
ET,2,20,,4,,,,1
TYPE,2
R,1,6.72,1.64,1.9,1.9
REAL,1
TREF,495
CSYS,0
N,1
N,2,,6
N,3,,10.5
N,4,,14.625
N,5,,17.625
N,6,,20.625
N,7,,24.75
N,8,,28.875
N,12,,72.875
FILL
TYPE,1 $MAT,1 $REAL,1
E,1,2
E,2,3
R,2,4.5,0.531,1.9,1.0
REAL,2
E,3,4
R,3,4.5,0.531,1.0 1.0
REAL,3
E,4,5
R,4,4.5,0.531,1.0,1.9
REAL,4
E,5,6
REAL,2 $TYPE,2 $MAT,2
E,6,7
REAL,4 $TYPE,2 $MAT,2
```

```
E,7,8
REAL,2 STYPE,1 SMAT,1
E,8,9
REAL,3
E,9,10
E,10,11
E,11,12
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
LOCAL,11,1,3.531,68.375,4.851,,-126.052
N,16,6,90
FILL
E,12,13
E,13,14
E,14,15
E,15,16
LOCAL,12,0,3.531,74.375,4.851,,-36.052
N,17,,,9
N,18,,,18
N,19,,,26
N,20,,,34
N,29,,,100.375
FILL
N,39,,-240,100.375
FILL
E,16,17
E,17,18
E,18,19
E,19,20
E,20,21
EGEN,18,1,20
E,38,39
CSYS,0
N,40,,24.75,-2.25
N,41,,24.75,-3.5
N,51,,24.75,-43
FILL
N,52,,24.75,-54.25
N,56,,24.75,-72.5
FILL
N,60,-32.875,24.75,-72.5
FILL
N,61,-38.875,24.75,-72.5
N,66,-82.375,24.75,-72.5
FILL
N,69,-82.375,24.75,-55
FILL
N,70,-38.875,24.75,-69.5
N,73,-38.875,24.75,-55
FILL
N,77,-79.375,24.75,-55
FILL
N,78,-82.375,24.75,-51
N,79,-82.375,24.75,-44.5
N,89,-82.375,-163.5,-44.5
FILL
TREF,495
R,5,2.375,0.343,1.0,1.0
REAL,5 STYPE,2 SMAT,2
E,7,40
R,6,2.375,0.343,1.0,1.9
REAL,6 STYPE,2 SMAT,2
E,40,41
```

```
R,7,2.375,0.343,1.9,1.
REAL,7 $TYPE,2 $MAT,2
E,41,42
REAL,5 $TYPE,2 $MAT,2
E,42,43
EGEN,7,1,42
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
E,49,50
REAL,6 $TYPE,2 $MAT,2
E,50,51
TREF,120
R,8,2.375,0.686,1.9,1.9
REAL,8 $TYPE,1 $MAT,1
E,51,52                                      * VALVE INSTALLATION
REAL,7 $MAT,3
E,52,53
REAL,5
E,53,54
E,54,55
E,55,56
E,56,57
E,57,58
E,58,59
EGEN,11,1,58
E,61,70                                      *START OF REDUNDANT LOOP
E,70,71
E,71,72
EGEN,6,1,71
E,77,69
E,69,78
E,78,79
E,79,80
E,80,81
E,81,82
E,82,83
E,83,84
E,84,85
E,85,86
E,86,87
E,87,88
E,88,89
F,39,MX  $F,39,MY  $F,39,MZ
D,39,UX $D,39,UZ
D,1,UX    $D,1,UY,2.021  $D,1,UZ
D,1,ROTX  $D,1,ROTY      $D,1,ROTZ
D,89,UX  $D,89,UY $D,89,UZ
F,89,MX  $F,89,MY $F,89,MZ
PRSTR,5,1,2
CNVR,0.01,,,,1
KNL,1
POSTR,5,1,6,2,6
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,570,570,570
TEGEN,38,1,1
TE,39,513,513,499
TEGEN,3,1,39
TE,42,513,513,499
```

```
TEGEN,9,1,42
TE,51,120,120,120
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,570,570,570
TEGEN,38,1,1
TE,39,513,513,484
TEGEN,3,1,39
TE,42,513,513,484
TEGEN,9,1,42
TE,51,120,120,120
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,570,570,570
TEGEN,38,1,1
TE,39,513,513,470
TEGEN,3,1,39
TE,42,513,513,470
TEGEN,9,1,42
TE,51,120,120,120
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,570,570,570
TEGEN,38,1,1
TE,39,513,513,455
TEGEN,3,1,39
TE,42,513,513,455
TEGEN,9,1,42
TE,51,120,120,120
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
SAVE
AFWRITE
FINISH
/INPUT,27
```

```
FINISH
/POST1
STRESS,STRA,20,13  $STRESS,STRR,20,14
STRESS,STRH,20,15  $STRESS,STRXH,20,16
```

1

*********** ANSYS INPUT DATA LISTING (FILE18) **********

```
STRESS,STRD,20,223  $STRESS,STRTT,20,225  $STRESS,STRPP,20,226
STRESS,STINT,20,235 $STRESS,STINT,20,236
STRESS,RATYS,20,98 $STRESS,AESTRA,20,95
STRESS,APSTRA,20,96  $STRESS,PLSIG,20,100
SET,4,5
PRDISP  $PRESTR  $PRSTRS
FINI
```

1 ANSYS - ENGINEERING ANALYSIS SYSTEM REVISION 4.4 A166 ARIZONA PUBLIC
MAY 1,1990



FOR SUPPORT CALL BOB WESOLOWSKI PHONE (602) 250-3428 TWX

TITLE 17.0744
OCT 15,1992 CP= 1.050

***** ANSYS ANALYSIS DEFINITION (PREP7) *****

NEW TITLE= Normal -10% Change 570-455 Strat. Aux. Spray Line Inelastic Analysis

ANALYSIS TYPE= 0 (STATIC ANALYSIS)

USE FULL NEWTON-RAPHSON SOLUTION PROCEDURE (KAY(9)=1)

MATERIAL 1 COEFFICIENTS OF EX VS. TEMP EQUATION
C0 = 0.2550000E+08

PROPERTY TABLE EX MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.25500E+08 | 9999.0 | 0.25500E+08 |

MATERIAL 1 COEFFICIENTS OF ALPX VS. TEMP EQUATION
C0 = 0.9480000E-05

PROPERTY TABLE ALPX MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.94800E-05 | 9999.0 | 0.94800E-05 |

MATERIAL 1 COEFFICIENTS OF DENS VS. TEMP EQUATION
C0 = 0.2836000

PROPERTY TABLE DENS MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.28360 | 9999.0 | 0.28360 |

MATERIAL NUMBER SET TO 1

MATERIAL 2 COEFFICIENTS OF EX VS. TEMP EQUATION
C0 = 0.2550000E+08

IF RUNNING INTERACTIVELY, ENTER /INTER

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
/PREP7
/TITLE, Normal +10% Change Aux. Spray Line Inelastic Analysis
KAN,0
KAY,9,1
MP,EX,1,25.5E6
MP,ALPX,1,9.47E-6
MP,DENS,1,0.2836
MAT,1
MP,EX,2,25.5E6
MP,ALPX,2,9.47E-6
MP,DENS,2,0.2836
NL,2,13,10
NL,2,25,18800
NL,2,31,100000
MAT,2
MPPLOT,PLAS,2
MP,EX,3,25.5E6
MP,ALPX,3,8.60E-6
MP,DENS,3,0.2836
MAT,3
ET,1,20,,4,,,,
TYPE,1
ET,2,20,,4,,,,1
TYPE,2
R,1,6.72,1.64,1.9,1.9
REAL,1
TREF,495
CSYS,0
N,1
N,2,,6
N,3,,10.5
N,4,,14.625
N,5,,17.625
N,6,,20.625
N,7,,24.75
N,8,,28.875
N,12,,72.875
FILL
TYPE,1 $MAT,1 $REAL,1
E,1,2
E,2,3
R,2,4.5,0.531,1.9,1.0
REAL,2
E,3,4
R,3 4.5,0.531,1.0,1.0
REAL,3
E,4,5
R,4,4.5,0.531,1.0,1.9
REAL,4
E,5,6
REAL,2 $TYPE,2 $MAT,2
E,6,7
REAL,4 $TYPE,2 $MAT,2
```

ATT-2
SHT. 8 of 61

```
E,7,8
REAL,2 $TYPE,1 $MAT,1
E,8,9
REAL,3
E,9,10
E,10,11
E,11,12
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
LOCAL,11,1,3.531,68.375,4.851,,-126.052
N,16,6,90
FILL
E,12,13
E,13,14
E,14,15
E,15,16
LOCAL,12,0,3.531,74.375,4.851,,-36.052
N,17,,,9
N,18,,,18
N,19,,,26
N,20,,,34
N,29,,,100.375
FILL
N,39,,-240,100.375
FILL
E,16,17
E,17,18
E,18,19
E,19,20
E,20,21
EGEN,18,1,20
E,38,39
CSYS,0
N,40,,24.75,-2.25
N,41,,24.75,-3.5
N,51,,24.75,-43
FILL
N,52,,24.75,-54.25
N,56,,24.75,-72.5
FILL
N,60,-32.875,24.75,-72.5
FILL
N,61,-38.875,24.75,-72.5
N,66,-82.375,24.75,-72.5
FILL
N,69,-82.375,24.75,-55
FILL
N,70,-38.875,24.75,-69.5
N,73,-38.875,24.75,-55
FILL
N,77,-79.375,24.75,-55
FILL
N,78,-82.375,24.75,-51
N,79,-82.375,24.75,-44.5
N,89,-82.375,-163.5,-44.5
FILL
TREF,495
R,5,2.375,0.343,1.0,1.0
REAL,5 $TYPE,2 $MAT,2
E,7,40
R,6,2.375,0.343,1.0,1.9
REAL,6 $TYPE,2 $MAT,2
E,40,41
```

ATT -2
SHT 9 OF 61

```
R,7,2.375,0.343,1.9,1
REAL,7 $TYPE,2 $MAT,2
E,41,42
REAL,5 $TYPE,2 $MAT,2
E,42,43
EGEN,7,1,42
```

1

*********** ANSYS INPUT DATA LISTING (FILE18) **********

```
E,49,50
REAL,6 $TYPE,2 $MAT,2
E,50,51
TREF,120
R,8,2.375,0.686,1.9,1.9
REAL,8 $TYPE,1 $MAT,1
E,51,52                                   * VALVE INSTALLATION
REAL,7 $MAT,3
E,52,53
REAL,5
E,53,54
E,54,55
E,55,56
E,56,57
E,57,58
E,58,59
EGEN,11,1,58
E,61,70                                   *START OF REDUNDANT LOOP
E,70,71
E,71,72
EGEN,6,1,71
E,77,69
E,69,78
E,78,79
E,79,80
E,80,81
E,81,82
E,82,83
E,83,84
E,84,85
E,85,86
E,86,87
E,87,88
E,88,89
F,39,MX  $F,39,MY  $F,39,MZ
D,39,UX $D,39,UZ
D,1,UX    $D,1,UY,2.021  $D,1,UZ
D,1,ROTX  $D,1,ROTY       $D,1,ROTZ
D,89,UX  $D,89,UY $D,89,UZ
F,89,MX  $F,89,MY $F,89,MZ
PRSTR,5,1,2
CNVR,0.01,,,,1
KNL,1
POSTR,5,1,6,2,6
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,565,565,565
TEGEN,38,1,1
TE,39,508,508,494
TEGEN,3,1,39
TE,42,508,508,494
```

```
TEGEN,9,1,42
TE,51,120,120,120
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
```

1

```
********** ANSYS INPUT DATA LISTING (FILE18) **********
```

```
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,565,565,565
TEGEN,38,1,1
TE,39,508,508,479
TEGEN,3,1,39
TE,42,508,508,479
TEGEN,9,1,42
TE,51,120,120,120
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,565,565,565
TEGEN,38,1,1
TE,39,508,508,465
TEGEN,3,1,39
TE,42,508,508,465
TEGEN,9,1,42
TE,51,120,120,120
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,565,565,565
TEGEN,38,1,1
TE,39,508,508,450
TEGEN,3,1,39
TE,42,508,508,450
TEGEN,9,1,42
TE,51,120,120,120
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
SAVE
AFWRITE
FINISH
/INPUT,27
FINISH
```

```
/POST1
STRESS,STRA,20,13  $STRESS,STRR,20,14
STRESS,STRH,20,15  $STRESS,STRXH,20,16
STRESS,STRD,20,223  $STRESS,STRTT,20,225  $STRESS,STRPP,20,226
```

1

*********** ANSYS INPUT DATA LISTING (FILE18) **********

```
STRESS,STINT,20,235 $STRESS,STINT,20,236
STRESS,RATYS,20,98 $STRESS,AESTRA,20,95
STRESS,APSTRA,20,96  $STRESS,PLSIG,20,100
SET,4,5
PRDISP  $PRESTR  $PRSTRS
FINI
```

1 ANSYS - ENGINEERING ANALYSIS SYSTEM REVISION 4.4 A166 ARIZONA PUBLIC
MAY 1,1990



FOR SUPPORT CALL BOB WESOLOWSKI PHONE (602) 250-3428 TWX

TITLE 9.2556
OCT 16,1992 CP= 1.100

***** ANSYS ANALYSIS DEFINITION (PREP7) *****

NEW TITLE= Normal +10% Change Aux. Spray Line Inelastic Analysis

ANALYSIS TYPE= 0 (STATIC ANALYSIS)

USE FULL NEWTON-RAPHSON SOLUTION PROCEDURE (KAY(9)=1)

MATERIAL 1 COEFFICIENTS OF EX VS. TEMP EQUATION
C0 = 0.2550000E+08

PROPERTY TABLE EX MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.25500E+08 | 9999.0 | 0.25500E+08 |

MATERIAL 1 COEFFICIENTS OF ALPX VS. TEMP EQUATION
C0 = 0.9470000E-05

PROPERTY TABLE ALPX MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.94700E-05 | 9999.0 | 0.94700E-05 |

MATERIAL 1 COEFFICIENTS OF DENS VS. TEMP EQUATION
C0 = 0.2836000

PROPERTY TABLE DENS MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.28360 | 9999.0 | 0.28360 |

MATERIAL NUMBER SET TO 1

MATERIAL 2 COEFFICIENTS OF EX VS. TEMP EQUATION
C0 = 0.2550000E+08

PROPERTY TABLE EX MAT= 2 NUM. POINTS= 2

ATT-2
SHT. 12 OF 61



IF RUNNING INTERACTIVELY, ENTER /INTER

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
/PREP7
/TITLE, Normal Start Up Aux. Spray Line Inelastic Analysis
KAN,0
KAY,9,1
MP,EX,1,25.5E6
MP,ALPX,1,9.36E-6
MP,DENS,1,0.2836
MAT,1
MP,EX,2,25.5E6
MP,ALPX,2,9.36E-6
MP,DENS,2,0.2836
NL,2,13,10
NL,2,25,18800
NL,2,31,100000
MAT,2
MPPLOT,PLAS,2
MP,EX,3,25.5E6
MP,ALPX,3,9.36E-6
MP,DENS,3,0.2836
MAT,3
ET,1,20,,4,,,,
TYPE,1
ET,2,20,,4,,,,1
TYPE,2
R,1,6.72,1.64,1.9,1.9
REAL,1
TREF,70
CSYS,0
N,1
N,2,,6
N,3,,10.5
N,4,,14.625
N,5,,17.625
N,6,,20.625
N,7,,24.75
N,8,,28.875
N,12,,72.875
FILL
TYPE,1 $MAT,1 $REAL,1
E,1,2
E,2,3
R,2,4.5,0.531,1.9,1.0
REAL,2
E,3,4
R,3,4.5,0.531,1.0,1.0
REAL,3
E,4,5
R,4,4.5,0.531,1.0,1.9
REAL,4
E,5,6
REAL,2 $TYPE,2 $MAT,2
E,6,7
REAL,4 $TYPE,2 $MAT,2
```

```
E,7,8
REAL,2 $TYPE,1 $MAT,1
E,8,9
REAL,3
E,9,10
E,10,11
E,11,12
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
LOCAL,11,1,3.531,68.375,4.851,,-126.052
N,16,6,90
FILL
E,12,13
E,13,14
E,14,15
E,15,16
LOCAL,12,0,3.531,74.375,4.851,,-36.052
N,17,,,9
N,18,,,18
N,19,,,26
N,20,,,34
N,29,,,100.375
FILL
N,39,,-240,100.375
FILL
E,16,17
E,17,18
E,18,19
E,19,20
E,20,21
EGEN,18,1,20
E,38,39
CSYS,0
N,40,,24.75,-2.25
N,41,,24.75,-3.5
N,51,,24.75,-43
FILL
N,52,,24.75,-54.25
N,56,,24.75,-72.5
FILL
N,60,-32.875,24.75,-72.5
FILL
N,61,-38.875,24.75,-72.5
N,66,-82.375,24.75,-72.5
FILL
N,69,-82.375,24.75,-55
FILL
N,70,-38.875,24.75,-69.5
N,73,-38.875,24.75,-55
FILL
N,77,-79.375,24.75,-55
FILL
N,78,-82.375,24.75,-51
N,79,-82.375,24.75,-44.5
N,89,-82.375,-163.5,-44.5
FILL
TREF,70
R,5,2.375,0.343,1.0,1.0
REAL,5 $TYPE,2 $MAT,2
E,7,40
R,6,2.375,0.343,1.0,1.9
REAL,6 $TYPE,2 $MAT,2
E,40,41
```

ATT-2
SHT. 14 of 61

```
R,7,2.375,0.343,1.9,1.
REAL,7 $TYPE,2 $MAT,2
E,41,42
REAL,5 $TYPE,2 $MAT,2
E,42,43
EGEN,7,1,42
```

1

*********** ANSYS INPUT DATA LISTING (FILE18) **********

```
E,49,50
REAL,6 $TYPE,2 $MAT,2
E,50,51
TREF,70
R,8,2.375,0.686,1.9,1.9
REAL,8 $TYPE,1 $MAT,1
E,51,52                          * VALVE INSTALLATION
REAL,7 $MAT,3
E,52,53
REAL,5
E,53,54
E,54,55
E,55,56
E,56,57
E,57,58
E,58,59
EGEN,11,1,58
E,61,70                          *START OF REDUNDANT LOOP
E,70,71
E,71,72
EGEN,6,1,71
E,77,69
E,69,78
E,78,79
E,79,80
E,80,81
E,81,82
E,82,83
E,83,84
E,84,85
E,85,86
E,86,87
E,87,88
E,88,89
F,39,MX  $F,39,MY  $F,39,MZ
D,39,UX $D,39,UZ
D,1,UX    $D,1,UY,2.021  $D,1,UZ
D,1,ROTX  $D,1,ROTY       $D,1,ROTZ
D,89,UX  $D,89,UY $D,89,UZ
F,89,MX  $F,89,MY $F,89,MZ
PRSTR,5,1,2
CNVR,0.01,,,,1
KNL,1
POSTR,5,1,6,2,6
,EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,495,495,495
TEGEN,38,1,1
TE,39,438,438,424
TEGEN,3,1,39
TE,42,438,438,424
```

```
TEGEN,9,1,42
TE,51,495,495,495
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,495,495,495
TEGEN,38,1,1
TE,39,438,438,409
TEGEN,3,1,39
TE,42,438,438,409
TEGEN,9,1,42
TE,51,495,495,495
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,495,495,495
TEGEN,38,1,1
TE,39,438,438,395
TEGEN,3,1,39
TE,42,438,438,395
TEGEN,9,1,42
TE,51,495,495,495
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,495,495,495
TEGEN,38,1,1
TE,39,438,438,380
TEGEN,3,1,39
TE,42,438,438,380
TEGEN,9,1,42
TE,51,495,495,495
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
SAVE
AFWRITE
FINISH
/INPUT,27
FINISH
```

ATT-2
SHT 16 of 61

```
/POST1
STRESS,STRA,20,13  $STRESS,STRR,20,14
STRESS,STRH,20,15  $STRESS,STRXH,20,16
STRESS,STRD,20,223  $STRESS,STRTT,20,225  $STRESS,STRPP,20,226
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
STRESS,STINT,20,235 $STRESS,STINT,20,236
STRESS,RATYS,20,98 $STRESS,AESTRA,20,95
STRESS,APSTRA,20,96  $STRESS,PLSIG,20,100
SET,4,5
PRDISP  $PRESTR  $PRSTRS
FINI
```

1 ANSYS - ENGINEERING ANALYSIS SYSTEM REVISION 4.4 A166 ARIZONA PUBLIC MAY 1,1990



FOR SUPPORT CALL BOB WESOLOWSKI PHONE (602) 250-3428 TWX

TITLE 7.3092
OCT 16,1992 CP= 1.060

***** ANSYS ANALYSIS DEFINITION (PREP7) *****

NEW TITLE= Normal Start Up Aux. Spray Line Inelastic Analysis

ANALYSIS TYPE= 0 (STATIC ANALYSIS)

USE FULL NEWTON-RAPHSON SOLUTION PROCEDURE (KAY(9)=1)

MATERIAL 1 COEFFICIENTS OF EX VS. TEMP EQUATION
C0 = 0.2550000E+08

PROPERTY TABLE EX MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.25500E+08 | 9999.0 | 0.25500E+08 |

MATERIAL 1 COEFFICIENTS OF ALPX VS. TEMP EQUATION
C0 = 0.9360000E-05

PROPERTY TABLE ALPX MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.93600E-05 | 9999.0 | 0.93600E-05 |

MATERIAL 1 COEFFICIENTS OF DENS VS. TEMP EQUATION
C0 = 0.2836000

PROPERTY TABLE DENS MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.28360 | 9999.0 | 0.28360 |

MATERIAL NUMBER SET TO 1

MATERIAL 2 COEFFICIENTS OF EX VS. TEMP EQUATION
C0 = 0.2550000E+08

PROPERTY TABLE EX MAT= 2 NUM. POINTS= 2

ATT-2
SHT 17 OF 61



IF RUNNING INTERACTIVELY, ENTER /INTER
1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
/PREP7
/TITLE, Upset Load Rejection At 100% Aux. Spray Line Inelastic Analysis
KAN,0
KAY,9,1
MP,EX,1,25.5E6
MP,ALPX,1,9.41E-6
MP,DENS,1,0.2836
MAT,1
MP,EX,2,25.5E6
MP,ALPX,2,9.41E-6
MP,DENS,2,0.2836
NL,2,13,10
NL,2,25,18800
NL,2,31,100000
MAT,2
MPPLOT,PLAS,2
MP,EX,3,25.5E6
MP,ALPX,3,8.60E-6
MP,DENS,3,0.2836
MAT,3
ET,1,20,,4,,,,
TYPE,1
ET,2,20,,4,,,,1
TYPE,2
R,1,6.72,1.64,1.9,1.9
REAL,1
TREF,495
CSYS,0
N,1
N,2,,6
N,3,,10.5
N,4,,14.625
N,5,,17.625
N,6,,20.625
N,7,,24.75
N,8,,28.875
N,12,,72.875
FILL
TYPE,1 $MAT,1 $REAL,1
E,1,2
E,2,3
R,2,4.5,0.531,1.9,1.0
REAL,2
E,3,4
R,3,4.5,0.531,1.0,1.0
REAL,3
E,4,5
R,4,4.5,0.531,1.0,1.9
REAL,4
E,5,6
REAL,2 $TYPE,2 $MAT,2
E,6,7
REAL,4 $TYPE,2 $MAT,2
```

```
E,7,8
REAL,2 $TYPE,1 $MAT,1
E,8,9
REAL,3
E,9,10
E,10,11
E,11,12
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
LOCAL,11,1,3.531,68.375,4.851,,-126.052
N,16,6,90
FILL
E,12,13
E,13,14
E,14,15
E,15,16
LOCAL,12,0,3.531,74.375,4.851,,-36.052
N,17,,,9
N,18,,,18
N,19,,,26
N,20,,,34
N,29,,,100.375
FILL
N,39,,-240,100.375
FILL
E,16,17
E,17,18
E,18,19
E,19,20
E,20,21
EGEN,18,1,20
E,38,39
CSYS,0
N,40,,24.75,-2.25
N,41,,24.75,-3.5
N,51,,24.75,-43
FILL
N,52,,24.75,-54.25
N,56,,24.75,-72.5
FILL
N,60,-32.875,24.75,-72.5
FILL
N,61,-38.875,24.75,-72.5
N,66,-82.375,24.75,-72.5
FILL
N,69,-82.375,24.75,-55
FILL
N,70,-38.875,24.75,-69.5
N,73,-38.875,24.75,-55
FILL
N,77,-79.375,24.75,-55
FILL
N,78,-82.375,24.75,-51
N,79,-82.375,24.75,-44.5
N,89,-82.375,-163.5,-44.5
FILL
TREF,495
R,5,2.375,0.343,1.0,1.0
REAL,5 $TYPE,2 $MAT,2
E,7,40
R,6,2.375,0.343,1.0,1.9
REAL,6 $TYPE,2 $MAT,2
E,40,41
```

```
R,7,2.375,0.343,1.9,1.
REAL,7 $TYPE,2 $MAT,2
E,41,42
REAL,5 $TYPE,2 $MAT,2
E,42,43
EGEN,7,1,42
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
E,49,50
REAL,6 $TYPE,2 $MAT,2
E,50,51
TREF,120
R,8,2.375,0.686,1.9,1.9
REAL,8 $TYPE,1 $MAT,1
E,51,52                             * VALVE INSTALLATION
REAL,7 $MAT,3
E,52,53
REAL,5
E,53,54
E,54,55
E,55,56
E,56,57
E,57,58
E,58,59
EGEN,11,1,58
E,61,70                             *START OF REDUNDANT LOOP
E,70,71
E,71,72
EGEN,6,1,71
E,77,69
E,69,78
E,78,79
E,79,80
E,80,81
E,81,82
E,82,83
E,83,84
E,84,85
E,85,86
E,86,87
E,87,88
E,88,89
F,39,MX  $F,39,MY  $F,39,MZ
D,39,UX $D,39,UZ
D,1,UX    $D,1,UY,2.021  $D,1,UZ
D,1,ROTX  $D,1,ROTY       $D,1,ROTZ
D,89,UX  $D,89,UY $D,89,UZ
F,89,MX  $F,89,MY $F,89,MZ
PRSTR,5,1,2
CNVR,0.01,,,,1
KNL,1
POSTR,5,1,6,2,6
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,575,575,575
TEGEN,38,1,1
TE,39,518,518,504
TEGEN,3,1,39
TE,42,518,518,504
```

```
TEGEN,9,1,42
TE,51,120,120,120
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,575,575,575
TEGEN,38,1,1
TE,39,518,518,489
TEGEN,3,1,39
TE,42,518,518,489
TEGEN,9,1,42
TE,51,120,120,120
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,575,575,575
TEGEN,38,1,1
TE,39,518,518,475
TEGEN,3,1,39
TE,42,518,518,475
TEGEN,9,1,42
TE,51,120,120,120
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,575,575,575
TEGEN,38,1,1
TE,39,518,518,460
TEGEN,3,1,39
TE,42,518,518,460
TEGEN,9,1,42
TE,51,120,120,120
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
SAVE
AFWRITE
FINISH
/INPUT,27
FINISH
```

```
/POST1
STRESS,STRA,20,13  $STRESS,STRR,20,14
STRESS,STRH,20,15  $STRESS,STRXH,20,16
STRESS,STRD,20,223  $STRESS,STRTT,20,225  $STRESS,STRPP,20,226
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
STRESS,STINT,20,235 $STRESS,STINT,20,236
STRESS,RATYS,20,98 $STRESS,AESTRA,20,95
STRESS,APSTRA,20,96  $STRESS,PLSIG,20,100
SET,4,5
PRDISP  $PRESTR  $PRSTRS
FINI
```

1 ANSYS - ENGINEERING ANALYSIS SYSTEM REVISION 4.4 A166 ARIZONA PUBLIC MAY 1,1990



FOR SUPPORT CALL BOB WESOLOWSKI PHONE (602) 250-3428 TWX

TITLE 10.8894
OCT 16,1992 CP= 1.100

***** ANSYS ANALYSIS DEFINITION (PREP7) *****

NEW TITLE= Upset Load Rejection At 100% Aux. Spray Line Inelastic Analysis

ANALYSIS TYPE= 0 (STATIC ANALYSIS)

USE FULL NEWTON-RAPHSON SOLUTION PROCEDURE (KAY(9)=1)

MATERIAL 1 COEFFICIENTS OF EX VS. TEMP EQUATION
C0 = 0.2550000E+08

PROPERTY TABLE EX MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.25500E+08 | 9999.0 | 0.25500E+08 |

MATERIAL 1 COEFFICIENTS OF ALPX VS. TEMP EQUATION
C0 = 0.9410000E-05

PROPERTY TABLE ALPX MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.94100E-05 | 9999.0 | 0.94100E-05 |

MATERIAL 1 COEFFICIENTS OF DENS VS. TEMP EQUATION
C0 = 0.2836000

PROPERTY TABLE DENS MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.28360 | 9999.0 | 0.28360 |

MATERIAL NUMBER SET TO 1

MATERIAL 2 COEFFICIENTS OF EX VS. TEMP EQUATION
C0 = 0.2550000E+08

PROPERTY TABLE EX MAT= 2 NUM. POINTS= 2

IF RUNNING INTERACTIVELY, ENTER /INTER
1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
/PREP7
/TITLE, Upset - Inadvertent Aux Initiation - Aux. Spray Line Inelastic Analysis
KAN,0
KAY,9,1
MP,EX,1,25.5E6
MP,ALPX,1,9.36E-6
MP,DENS,1,0.2836
MAT,1
MP,EX,2,25.5E6
MP,ALPX,2,9.30E-6
MP,DENS,2,0.2836
NL,2,13,10
NL,2,25,18800
NL,2,31,100000
MAT,2
MPPLOT,PLAS,2
MP,EX,3,25.5E6
MP,ALPX,3,9.14E-6
MP,DENS,3,0.2836
MAT,3
ET,1,20,,4,,,,
TYPE,1
ET,2,20,,4,,,,1
TYPE,2
R,1,6.72,1.64,1.9,1.9
REAL,1
TREF,495
CSYS,0
N,1
N,2,,6
N,3,,10.5
N,4,,14.625
N,5,,17.625
N,6,,20.625
N,7,,24.75
N,8,,28.875
N,12,,72.875
FILL
TYPE,1 $MAT,1 $REAL,1
E,1,2
E,2,3
R,2,4.5,0.531,1.9,1.0
REAL,2
E,3,4
R,3,4.5,0.531,1.0,1.0
REAL,3
E,4,5
R,4,4.5,0.531,1.0,1.9
REAL,4
E,5,6
REAL,2 $TYPE,2 $MAT,2
E,6,7
REAL,4 $TYPE,2 $MAT,2
```

```
E,7,8
REAL,2 $TYPE,1 $MAT,1
E,8,9
REAL,3
E,9,10
E,10,11
E,11,12
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
LOCAL,11,1,3.531,68.375,4.851,,-126.052
N,16,6,90
FILL
E,12,13
E,13,14
E,14,15
E,15,16
LOCAL,12,0,3.531,74.375,4.851,,-36.052
N,17,,,9
N,18,,,18
N,19,,,26
N,20,,,34
N,29,,,100.375
FILL
N,39,,-240,100.375
FILL
E,16,17
E,17,18
E,18,19
E,19,20
E,20,21
EGEN,18,1,20
E,38,39
CSYS,0
N,40,,24.75,-2.25
N,41,,24.75,-3.5
N,51,,24.75,-43
FILL
N,52,,24.75,-54.25
N,56,,24.75,-72.5
FILL
N,60,-32.875,24.75,-72.5
FILL
N,61,-38.875,24.75,-72.5
N,66,-82.375,24.75,-72.5
FILL
N,69,-82.375,24.75,-55
FILL
N,70,-38.875,24.75,-69.5
N,73,-38.875,24.75,-55
FILL
N,77,-79.375,24.75,-55
FILL
N,78,-82.375,24.75,-51
N,79,-82.375,24.75,-44.5
N,89,-82.375,-163.5,-44.5
FILL
TREF,450
R,5,2.375,0.343,1.0,1.0
REAL,5 $TYPE,2 $MAT,2
E,7,40
R,6,2.375,0.343,1.0,1.9
REAL,6 $TYPE,2 $MAT,2
E,40,41
```

```
R,7,2.375,0.343,1.9,1.
REAL,7 $TYPE,2 $MAT,2
E,41,42
REAL,5 $TYPE,2 $MAT,2
E,42,43
EGEN,7,1,42
1
          ********** ANSYS INPUT DATA LISTING (FILE18) **********

E,49,50
REAL,6 $TYPE,2 $MAT,2
E,50,51
TREF,160
R,8,2.375,0.686,1.9,1.9
REAL,8 $TYPE,1 $MAT,1
E,51,52                             * VALVE INSTALLATION
REAL,7 $MAT,3
E,52,53
REAL,5
E,53,54
E,54,55
E,55,56
E,56,57
E,57,58
E,58,59
EGEN,11,1,58
E,61,70                             *START OF REDUNDANT LOOP
E,70,71
E,71,72
EGEN,6,1,71
E,77,69
E,69,78
E,78,79
E,79,80
E,80,81
E,81,82
E,82,83
E,83,84
E,84,85
E,85,86
E,86,87
E,87,88
E,88,89
F,39,MX  $F,39,MY  $F,39,MZ
D,39,UX $D,39,UZ
D,1,UX    $D,1,UY,2.021  $D,1,UZ
D,1,ROTX  $D,1,ROTY      $D,1,ROTZ
D,89,UX  $D,89,UY $D,89,UZ
F,89,MX  $F,89,MY $F,89,MZ
PRSTR,5,1,2
CNVR,0.01,,,,1
KNL,1
POSTR,5,1,6,2,6
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,495,495,495
TEGEN,38,1,1
TE,39,460,460,460
TEGEN,3,1,39
TE,42,460,460,460
```

```
TEGEN,9,1,42
TE,51,370,370,370
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,495,495,495
TEGEN,38,1,1
TE,39,460,460,460
TEGEN,3,1,39
TE,42,460,460,460
TEGEN,9,1,42
TE,51,370,370,370
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,495,495,495
TEGEN,38,1,1
TE,39,460,460,460
TEGEN,3,1,39
TE,42,460,460,460
TEGEN,9,1,42
TE,51,370,370,370
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,495,495,495
TEGEN,38,1,1
TE,39,460,460,460
TEGEN,3,1,39
TE,42,460,460,460
TEGEN,9,1,42
TE,51,370,370,370
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
SAVE
AFWRITE
FINISH
/INPUT,27
FINISH
```

ATT-2
SHT 26 OF 61

```
/POST1
STRESS,STRA,20,13  $STRESS,STRR,20,14
STRESS,STRH,20,15  $STRESS,STRXH,20,16
STRESS,STRD,20,223  $STRESS,STRTT,20,225  $STRESS,STRPP,20,226
```

1
********** ANSYS INPUT DATA LISTING (FILE18) **********

```
STRESS,STINT,20,235 $STRESS,STINT,20,236
STRESS,RATYS,20,98 $STRESS,AESTRA,20,95
STRESS,APSTRA,20,96  $STRESS,PLSIG,20,100
SET,4,5
PRDISP  $PRESTR  $PRSTRS
FINI
```

1 ANSYS - ENGINEERING ANALYSIS SYSTEM REVISION 4.4 A166 ARIZONA PUBLIC
MAY 1,1990


FOR SUPPORT CALL BOB WESOLOWSKI PHONE (602) 250-3428 TWX

TITLE 12.9375
OCT 16,1992 CP= 1.040

***** ANSYS ANALYSIS DEFINITION (PREP7) *****

NEW TITLE= Upset - Inadvertent Aux Initiation - Aux. Spray Line Inelastic Analysis

ANALYSIS TYPE= 0 (STATIC ANALYSIS)

USE FULL NEWTON-RAPHSON SOLUTION PROCEDURE (KAY(9)=1)

MATERIAL 1 COEFFICIENTS OF EX VS. TEMP EQUATION
C0 = 0.2550000E+08

PROPERTY TABLE EX MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.25500E+08 | 9999.0 | 0.25500E+08 |

MATERIAL 1 COEFFICIENTS OF ALPX VS. TEMP EQUATION
C0 = 0.9360000E-05

PROPERTY TABLE ALPX MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.93600E-05 | 9999.0 | 0.93600E-05 |

MATERIAL 1 COEFFICIENTS OF DENS VS. TEMP EQUATION
C0 = 0.2836000

PROPERTY TABLE DENS MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.28360 | 9999.0 | 0.28360 |

MATERIAL NUMBER SET TO 1

MATERIAL 2 COEFFICIENTS OF EX VS. TEMP EQUATION
C0 = 0.2550000E+08

PROPERTY TABLE EX MAT= 2 NUM. POINTS= 2

IF RUNNING INTERACTIVELY, ENTER /INTER

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
/PREP7
/TITLE, Upset - Spurious Upset Events Aux. Spray Line Inelastic Analysis
KAN,0
KAY,9,1
MP,EX,1,25.5E6
MP,ALPX,1,9.49E-6
MP,DENS,1,0.2836
MAT,1
MP,EX,2,25.5E6
MP,ALPX,2,9.49E-6
MP,DENS,2,0.2836
NL,2,13,10
NL,2,25,18800
NL,2,31,100000
MAT,2
MPPLOT,PLAS,2
MP,EX,3,25.5E6
MP,ALPX,3,9.49E-6
MP,DENS,3,0.2836
MAT,3
ET,1,20,,4,,,,
TYPE,1
ET,2,20,,4,,,,1
TYPE,2
R,1,6.72,1.64,1.9,1.9
REAL,1
TREF,495
CSYS,0
N,1
N,2,,6
N,3,,10.5
N,4,,14.625
N,5,,17.625
N,6,,20.625
N,7,,24.75
N,8,,28.875
N,12,,72.875
FILL
TYPE,1 $MAT,1 $REAL,1
E,1,2
E,2,3
R,2,4.5,0.531,1.9,1.0
REAL,2
E,3,4
R,3,4.5,0.531,1.0,1.0
REAL,3
E,4,5
R,4,4.5,0.531,1.0,1.9
REAL,4
E,5,6
REAL,2 $TYPE,2 $MAT,2
E,6,7
REAL,4 $TYPE,2 $MAT,2
```

```
E,7,8
REAL,2 $TYPE,1 $MAT,1
E,8,9
REAL,3
E,9,10
E,10,11
E,11,12
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
LOCAL,11,1,3.531,68.375,4.851,,-126.052
N,16,6,90
FILL
E,12,13
E,13,14
E,14,15
E,15,16
LOCAL,12,0,3.531,74.375,4.851,,-36.052
N,17,,,9
N,18,,,18
N,19,,,26
N,20,,,34
N,29,,,100.375
FILL
N,39,,-240,100.375
FILL
E,16,17
E,17,18
E,18,19
E,19,20
E,20,21
EGEN,18,1,20
E,38,39
CSYS,0
N,40,,24.75,-2.25
N,41,,24.75,-3.5
N,51,,24.75,-43
FILL
N,52,,24.75,-54.25
N,56,,24.75,-72.5
FILL
N,60,-32.875,24.75,-72.5
FILL
N,61,-38.875,24.75,-72.5
N,66,-82.375,24.75,-72.5
FILL
N,69,-82.375,24.75,-55
FILL
N,70,-38.875,24.75,-69.5
N,73,-38.875,24.75,-55
FILL
N,77,-79.375,24.75,-55
FILL
N,78,-82.375,24.75,-51
N,79,-82.375,24.75,-44.5
N,89,-82.375,-163.5,-44.5
FILL
TREF,495
R,5,2.375,0.343,1.0,1.0
REAL,5 $TYPE,2 $MAT,2
E,7,40
R,6,2.375,0.343,1.0,1.9
REAL,6 $TYPE,2 $MAT,2
E,40,41
```

```
R,7,2.375,0.343,1.9,1.
REAL,7 $TYPE,2 $MAT,2
E,41,42
REAL,5 $TYPE,2 $MAT,2
E,42,43
EGEN,7,1,42
```

1

*********** ANSYS INPUT DATA LISTING (FILE18) ***********

```
E,49,50
REAL,6 $TYPE,2 $MAT,2
E,50,51
TREF,120
R,8,2.375,0.686,1.9,1.9
REAL,8 $TYPE,1 $MAT,1
E,51,52                                   * VALVE INSTALLATION
REAL,7 $MAT,3
E,52,53
REAL,5
E,53,54
E,54,55
E,55,56
E,56,57
E,57,58
E,58,59
EGEN,11,1,58
E,61,70                                   *START OF REDUNDANT LOOP
E,70,71
E,71,72
EGEN,6,1,71
E,77,69
E,69,78
E,78,79
E,79,80
E,80,81
E,81,82
E,82,83
E,83,84
E,84,85
E,85,86
E,86,87
E,87,88
E,88,89
F,39,MX  $F,39,MY  $F,39,MZ
D,39,UX $D,39,UZ
D,1,UX    $D,1,UY,2.021  $D,1,UZ
D,1,ROTX  $D,1,ROTY      $D,1,ROTZ
D,89,UX  $D,89,UY $D,89,UZ
F,89,MX  $F,89,MY $F,89,MZ
PRSTR,5,1,2
CNVR,0.01,,,,1
KNL,1
POSTR,5,1,6,2,6
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,573,573,573
TEGEN,38,1,1
TE,39,573,573,573
TEGEN,3,1,39
TE,42,573,573,573
```

```
TEGEN,9,1,42
TE,51,573,573,573
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,573,573,573
TEGEN,38,1,1
TE,39,573,573,573
TEGEN,3,1,39
TE,42,573,573,573
TEGEN,9,1,42
TE,51,573,573,573
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,573,573,573
TEGEN,38,1,1
TE,39,573,573,573
TEGEN,3,1,39
TE,42,573,573,573
TEGEN,9,1,42
TE,51,573,573,573
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,573,573,573
TEGEN,38,1,1
TE,39,573,573,573
TEGEN,3,1,39
TE,42,573,573,573
TEGEN,9,1,42
TE,51,573,573,573
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
SAVE
AFWRITE
FINISH
/INPUT,27
```

```
FINISH
/POST1
STRESS,STRA,20,13  $STRESS,STRR,20,14
STRESS,STRH,20,15  $STRESS,STRXH,20,16
```

1

*********** ANSYS INPUT DATA LISTING (FILE18) **********

```
STRESS,STRD,20,223  $STRESS,STRTT,20,225  $STRESS,STRPP,20,226
STRESS,STINT,20,235 $STRESS,STINT,20,236
STRESS,RATYS,20,98 $STRESS,AESTRA,20,95
STRESS,APSTRA,20,96  $STRESS,PLSIG,20,100
SET,4,5
PRDISP  $PRESTR  $PRSTRS
FINI
```

```
1           ANSYS - ENGINEERING ANALYSIS SYSTEM  REVISION 4.4      A166   ARIZONA PUBLIC
  MAY 1,1990
```


FOR SUPPORT CALL BOB WESOLOWSKI PHONE (602) 250-3428 TWX

```
 TITLE                                                                      13.1622
 OCT 16,1992 CP=       1.020

         ***** ANSYS ANALYSIS DEFINITION (PREP7) *****

 NEW TITLE= Upset - Spurious Upset Events Aux. Spray Line Inelastic Analysis


 ANALYSIS TYPE=  0   (STATIC ANALYSIS)

 USE FULL NEWTON-RAPHSON SOLUTION PROCEDURE  (KAY(9)=1)

  MATERIAL   1          COEFFICIENTS OF EX   VS. TEMP EQUATION
   C0 =  0.2550000E+08

 PROPERTY TABLE EX     MAT=   1  NUM. POINTS=  2
     TEMPERATURE      DATA    TEMPERATURE      DATA
       -9999.0      0.25500E+08  9999.0      0.25500E+08

  MATERIAL   1          COEFFICIENTS OF ALPX VS. TEMP EQUATION
   C0 =  0.9490000E-05

 PROPERTY TABLE ALPX  MAT=   1  NUM. POINTS=  2
     TEMPERATURE      DATA    TEMPERATURE      DATA
       -9999.0      0.94900E-05  9999.0      0.94900E-05

  MATERIAL   1          COEFFICIENTS OF DENS VS. TEMP EQUATION
   C0 =  0.2836000

 PROPERTY TABLE DENS  MAT=   1  NUM. POINTS=  2
     TEMPERATURE      DATA    TEMPERATURE      DATA
       -9999.0      0.28360      9999.0      0.28360

 MATERIAL NUMBER SET TO      1

  MATERIAL   2          COEFFICIENTS OF EX   VS. TEMP EQUATION
   C0 =  0.2550000E+08
```

IF RUNNING INTERACTIVELY, ENTER /INTER
1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
/PREP7
/TITLE, Normal Plant Cooldown (A) - Aux. Spray Line Inelastic Analysis
KAN,0
KAY,9,1
MP,EX,1,25.5E6
MP,ALPX,1,9.25E-6
MP,DENS,1,0.2836
MAT,1
MP,EX,2,25.5E6
MP,ALPX,2,9.25E-6
MP,DENS,2,0.2836
NL,2,13,10
NL,2,25,18800
NL,2,31,100000
MAT,2
MPPLOT,PLAS,2
MP,EX,3,25.5E6
MP,ALPX,3,8.16E-6
MP,DENS,3,0.2836
MAT,3
ET,1,20,,4,,,,
TYPE,1
ET,2,20,,4,,,,1
TYPE,2
R,1,6.72,1.64,1.9,1.9
REAL,1
TREF,60
CSYS,0
N,1
N,2,,6
N,3,,10.5
N,4,,14.625
N,5,,17.625
N,6,,20.625
N,7,,24.75
N,8,,28.875
N,12,,72.875
FILL
TYPE,1 $MAT,1 $REAL,1
E,1,2
E,2,3
R,2,4.5,0.531,1.9,1.0
REAL,2
E,3,4
R,3,4.5,0.531,1.0,1.0
REAL,3
E,4,5
R,4,4.5,0.531,1.0,1.9
REAL,4
E,5,6
TREF,70
REAL,2 $TYPE,2 $MAT,2
E,6,7
```

```
REAL,4 $TYPE,2 $MAT,2
E,7,8
REAL,2 $TYPE,1 $MAT,1
E,8,9
REAL,3
E,9,10
E,10,11
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
E,11,12
LOCAL,11,1,3.531,68.375,4.851,,-126.052
N,16,6,90
FILL
E,12,13
E,13,14
E,14,15
E,15,16
LOCAL,12,0,3.531,74.375,4.851,,-36.052
N,17,,,9
N,18,,,18
N,19,,,26
N,20,,,34
N,29,,,100.375
FILL
N,39,,-240,100.375
FILL
E,16,17
E,17,18
E,18,19
E,19,20
E,20,21
EGEN,18,1,20
E,38,39
CSYS,0
N,40,,24.75,-2.25
N,41,,24.75,-3.5
N,51,,24.75,-43
FILL
N,52,,24.75,-54.25
N,56,,24.75,-72.5
FILL
N,60,-32.875,24.75,-72.5
FILL
N,61,-38.875,24.75,-72.5
N,66,-82.375,24.75,-72.5
FILL
N,69,-82.375,24.75,-55
FILL
N,70,-38.875,24.75,-69.5
N,73,-38.875,24.75,-55
FILL
N,77,-79.375,24.75,-55
FILL
N,78,-82.375,24.75,-51
N,79,-82.375,24.75,-44.5
N,89,-82.375,-163.5,-44.5
FILL
TREF,60
R,5,2.375,0.343,1.0,1.0
REAL,5 $TYPE,2 $MAT,2
E,7,40
R,6,2.375,0.343,1.0,1.9
REAL,6 $TYPE,2 $MAT,2
```

```
E.40,41
R,7,2.375,0.343,1.9,1.
REAL,7 $TYPE,2 $MAT,2
E,41,42
REAL,5 $TYPE,2 $MAT,2
E,42,43
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
EGEN,7,1,42
E,49,50
REAL,6 $TYPE,2 $MAT,2
E,50,51
TREF,60
R,8,2.375,0.686,1.9,1.9
REAL,8 $TYPE,1 $MAT,1
E,51,52                               * VALVE INSTALLATION
REAL,7 $MAT,3
E,52,53
REAL,5
E,53,54
E,54,55
E,55,56
E,56,57
E,57,58
E,58,59
EGEN,11,1,58
E,61,70                               *START OF REDUNDANT LOOP
E,70,71
E,71,72
EGEN,6,1,71
E,77,69
E,69,78
E,78,79
E,79,80
E,80,81
E,81,82
E,82,83
E,83,84
E,84,85
E,85,86
E,86,87
E,87,88
E,88,89
F,39,MX  $F,39,MY  $F,39,MZ
D,39,UX $D,39,UZ
D,1,UX    $D,1,UY,2.021  $D,1,UZ
D,1,ROTX  $D,1,ROTY      $D,1,ROTZ
D,89,UX  $D,89,UY $D,89,UZ
F,89,MX  $F,89,MY $F,89,MZ
PRSTR,5,1,2
CNVR,0.01,,,,1
KNL,1
POSTR,5,1,6,2,6
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,435,435,435
TEGEN,38,1,1
TE,39,378,378,364
TEGEN,3,1,39
```

```
TE,42,378,378,364
TEGEN,9,1,42
TE,51,60,60,60
TEGEN,39,1,51
KTEMP,-1
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,435,435,435
TEGEN,38,1,1
TE,39,378,378,349
TEGEN,3,1,39
TE,42,378,378,349
TEGEN,9,1,42
TE,51,60,60,60
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,435,435,435
TEGEN,38,1,1
TE,39,378,378,335
TEGEN,3,1,39
TE,42,378,378,335
TEGEN,9,1,42
TE,51,60,60,60
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,435,435,435
TEGEN,38,1,1
TE,39,378,378,320
TEGEN,3,1,39
TE,42,378,378,320
TEGEN,9,1,42
TE,51,60,60,60
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
SAVE
AFWRITE
FINISH
```

ATT-2
SHT 36 OF 61



```
/INPUT,27,
FINISH
/POST1
STRESS,STRA,20,13  $STRESS,STRR,20,14
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
STRESS,STRH,20,15  $STRESS,STRXH,20,16
STRESS,STRD,20,223  $STRESS,STRTT,20,225  $STRESS,STRPP,20,226
STRESS,STINT,20,235 $STRESS,STINT,20,236
STRESS,RATYS,20,98 $STRESS,AESTRA,20,95
STRESS,APSTRA,20,96  $STRESS,PLSIG,20,10C
SET,4,5
PRDISP  $PRESTR  $PRSTRS
FINI
```

1          ANSYS - ENGINEERING ANALYSIS SYSTEM  REVISION 4.4       A166   ARIZONA PUBLIC
MAY 1,1990


FOR SUPPORT CALL BOB WESOLOWSKI    PHONE (602) 250-3428    TWX

TITLE                                                                    14.1933
OCT 16,1992 CP=       1.040

***** ANSYS ANALYSIS DEFINITION (PREP7) *****

NEW TITLE= Normal Plant Cooldown (A) - Aux. Spray Line Inelastic Analysis

ANALYSIS TYPE= 0   (STATIC ANALYSIS)

USE FULL NEWTON-RAPHSON SOLUTION PROCEDURE  (KAY(9)=1)

MATERIAL   1          COEFFICIENTS OF EX   VS. TEMP EQUATION
CO =  0.2550000E+08

PROPERTY TABLE EX    MAT=   1  NUM. POINTS=  2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.25500E+08 | 9999.0 | 0.25500E+08 |

MATERIAL   1          COEFFICIENTS OF ALPX VS. TEMP EQUATION
CO =  0.9250000E-05

PROPERTY TABLE ALPX  MAT=   1  NUM. POINTS=  2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.92500E-05 | 9999.0 | 0.92500E-05 |

MATERIAL   1          COEFFICIENTS OF DENS VS. TEMP EQUATION
CO =  0.2836000

PROPERTY TABLE DENS  MAT=   1  NUM. POINTS=  2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.28360 | 9999.0 | 0.28360 |

MATERIAL NUMBER SET TO     1

MATERIAL   2          COEFFICIENTS OF EX   VS. TEMP EQUATION
CO =  0.2550000E+08

IF RUNNING INTERACTIVELY, ENTER /INTER

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
/PREP7
/TITLE, Normal Plant Cooldown (B) - Aux. Spray Line Inelastic Analysis
KAN,0
KAY,9,1
MP,EX,1,25.5E6
MP,ALPX,1,9.25E-6
MP,DENS,1,0.2836
MAT,1
MP,EX,2,25.5E6
MP,ALPX,2,9.25E-6
MP,DENS,2,0.2836
NL,2,13,10
NL,2,25,18800
NL,2,31,100000
MAT,2
MPPLOT,PLAS,2
MP,EX,3,25.5E6
MP,ALPX,3,8.16E-6
MP,DENS,3,0.2836
MAT,3
ET,1,20,,4,,,,
TYPE,1
ET,2,20,,4,,,,1
TYPE,2
R,1,6.72,1.64,1.9,1.9
REAL,1
TREF,110
CSYS,0
N,1
N,2,,6
N,3,,10.5
N,4,,14.625
N,5,,17.625
N,6,,20.625
N,7,,24.75
N,8,,28.875
N,12,,72.875
FILL
TYPE,1 $MAT,1 $REAL,1
E,1,2
E,2,3
R,2,4.5,0.531,1.9,1.0
REAL,2
E,3,4
R,3,4.5,0.531,1.0,1.0
REAL,3
E,4,5
R,4,4.5,0.531,1.0,1.9
REAL,4
E,5,6
TREF,70
REAL,2 $TYPE,2 $MAT,2
E,6,7
```

```
REAL,4 STYPE,2 SMAT,2
E,7,8
REAL,2 STYPE,1 SMAT,1
E,8,9
REAL,3
E,9,10
E,10,11
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
E,11,12
LOCAL,11,1,3.531,68.375,4.851,,-126.052
N,16,6,90
FILL
E,12,13
E,13,14
E,14,15
E,15,16
LOCAL,12,0,3.531,74.375,4.851,,-36.052
N,17,,,9
N,18,,,18
N,19,,,26
N,20,,,34
N,29,,,100.375
FILL
N,39,,-240,100.375
FILL
E,16,17
E,17,18
E,18,19
E,19,20
E,20,21
EGEN,18,1,20
E,38,39
CSYS,0
N,40,,24.75,-2.25
N,41,,24.75,-3.5
N,51,,24.75,-43
FILL
N,52,,24.75,-54.25
N,56,,24.75,-72.5
FILL
N,60,-32.875,24.75,-72.5
FILL
N,61,-38.875,24.75,-72.5
N,66,-82.375,24.75,-72.5
FILL
N,69,-82.375,24.75,-55
FILL
N,70,-38.875,24.75,-69.5
N,73,-38.875,24.75,-55
FILL
N,77,-79.375,24.75,-55
FILL
N,78,-82.375,24.75,-51
N,79,-82.375,24.75,-44.5
N,89,-82.375,-163.5,-44.5
FILL
TREF,110
R,5,2.375,0.343,1.0,1.0
REAL,5 STYPE,2 SMAT,2
E,7,40
R,6,2.375,0.343,1.0,1.9
REAL,6 STYPE,2 SMAT,2
```

```
E,40,41
R,7,2.375,0.343,1.9,1.
REAL,7 $TYPE,2 $MAT,2
E,41,42
REAL,5 $TYPE,2 $MAT,2
E,42,43
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
EGEN,7,1,42
E,49,50
REAL,6 $TYPE,2 $MAT,2
E,50,51
TREF,110
R,8,2.375,0.686,1.9,1.9
REAL,8 $TYPE,1 $MAT,1
E,51,52                              * VALVE INSTALLATION
REAL,7 $MAT,3
E,52,53
REAL,5
E,53,54
E,54,55
E,55,56
E,56,57
E,57,58
E,58,59
EGEN,11,1,58
E,61,70                              *START OF REDUNDANT LOOP
E,70,71
E,71,72
EGEN,6,1,71
E,77,69
E,69,78
E,78,79
E,79,80
E,80,81
E,81,82
E,82,83
E,83,84
E,84,85
E,85,86
E,86,87
E,87,88
E,88,89
F,39,MX  $F,39,MY  $F,39,MZ
D,39,UX $D,39,UZ
D,1,UX    $D,1,UY,2.021  $D,1,UZ
D,1,ROTX  $D,1,ROTY      $D,1,ROTZ
D,89,UX  $D,89,UY $D,89,UZ
F,89,MX  $F,89,MY $F,89,MZ
PRSTR,5,1,2
CNVR,0.01,,,,1
KNL,1
POSTR,5,1,6,2,6
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,435,435,435
TEGEN,38,1,1
TE,39,378,378,364
TEGEN,3,1,39
```

```
TE,42,378,378,364
TEGEN,9,1,42
TE,51,110,110,110
TEGEN,39,1,51
KTEMP,-1
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,435,435,435
TEGEN,38,1,1
TE,39,378,378,349
TEGEN,3,1,39
TE,42,378,378,349
TEGEN,9,1,42
TE,51,110,110,110
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,435,435,435
TEGEN,38,1,1
TE,39,378,378,335
TEGEN,3,1,39
TE,42,378,378,335
TEGEN,9,1,42
TE,51,110,110,110
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,435,435,435
TEGEN,38,1,1
TE,39,378,378,320
TEGEN,3,1,39
TE,42,378,378,320
TEGEN,9,1,42
TE,51,110,110,110
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
SAVE
AFWRITE
FINISH
```

```
/INPUT,27
FINISH
/POST1
STRESS,STRA,20,13  $STRESS,STRR,20,14
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
STRESS,STRH,20,15  $STRESS,STRXH,20,16
STRESS,STRD,20,223  $STRESS,STRTT,20,225  $STRESS,STRPP,20,226
STRESS,STINT,20,235 $STRESS,STINT,20,236
STRESS,RATYS,20,98 $STRESS,AESTRA,20,95
STRESS,APSTRA,20,96  $STRESS,PLSIG,20,100
SET,4,5
PRDISP  $PRESTR  $PRSTRS
FINI
```

1 ANSYS - ENGINEERING ANALYSIS SYSTEM REVISION 4.4 A166 ARIZONA PUBLIC
MAY 1,1990


FOR SUPPORT CALL BOB WESOLOWSKI PHONE (602) 250-3428 TWX

TITLE 15.3361
OCT 16,1992 CP= 1.080

***** ANSYS ANALYSIS DEFINITION (PREP7) *****

NEW TITLE= Normal Plant Cooldown (B) - Aux. Spray Line Inelastic Analysis

ANALYSIS TYPE= 0 (STATIC ANALYSIS)

USE FULL NEWTON-RAPHSON SOLUTION PROCEDURE (KAY(9)=1)

MATERIAL 1 COEFFICIENTS OF EX VS. TEMP EQUATION
CO = 0.2550000E+08

PROPERTY TABLE EX MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.25500E+08 | 9999.0 | 0.25500E+08 |

MATERIAL 1 COEFFICIENTS OF ALPX VS. TEMP EQUATION
CO = 0.9250000E-05

PROPERTY TABLE ALPX MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.92500E-05 | 9999.0 | 0.92500E-05 |

MATERIAL 1 COEFFICIENTS OF DENS VS. TEMP EQUATION
CO = 0.2836000

PROPERTY TABLE DENS MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.28360 | 9999.0 | 0.28360 |

MATERIAL NUMBER SET TO 1

MATERIAL 2 COEFFICIENTS OF EX VS. TEMP EQUATION
CO = 0.2550000E+08

IF RUNNING INTERACTIVELY, ENTER /INTER

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
/PREP7
/TITLE, Normal Plant Cooldown (C) - Aux. Spray Line Inelastic Analysis
KAN,0
KAY,9,1
MP,EX,1,25.5E6
MP,ALPX,1,9.25E-6
MP,DENS,1,0.2836
MAT,1
MP,EX,2,25.5E6
MP,ALPX,2,9.25E-6
MP,DENS,2,0.2836
NL,2,13,10
NL,2,25,18800
NL,2,31,100000
MAT,2
MPPLOT,PLAS,2
MP,EX,3,25.5E6
MP,ALPX,3,8.16E-6
MP,DENS,3,0.2836
MAT,3
ET,1,20,,4,,,,
TYPE,1
ET,2,20,,4,,,,1
TYPE,2
R,1,6.72,1.64,1.9,1.9
REAL,1
TREF,160
CSYS,0
N,1
N,2,,6
N,3,,10.5
N,4,,14.625
N,5,,17.625
N,6,,20.625
N,7,,24.75
N,8,,28.875
N,12,,72.875
FILL
TYPE,1 $MAT,1 $REAL,1
E,1,2
E,2,3
R,2,4.5,0.531,1.9,1.0
REAL,2
E,3,4
R,3,4.5,0.531,1.0,1.0
REAL,3
E,4,5
R,4,4.5,0.531,1.0,1.9
REAL,4
E,5,6
TREF,70
REAL,2 $TYPE,2 $MAT,2
E,6,7
```

ATT-2
SHT 43 OF 61

```
REAL,4 $TYPE,2 $MAT,2
E,7,8
REAL,2 $TYPE,1 $MAT,1
E,8,9
REAL,3
E,9,10
E,10,11
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
E,11,12
LOCAL,11,1,3.531,68.375,4.851,,-126.052
N,16,6,90
FILL
E,12,13
E,13,14
E,14,15
E,15,16
LOCAL,12,0,3.531,74.375,4.851,,-36.052
N,17,,,9
N,18,,,18
N,19,,,26
N,20,,,34
N,29,,,100   75
FILL
N,39,,-24        75
FILL
E,16,17
E,17,18
E,18,19
E,19,20
E,20,21
EGEN,18,1,20
E,38,39
CSYS,0
N,40,,24.75,-2.25
N,41,,24.75,-3.5
N,51,,24.75,-43
FILL
N,52,,24.75,-54.25
N,56,,24.75,-72.5
FILL
N,60,-32.875,24.75,-72.5
FILL
N,61,-38.875,24.75,-72.5
N,66,-82.375,24.75,-72.5
FILL
N,69,-82.375,24.75,-55
FILL
N,70,-38.875,24.75,-69.5
N,73,-38.875,24.75,-55
FILL
N,77,-79.375,24.75,-55
FILL
N,78,-82.375,24.75,-51
N,79,-82.375,24.75,-44.5
N,89,-82.375,-163.5,-44.5
FILL
TREF,160
R,5,2.375,0.343,1.0,1.0
REAL,5 $TYPE,2 $MAT,2
E,7,40
R,6,2.375,0.343,1.0,1.9
REAL,6 $TYPE,2 $MAT,2
```

```
E,40,41
R,7,2.375,0.343,1.9,1.
REAL,7 $TYPE,2 $MAT,2
E,41,42
REAL,5 $TYPE,2 $MAT,2
E,42,43
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
EGEN,7,1,42
E,49,50
REAL,6 $TYPE,2 $MAT,2
E,50,51
TREF,160
R,8,2.375,0.686,1.9,1.9
REAL,8 $TYPE,1 $MAT,1
E,51,52                              * VALVE INSTALLATION
REAL,7 $MAT,3
E,52,53
REAL,5
E,53,54
E,54,55
E,55,56
E,56,57
E,57,58
E,58,59
EGEN,11,1,58
E,61,70                              *START OF REDUNDANT LOOP
E,70,71
E,71,72
EGEN,6,1,71
E,77,69
E,69,78
E,78,79
E,79,80
E,80,81
E,81,82
E,82,83
E,83,84
E,84,85
E,85,86
E,86,87
E,87,88
E,88,89
F,39,MX  $F,39,MY  $F,39,MZ
D,39,UX $D,39,UZ
D,1,UX    $D,1,UY,2.021  $D,1,UZ
D,1,ROTX  $D,1,ROTY       $D,1,ROTZ
D,89,UX  $D,89,UY $D,89,UZ
F,89,MX  $F,89,MY $F,89,MZ
PRSTR,5,1,2
CNVR,0.01,,,,1
KNL,1
POSTR,5,1,6,2,6
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,435,435,435
TEGEN,38,1,1
TE,39,378,378,364
TEGEN,3,1,39
```

```
TE,42,378,378,364
TEGEN,9,1,42
TE,51,160,160,160
TEGEN,39,1,51
KTEMP,-1
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,435,435,435
TEGEN,38,1,1
TE,39,378,378,349
TEGEN,3,1,39
TE,42,378,378,349
TEGEN,9,1,42
TE,51,160,160,160
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,435,435,435
TEGEN,38,1,1
TE,39,378,378,335
TEGEN,3,1,39
TE,42,378,378,335
TEGEN,9,1,42
TE,51,160,160,160
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,435,435,435
TEGEN,38,1,1
TE,39,378,378,320
TEGEN,3,1,39
TE,42,378,378,320
TEGEN,9,1.42
TE,51,160,160,160
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
SAVE
AFWRITE
FINISH
```

ATT-2
SHT 46 OF 61

```
/INPUT,27
FINISH
/POST1
STRESS,STRA,20,13  $STRESS,STRR,20,14
```
1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
STRESS,STRH,20,15  $STRESS,STRXH,20,16
STRESS,STRD,20,223  $STRESS,STRTT,20,225  $STRESS,STRPP,20,226
STRESS,STINT,20,235 $STRESS,STINT,20,236
STRESS,RATYS,20,98 $STRESS,AESTRA,20,95
STRESS,APSTRA,20,96  $STRESS,PLSIG,20,100
SET,4,5
PRDISP  $PRESTR  $PRSTRS
FINI
```

1 ANSYS - ENGINEERING ANALYSIS SYSTEM REVISION 4.4 A166 ARIZONA PUBLIC MAY 1,1990


FOR SUPPORT CALL BOB WESOLOWSKI PHONE (602) 250-3428 TWX

TITLE 15.7394
OCT 16,1992 CP= 1.110

***** ANSYS ANALYSIS DEFINITION (PREP7) *****

NEW TITLE= Normal Plant Cooldown (C) - Aux. Spray Line Inelastic Analysis

ANALYSIS TYPE= 0 (STATIC ANALYSIS)

USE FULL NEWTON-RAPHSON SOLUTION PROCEDURE (KAY(9)=1)

MATERIAL 1 COEFFICIENTS OF EX VS. TEMP EQUATION
C0 = 0.2550000E+08

PROPERTY TABLE EX MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.25500E+08 | 9999.0 | 0.25500E+08 |

MATERIAL 1 COEFFICIENTS OF ALPX VS. TEMP EQUATION
C0 = 0.9250000E-05

PROPERTY TABLE ALPX MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.92500E-05 | 9999.0 | 0.92500E-05 |

MATERIAL 1 COEFFICIENTS OF DENS VS. TEMP EQUATION
C0 = 0.2836000

PROPERTY TABLE DENS MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.28360 | 9999.0 | 0.28360 |

MATERIAL NUMBER SET TO 1

MATERIAL 2 COEFFICIENTS OF EX VS. TEMP EQUATION
C0 = 0.2550000E+08

IF RUNNING INTERACTIVELY, ENTER /INTER
1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
/PREP7
/TITLE, Normal Start Up - Baseline Run Wothout Stratification
KAN,0
KAY,9,1
MP,EX,1,25.5E6
MP,ALPX,1,9.36E-6
MP,DENS,1,0.2836
MAT,1
MP,EX,2,25.5E6
MP,ALPX,2,9.36E-6
MP,DENS,2,0.2836
NL,2,13,10
NL,2,25,18800
NL,2,31,100000
MAT,2
MPPLOT,PLAS,2
MP,EX,3,25.5E6
MP,ALPX,3,9.36E-6
MP,DENS,3,0.2836
MAT,3
ET,1,20,,4,,,,
TYPE,1
ET,2,20,,4,,,,1
TYPE,2
R,1,6.72,1.64,1.9,1.9
REAL,1
TREF,70
CSYS,0
N,1
N,2,,6
N,3,,10.5
N,4,,14.625
N,5,,17.625
N,6,,20.625
N,7,,24.75
N,8,,28.875
N,12,,72.875
FILL
TYPE,1 $MAT,1 $REAL,1
E,1,2
E,2,3
R,2,4.5,0.531,1.9,1.0
REAL,2
E,3,4
R,3,4.5,0.531,1.0,1.0
REAL,3
E,4,5
R,4,4.5,0.531,1.0,1.9
REAL,4
E,5,6
REAL,2 $TYPE,2 $MAT,2
E,6,7
REAL,4 $TYPE,2 $MAT,2
```

```
E,7,8
REAL,2 $TYPE,1 $MAT,1
E,8,9
REAL,3
E,9,10
E,10,11
E,11,12
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
LOCAL,11,1,3.531,68.375,4.851,,-126.052
N,16,6,90
FILL
E,12,13
E,13,14
E,14,15
E,15,16
LOCAL,12,0,3.531,74.375,4.851,,-36.052
N,17,,,9
N,18,,,18
N,19,,,26
N,20,,,34
N,29,,,100.375
FILL
N,39,,-240,100.375
FILL
E,16,17
E,17,18
E,18,19
E,19,20
E,20,21
EGEN,18,1,20
E,38,39
CSYS,0
N,40,,24.75,-2.25
N,41,,24.75,-3.5
N,51,,24.75,-43
FILL
N,52,,24.75,-54.25
N,56,,24.75,-72.5
FILL
N,60,-32.875,24.75,-72.5
FILL
N,61,-38.875,24.75,-72.5
N,66,-82.375,24.75,-72.5
FILL
N,69,-82.375,24.75,-55
FILL
N,70,-38.875,24.75,-69.5
N,73,-38.875,24.75,-55
FILL
N,77,-79.375,24.75,-55
FILL
N,78,-82.375,24.75,-51
N,79,-82.375,24.75,-44.5
N,89,-82.375,-163.5,-44.5
FILL
TREF,70
R,5,2.375,0.343,1.0,1.0
REAL,5 $TYPE,2 $MAT,2
E,7,40
R,6,2.375,0.343,1.0,1.9
REAL,6 $TYPE,2 $MAT,2
E,40,41
```

```
R,7,2.375,0.343,1.9,1.
REAL,7 $TYPE,2 $MAT,2
E,41,42
REAL,5 $TYPE,2 $MAT,2
E,42,43
EGEN,7,1,42
```

1

*********** ANSYS INPUT DATA LISTING (FILE18) **********

```
E,49,50
REAL,6 $TYPE,2 $MAT,2
E,50,51
TREF,70
R,8,2.375,0.686,1.9,1.9
REAL,8 $TYPE,1 $MAT,1
E,51,52                          * VALVE INSTALLATION
REAL,7 $MAT,3
E,52,53
REAL,5
E,53,54
E,54,55
E,55,56
E,56,57
E,57,58
E,58,59
EGEN,11,1,58
E,61,70                          *START OF REDUNDANT LOOP
E,70,71
E,71,72
EGEN,6,1,71
E,77,69
E,69,78
E,78,79
E,79,80
E,80,81
E,81,82
E,82,83
E,83,84
E,84,85
E,85,86
E,86,87
E,87,88
E,88,89
F,39,MX  $F,39,MY  $F,39,MZ
D,39,UX $D,39,UZ
D,1,UX    $D,1,UY,2.021  $D,1,UZ
D,1,ROTX  $D,1,ROTY      $D,1,ROTZ
D,89,UX  $D,89,UY $D,89,UZ
F,89,MX  $F,89,MY $F,89,MZ
PRSTR,5,1,2
CNVR,0.01,,,,1
KNL,1
POSTR,5,1,6,2,6
,EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,495,495,495
TEGEN,38,1,1
TE,39,495,495,495
TEGEN,3,1,39
TE,42,495,495,495
```

```
TEGEN,9,1,42
TE,51,495,495,495
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,495,495,495
TEGEN,38,1,1
TE,39,495,495,495
TEGEN,3,1,39
TE,42,495,495,495
TEGEN,9,1,42
TE,51,495,495,495
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,495,495,495
TEGEN,38,1,1
TE,39,495,495,495
TEGEN,3,1,39
TE,42,495,495,495
TEGEN,9,1,42
TE,51,495,495,495
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,495,495,495
TEGEN,38,1,1
TE,39,495,495,495
TEGEN,3,1,39
TE,42,495,495,495
TEGEN,9,1,42
TE,51,495,495,495
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
SAVE
AFWRITE
FINISH
/INPUT,27
FINISH
```

```
/POST1
STRESS,STRA,20,13 $STRESS,STRR,20,14
STRESS,STRH,20,15 $STRESS,STRXH,20,16
STRESS,STRD,20,223 $STRESS,STRTT,20,225 $STRESS,STRPP,20,226
1
           ********** ANSYS INPUT DATA LISTING (FILE18) **********

STRESS,STINT,20,235 $STRESS,STINT,20,236
STRESS,RATYS,20,98 $STRESS,AESTRA,20,95
STRESS,APSTRA,20,96 $STRESS,PLSIG,20,100
SET,4,5
PRDISP $PRESTR $PRSTRS
FINI
```

```
1          ANSYS - ENGINEERING ANALYSIS SYSTEM  REVISION 4.4      A166   ARIZONA PUBLIC
 MAY 1,1990
```


FOR SUPPORT CALL BOB WESOLOWSKI PHONE (602) 250-3428 TWX

```
 TITLE                                                                      13.7056
 NOV  2,1992 CP=      1.100

        ***** ANSYS ANALYSIS DEFINITION (PREP7) *****

 NEW TITLE=  Normal Start Up -  Baseline Run Wothout Stratification



 ANALYSIS TYPE=  0    (STATIC ANALYSIS)

 USE FULL NEWTON-RAPHSON SOLUTION PROCEDURE  (KAY(9)=1)

  MATERIAL    1          COEFFICIENTS OF EX   VS. TEMP EQUATION
   C0 =  0.2550000E+08

 PROPERTY TABLE EX    MAT=   1  NUM. POINTS=  2
    TEMPERATURE     DATA    TEMPERATURE     DATA
      -9999.0     0.25500E+08  9999.0     0.25500E+08

  MATERIAL    1          COEFFICIENTS OF ALPX VS. TEMP EQUATION
   C0 =  0.9360000E-05

 PROPERTY TABLE ALPX  MAT=   1  NUM. POINTS=  2
    TEMPERATURE     DATA    TEMPERATURE     DATA
      -9999.0     0.93600E-05  9999.0     0.93600E-05

  MATERIAL    1          COEFFICIENTS OF DENS VS. TEMP EQUATION
   C0 =  0.2836000

 PROPERTY TABLE DENS  MAT=   1  NUM. POINTS=  2
    TEMPERATURE     DATA    TEMPERATURE     DATA
      -9999.0     0.28360      9999.0     0.28360

 MATERIAL NUMBER SET TO      1

  MATERIAL    2          COEFFICIENTS OF EX   VS. TEMP EQUATION
   C0 =  0.2550000E+08

 PROPERTY TABLE EX    MAT=   2  NUM. POINTS=  2
```

IF RUNNING INTERACTIVELY, ENTER /INTER

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
/PREP7
/TITLE, Upset Load Rejection At 100% Baseline Run Without Strat.
KAN,0
KAY,9,1
MP,EX,1,25.5E6
MP,ALPX,1,9.41E-6
MP,DENS,1,0.2836
MAT,1
MP,EX,2,25.5E6
MP,ALPX,2,9.41E-6
MP,DENS,2,0.2836
NL,2,13,10
NL,2,25,18800
NL,2,31,100000
MAT,2
MPPLOT,PLAS,2
MP,EX,3,25.5E6
MP,ALPX,3,8.60E-6
MP,DENS,3,0.2836
MAT,3
ET,1,20,,4,,,,
TYPE,1
ET,2,20,,4,,,,1
TYPE,2
R,1,6.72,1.64,1.9,1.9
REAL,1
TREF,495
CSYS,0
N,1
N,2,,6
N,3,,10.5
N,4,,14.625
N,5,,17.625
N,6,,20.625
N,7,,24.75
N,8,,28.875
N,12,,72.875
FILL
TYPE,1 $MAT,1 $REAL,1
E,1,2
E,2,3
R,2,4.5,0.531,1.9,1.0
REAL,2
E,3,4
R,3,4.5,0.531,1.0;1.0
REAL,3
E,4,5
R,4,4.5,0.531,1.0,1.9
REAL,4
E,5,6
REAL,2 $TYPE,2 $MAT,2
E,6,7
REAL,4 $TYPE,2 $MAT,2
```

```
E,7,8
REAL,2 $TYPE,1 $MAT,1
E,8,9
REAL,3
E,9,10
E,10,11
E,11,12
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
LOCAL,11,1,3.531,68.375,4.851,,-126.052
N,16,6,90
FILL
E,12,13
E,13,14
E,14,15
E,15,16
LOCAL,12,0,3.531,74.375,4.851,,-36.052
N,17,,,9
N,18,,,18
N,19,,,26
N,20,,,34
N,29,,,100.375
FILL
N,39,,-240,100.375
FILL
E,16,17
E,17,18
E,18,19
E,19,20
E,20,21
EGEN,18,1,20
E,38,39
CSYS,0
N,40,,24.75,-2.25
N,41,,24.75,-3.5
N,51,,24.75,-43
FILL
N,52,,24.75,-54.25
N,56,,24.75,-72.5
FILL
N,60,-32.875,24.75,-72.5
FILL
N,61,-38.875,24.75,-72.5
N,66,-82.375,24.75,-72.5
FILL
N,69,-82.375,24.75,-55
FILL
N,70,-38.875,24.75,-69.5
N,73,-38.875,24.75,-55
FILL
N,77,-79.375,24.75,-55
FILL
N,78,-82.375,24.75,-51
N,79,-82.375,24.75,-44.5
N,89,-82.375,-163.5,-44.5
FILL
TREF,495
R,5,2.375,0.343,1.0,1.0
REAL,5 $TYPE,2 $MAT,2
E,7,40
R,6,2.375,0.343,1.0,1.9
REAL,6 $TYPE,2 $MAT,2
E,40,41
```

```
R,7,2.375,0.343,1.9,1.
REAL,7 $TYPE,2 $MAT,2
E,41,42
REAL,5 $TYPE,2 $MAT,2
E,42,43
EGEN,7,1,42
```

1

```
          **********  ANSYS INPUT DATA LISTING (FILE18)  **********

E,49,50
REAL,6 $TYPE,2 $MAT,2
E,50,51
TREF,120
R,8,2.375,0.686,1.9,1.9
REAL,8 $TYPE,1 $MAT,1
E,51,52                             * VALVE INSTALLATION
REAL,7 $MAT,3
E,52,53
REAL,5
E,53,54
E,54,55
E,55,56
E,56,57
E,57,58
E,58,59
EGEN,11,1,58
E,61,70                             *START OF REDUNDANT LOOP
E,70,71
E,71,72
EGEN,6,1,71
E,77,69
E,69,78
E,78,79
E,79,80
E,80,81
E,81,82
E,82,83
E,83,84
E,84,85
E,85,86
E,86,87
E,87,88
E,88,89
F,39,MX  $F,39,MY  $F,39,MZ
D,39,UX $D,39,UZ
D,1,UX    $D,1,UY,2.021  $D,1,UZ
D,1,ROTX  $D,1,ROTY      $D,1,ROTZ
D,89,UX  $D,89,UY $D,89,UZ
F,89,MX  $F,89,MY $F,89,MZ
PRSTR,5,1,2
CNVR,0.01,,,,1
KNL,1
POSTR,5,1,6,2,6
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,575,575,575
TEGEN,38,1,1
TE,39,575,575,575
TEGEN,3,1,39
TE,42,575,575,575
```

```
TEGEN,9,1,42
TE,51,120,120,120
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,575,575,575
TEGEN,38,1,1
TE,39,575,575,575
TEGEN,3,1,39
TE,42,575,575,575
TEGEN,9,1,42
TE,51,120,120,120
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,575,575,575
TEGEN,38,1,1
TE,39,575,575,575
TEGEN,3,1,39
TE,42,575,575,575
TEGEN,9,1,42
TE,51,120,120,120
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,575,575,575
TEGEN,38,1,1
TE,39,575,575,575
TEGEN,3,1,39
TE,42,575,575,575
TEGEN,9,1,42
TE,51,120,120,120
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
SAVE
AFWRITE
FINISH
/INPUT,27
FINISH
```

```
/POST1
STRESS,STRA,20,13  $STRESS,STRR,20,14
STRESS,STRH,20,15  $STRESS,STRXH,20,16
STRESS,STRD,20,223  $STRESS,STRTT,20,225  $STRESS,STRPP,20,226
```

1

*********** ANSYS INPUT DATA LISTING (FILE18) **********

```
STRESS,STINT,20,235 $STRESS,STINT,20,236
STRESS,RATYS,20,98 $STRESS,AESTRA,20,95
STRESS,APSTRA,20,96  $STRESS,PLSIG,20,100
SET,4,5
PRDISP  $PRESTR  $PRSTRS
FINI
```

1 ANSYS - ENGINEERING ANALYSIS SYSTEM REVISION 4.4 A166 ARIZONA PUBLIC
MAY 1,1990



FOR SUPPORT CALL BOB WESOLOWSKI PHONE (602) 250-3428 TWX

TITLE 11.1300
NOV 2,1992 CP= 1.090

***** ANSYS ANALYSIS DEFINITION (PREP7) *****

NEW TITLE= Upset Load Rejection At 100% Baseline Run Without Strat.

ANALYSIS TYPE= 0 (STATIC ANALYSIS)

USE FULL NEWTON-RAPHSON SOLUTION PROCEDURE (KAY(9)=1)

MATERIAL 1 COEFFICIENTS OF EX VS. TEMP EQUATION
C0 = 0.2550000E+08

PROPERTY TABLE EX MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.25500E+08 | 9999.0 | 0.25500E+08 |

MATERIAL 1 COEFFICIENTS OF ALPX VS. TEMP EQUATION
C0 = 0.9410000E-05

PROPERTY TABLE ALPX MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.94100E-05 | 9999.0 | 0.94100E-05 |

MATERIAL 1 COEFFICIENTS OF DENS VS. TEMP EQUATION
C0 = 0.2836000

PROPERTY TABLE DENS MAT= 1 NUM. POINTS= 2

| TEMPERATURE | DATA | TEMPERATURE | DATA |
|---|---|---|---|
| -9999.0 | 0.28360 | 9999.0 | 0.28360 |

MATERIAL NUMBER SET TO 1

MATERIAL 2 COEFFICIENTS OF EX VS. TEMP EQUATION
C0 = 0.2550000E+08

PROPERTY TABLE EX MAT= 2 NUM. POINTS= 2

IF RUNNING INTERACTIVELY, ENTER /INTER
1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
/PREP7
/TITLE, Normal Plant Cooldown (A) - Baseline Run Without Strat.
KAN,0
KAY,9,1
MP,EX,1,25.5E6
MP,ALPX,1,9.25E-6
MP,DENS,1,0.2836
MAT,1
MP,EX,2,25.5E6
MP,ALPX,2,9.25E-6
MP,DENS,2,0.2836
NL,2,13,10
NL,2,25,18800
NL,2,31,100000
MAT,2
MPPLOT,PLAS,2
MP,EX,3,25.5E6
MP,ALPX,3,8.16E-6
MP,DENS,3,0.2836
MAT,3
ET,1,20,,4,,,,
TYPE,1
ET,2,20,,4,,,,1
TYPE,2
R,1,6.72,1.64,1.9,1.9
REAL,1
TREF,60
CSYS,0
N,1
N,2,,6
N,3,,10.5
N,4,,14.625
N,5,,17.625
N,6,,20.625
N,7,,24.75
N,8,,28.875
N,12,,72.875
FILL
TYPE,1 $MAT,1 $REAL,1
E,1,2
E,2,3
R,2,4.5,0.531,1.9,1.0
REAL,2
E,3,4
R,3,4.5,0.531,1.0,1.0
REAL,3
E,4,5
R,4,4.5,0.531,1.0,1.9
REAL,4
E,5,6
TREF,70
REAL,2 $TYPE,2 $MAT,2
E,6,7
```

```
REAL,4 $TYPE,2 $MAT,2
E,7,8
REAL,2 $TYPE,1 $MAT,1
E,8,9
REAL,3
E,9,10
E,10,11
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
E,11,12
LOCAL,11,1,3.531,68.375,4.851,,-126.052
N,16,6,90
FILL
E,12,13
E,13,14
E,14,15
E,15,16
LOCAL,12,0,3.531,74.375,4.851,,-36.052
N,17,,,9
N,18,,,18
N,19,,,26
N,20,,,34
N,29,,,100.375
FILL
N,39,,-240,100.375
FILL
E,16,17
E,17,18
E,18,19
E,19,20
E,20,21
EGEN,18,1,20
E,38,39
CSYS,0
N,40,,24.75,-2.25
N,41,,24.75,-3.5
N,51,,24.75,-43
FILL
N,52,,24.75,-54.25
N,56,,24.75,-72.5
FILL
N,60,-32.875,24.75,-72.5
FILL
N,61,-38.875,24.75,-72.5
N,66,-82.375,24.75,-72.5
FILL
N,69,-82.375,24.75,-55
FILL
N,70,-38.875,24.75,-69.5
N,73,-38.875,24.75,-55
FILL
N,77,-79.375,24.75,-55
FILL
N,78,-82.375,24.75,-51
N,79,-82.375,24.75,-44.5
N,89,-82.375,-163.5,-44.5
FILL
TREF,60
R,5,2.375,0.343,1.0,1.0
REAL,5 $TYPE,2 $MAT,2
E,7,40
R,6,2.375,0.343,1.0,1.9
REAL,6 $TYPE,2 $MAT,2
```

```
E,40,41
R,7,2.375,0.343,1.9,1.
REAL,7 $TYPE,2 $MAT,2
E,41,42
REAL,5 $TYPE,2 $MAT,2
E,42,43
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
EGEN,7,1,42
E,49,50
REAL,6 $TYPE,2 $MAT,2
E,50,51
TREF,60
R,8,2.375,0.686,1.9,1.9
REAL,8 $TYPE,1 $MAT,1
E,51,52                          * VALVE INSTALLATION
REAL,7 $MAT,3
E,52,53
REAL,5
E,53,54
E,54,55
E,55,56
E,56,57
E,57,58
E,58,59
EGEN,11,1,58
E,61,70                          *START OF REDUNDANT LOOP
E,70,71
E,71,72
EGEN,6,1,71
E,77,69
E,69,78
E,78,79
E,79,80
E,80,81
E,81,82
E,82,83
E,83,84
E,84,85
E,85,86
E,86,87
E,87,88
E,88,89
F,39,MX  $F,39,MY  $F,39,MZ
D,39,UX $D,39,UZ
D,1,UX    $D,1,UY,2.021  $D,1,UZ
D,1,ROTX  $D,1,ROTY      $D,1,ROTZ
D,89,UX  $D,89,UY $D,89,UZ
F,89,MX  $F,89,MY $F,89,MZ
PRSTR,5,1,2
CNVR,0.01,,,,1
KNL,1
POSTR,5,1,6,2,6
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,435,435,435
TEGEN,38,1,1
TE,39,435,435,435
TEGEN,3,1,39
```

```
TE,42,435,435,435
TEGEN,9,1,42
TE,51,60,60,60
TEGEN,39,1,51
KTEMP,-1
```

1

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,435,435,435
TEGEN,38,1,1
TE,39,435,435,435
TEGEN,3,1,39
TE,42,435,435,435
TEGEN,9,1,42
TE,51,60,60,60
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,435,435,435
TEGEN,38,1,1
TE,39,435,435,435
TEGEN,3,1,39
TE,42,435,435,435
TEGEN,9,1,42
TE,51,60,60,60
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
EP,1,P,2250
EPGEN,38,1,1
EP,39,P,2250
EPGEN,13,1,39
EP,52,P,2300
EPGEN,38,1,52
TE,1,435,435,435
TEGEN,38,1,1
TE,39,435,435,435
TEGEN,3,1,39
TE,42,435,435,435
TEGEN,9,1,42
TE,51,60,60,60
TEGEN,39,1,51
KTEMP,-1
ITER,-5,5,5
LWRITE
SAVE
AFWRITE
FINISH
```

```
/INPUT,27
FINISH
/POST1
STRESS,STRA,20,13  $STRESS,STRR,20,14
```

1

```
          **********  ANSYS INPUT DATA LISTING (FILE18)  **********

STRESS,STRH,20,15  $STRESS,STRXH,20,16
STRESS,STRD,20,223  $STRESS,STRTT,20,225  $STRESS,STRPP,20,226
STRESS,STINT,20,2?5 $STRESS,STINT,20,236
STRESS,RATYS,20,98 $STRESS,AESTRA,20,95
STRESS,APSTRA,70,96  $STRESS,PLSIG,20,100
SET,4,5
PRDISP  $PRESTR  $PRSTRS
FINI
```

```
1           ANSYS - ENGINEERING ANALYSIS SYSTEM  REVISION 4.4      A166   ARIZONA PUBLIC
  MAY 1,1990
```



```
     FOR SUPPORT CALL BOB WESOLOWSKI    PHONE (602) 250-3428    TWX

 TITLE                                                                     11.3117
 NOV  2,1992 CP=      1.100

        ***** ANSYS ANALYSIS DEFINITION (PREP7) *****

 NEW TITLE=  Normal Plant Cooldown (A) - Baseline Run Without Strat.



 ANALYSIS TYPE=  0   (STATIC ANALYSIS)

 USE FULL NEWTON-RAPHSON SOLUTION PROCEDURE  (KAY(9)=1)

  MATERIAL   1          COEFFICIENTS OF EX   VS. TEMP EQUATION
   C0 =  0.2550000E+08

 PROPERTY TABLE EX    MAT=   1  NUM. POINTS=  2
    TEMPERATURE     DATA    TEMPERATURE     DATA
      -9999.0     0.25500E+08  9999.0     0.25500E+08

  MATERIAL   1          COEFFICIENTS OF ALPX VS. TEMP EQUATION
   C0 =  0.9250000E-05

 PROPERTY TABLE ALPX  MAT=   1  NUM. POINTS=  2
    TEMPERATURE     DATA    TEMPERATURE     DATA
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  MATERIAL   1          COEFFICIENTS OF DENS VS. TEMP EQUATION
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 PROPERTY TABLE DENS  MAT=   1  NUM. POINTS=  2
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 MATERIAL NUMBER SET TO     1

  MATERIAL   2          COEFFICIENTS OF EX   VS. TEMP EQUATION
   C0 =  0.2550000E+08
```

ANPP

# CALCULATION SHEET

CALC. TITLE AUXILIARY SPRAY LINE THERMAL STRATIFICATION CALC. NO 13-MC-ZZ-643

SUBJECT STRATIFIED THERMAL ANALYSIS OF THE 2-INCH DIA. PIPE SHEET NO. 1 OF 4

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. Indi-cator |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | DOUG BERG | 11/13/92 | AMIT BHATTACHARYA | 11/13/92 | | | | | | ↓ |
| | | | | | | | | | | |

ATTACHMENT 3

LETTER ID# 281-00896-MAR/KMS

ATT-3
SHT 2 of 4

**APS**

Arizona Public Service Company
COMPANY CORRESPONDENCE

ID#: 281-00896-MAR/KMS

DATE: July 31, 1992

TO: File
Sta.#
Ext.:

FROM: M. A. Radspinner
Sta.#: 1796
Ext.: 4070

FILE: 92-055-026

SUBJECT: **CATS Item 41011, IEB 88-08 Thermal Stresses in Piping Connected to the RCS**

REFERENCE: Letter 161-04571-WFC/JMQ, dated January 15, 1992, from W.F. Conway, APS to NRC, "Response to NRC Request for Additional Information on NRC Bulletin 88-08"

The subject CATS Item identifies a commitment specified in the referenced letter to complete NED's assessment of the Unit 3 Auxiliary Pressurizer Spray System (APSS) temperature data. This data was recorded to evaluate the potential for thermal stratification in the APSS piping. The remainder of the Engineering's effort included the review of data not included in ABB-CE's spray line data reduction effort.

The data reduction performed by ABB-CE focused primarily on plant heat-up and cooldown operation. In the referenced letter to the NRC, APS concluded that the APSS piping did not exhibit thermal stratification due to inleakage as described in IE Bulletin 88-08. However, steady state top-to-bottom temperature differences of up to 115 F was observed in the piping system. This temperature difference was considered to be the result of either convective cooling, temperature bias or insulation effects. Although no evidence of cyclic stratification was observed, NED committed to evaluating the effects of the indicated delta-T values in a bounding stress analysis.

In connection with Action 2 of the subject CATS item, NED has reviewed normal operation data, to determine if contrary evidence to the conclusions drawn in the referenced letter could be identified. As shown in the attached graph, a delta-T of 90 F is present in the piping downstream of check valve V431. Similar to the heat-up and cooldown data, the fluctuation of temperatures is non-existent, whereas cyclic variations would be expected in the case of valve leakage. The data also indicates that the observed delta-T is bounded by the temperature difference to be applied in the stratification stress analysis currently in progress (Action 4 of the subject CATS Item).

Based on our review, no further APSS temperature data acquisition or reduction activities are required at this time. This memorandum completes NED's action with regard to Action 2 of CATS # 41011.

MAR/KMS/kms

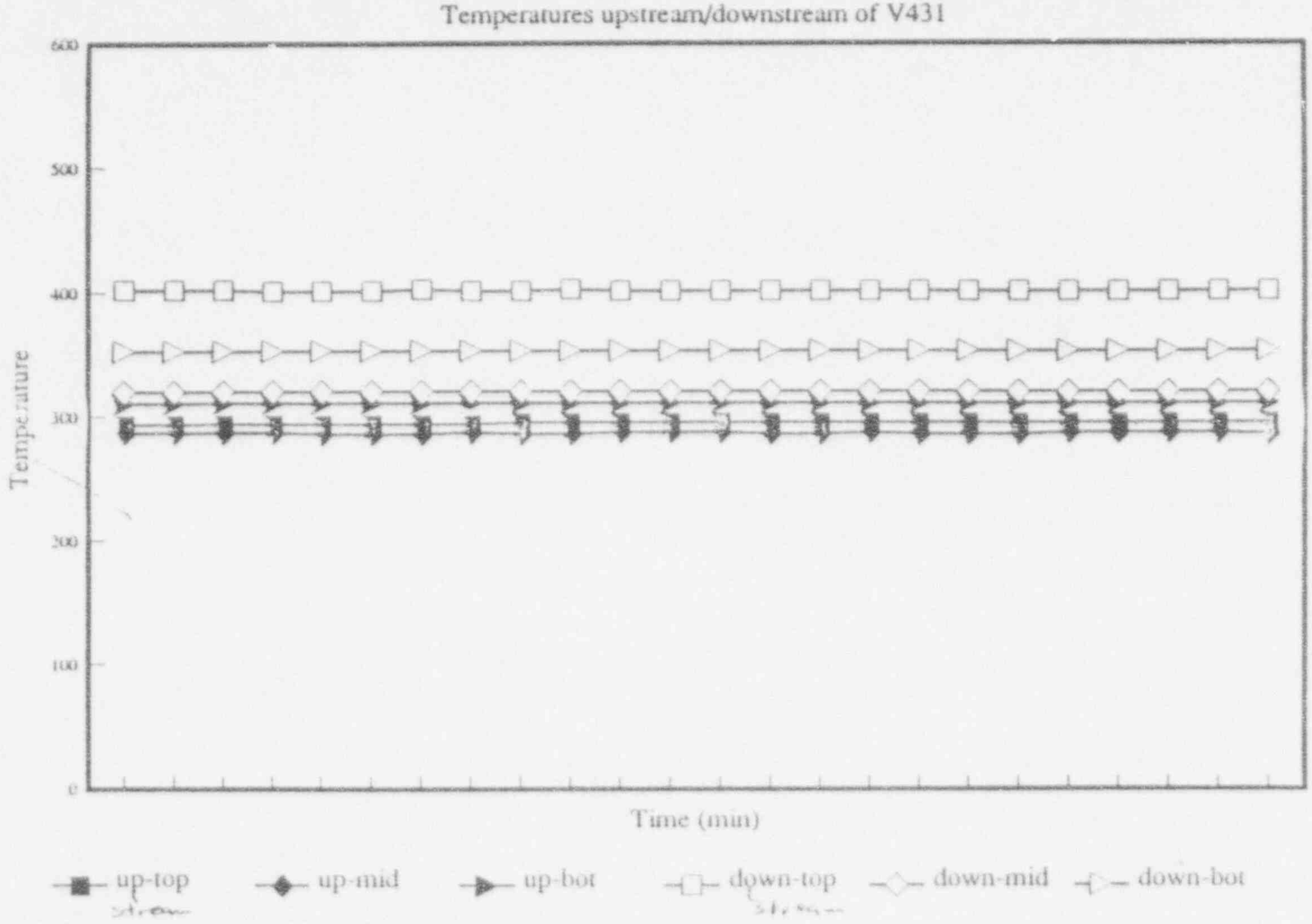
ATT-3
SHT 3 OF 4

Attachment:

cc: M. F. Hodge
H. R. Miyahara
J. R. Provasoli
M. J. Kunz
J. A. Brown
A. Amr

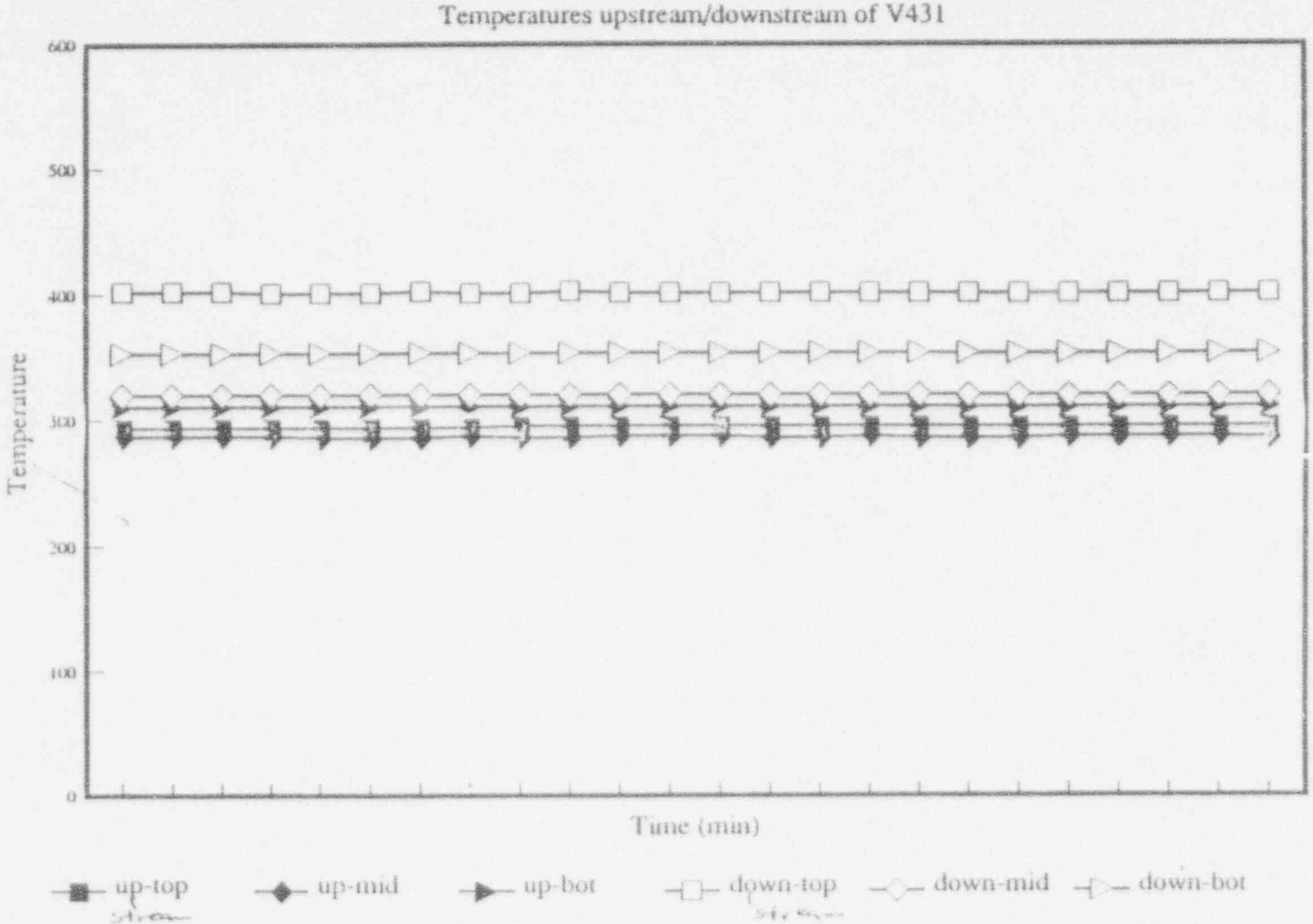
# Auxiliary Pressurizer Spray Line - Normal Operation

ATT-3
SHT 4 of 4



ATT-3
SHT 4 of 4

# Auxiliary Pressurizer Spray Line - Normal Operation



ANPP

# CALCULATION SHEET

CALC. TITLE AUXILIARY SPRAY LINE THERMAL STRATIFICATION CALC. NO 13-MC-ZZ-643

SUBJECT STRATIFIED THERMAL ANALYSIS OF THE 2-INCH DIA. PIPE SHEET NO. 1 OF 25

| REV | ORIGINATOR | DATE | CHECKER | DATE | REV | ORIGINATOR | DATE | CHECKER | DATE | Rev. Indicator |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | DOUG BERG | 11/13/92 | AMIT BHATTACHARYA | 11/13/92 | | | | | | ↓ |
| | | | | | | | | | | |

## ATTACHMENT 4

LETTER ID# 161-04571-WFC/JMQ

ATT-4
SHT 2 OF 25

Arizona Public Service Company
P.O. BOX 53999 · PHOENIX, ARIZONA 85072-3999

WILLIAM F. CONWAY
EXECUTIVE VICE PRESIDENT
NUCLEAR

161-04571-WFC/JMQ

January 15, 1992

Docket Nos. STN 50-528/529/530

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Mail Station P1-37
Washington, DC 20555

References: A) Letter dated October 18, 1991, from C. M. Thompson, NRC, to W. F. Conway, APS, "NRC Bulletin 88-08, Thermal Stresses in Piping Connected to Reactor Coolant Systems" (TAC NOS. 69664, 69665, and 69666)

B) Letter 161-01356-DBK/BJA, dated October 3, 1988, from D. B. Karner, APS, to NRC, "Response to NRC Bulletin No. 88-08"

Dear Sirs:

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2, and 3
Response to NRC Request for Additional Information on NRC Bulletin 88-08
File: 92-056-026

The purpose of this letter is to: 1) respond to the NRC request for additional information as provided in Reference A, and 2) provide an updated status of the Arizona Public Service Company (APS) response to Bulletin 88-08 as provided in Reference B.

The Reference A letter indicated that the APS response to Action 3 of NRC Bulletin 88-08 (Reference B) did not provide sufficient assurance that unisolable portions of all piping connected to the Reactor Coolant System (RCS) will not be subjected to combined cyclic and static thermal stresses together with other stresses that could cause fatigue failure during the remaining life of the unit. The letter stated that a program must be implemented to provide such assurance by means of redesign, modification, or temperature and pressure monitoring. In addition, criteria to aid in preparing an acceptable response was provided in the enclosure to Reference A. Enclosure 1 provides a PVNGS comparison with Section 4.0 "Acceptable Actions" of the evaluation criteria for responses to NRC Bulletin 88-08 Action 3.

In Reference B, APS indicated that only the Auxiliary Pressurizer Spray System (APSS) was susceptible to the phenomena described in the Bulletin (Action 1 of NRC Bulletin 88-08). APS committed, in Reference B, to the performance of Non-destructive Examination (NDE) of the affected lines of the APSS piping (Action 2 of NRC Bulletin 88-08). Reference B also stated that as part of the PVNGS long-term corrective action plan, several options were being considered. These included the following:

a. Performing additional analyses of the APSS piping to determine the piping fatigue life.

b. Replacement of the existing APSS solenoid valves with modulating valves.

c. Performance of additional temperature monitoring of the APSS lines.

d. Additional design modifications to reduce the possibility of leakage past the normally closed APSS valves.

Although these actions describe specific activities which are consistent with Action 3 of the NRC Bulletin 88-08, no commitment was provided to the NRC Staff. It should be noted that many of these proposed actions were ongoing efforts resulting from earlier work performed by APS and Bechtel in 1987 as part of APS' Pressurizer Spray System Cumulative Fatigue Life Evaluation, and are not necessarily related to the Staff's concerns regarding thermal stratification due to in-leakage. For example, the modification specified in Item (b) reduces overall APSS piping fatigue by reducing the number of thermal cycles associated with auxiliary pressurizer spray actuation. Actions completed or planned since the transmittal of Reference B are summarized below:

<u>Action 2 - NDE</u>

In each unit, the entire length of pipe from check valve V431 to the APSS inlet tee (See Figure 1) was inspected via ultrasonic examination techniques. No indication of high cycle thermal fatigue was detected.

<u>Action 3 - Monitoring, Analysis, and Modifications</u>

APS has initiated several efforts to determine the impact of thermal cycling and stratification in the APSS piping. The sequence of activities includes data acquisition, reduction and assessment. This effort is followed by a fatigue assessment to determine the impact of increased thermal stresses in the APSS piping.

Temperature Monitoring

In response to the concerns identified in NRC Bulletin 88-08, APS instituted a temperature monitoring program of the APSS piping in Unit 3. Thermocouples were installed upstream and downstream of check valve V431 and adjacent to the APSS pipe tee (See Figure 1). Temperature data was recorded in one minute intervals over the Unit 3 second operating cycle including the entire RCS heatup and cooldown as well as normal steady state operation. Due to extended outages at PVNGS in 1989 and 1990, and in an effort to obtain representative data for a complete operating cycle, data acquisition activities were not complete until April 1991.

The heatup and cooldown data was reduced, with assistance from Asea Brown Boveri-Combustion Engineering (ABB-CE), and a preliminary assessment was performed. The data revealed the presence of top-to-bottom temperature differences in the range of 60°F to 115°F (See Figures 2[1], 3[2], and 4[3]). These temperature differences occurred

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[1]Figure 2 represents temperature data taken during Reactor Coolant System (RCS) cooldown in Unit 3. The monitoring node point is at Location 8 adjacent to the Auxiliary Pressurizer Spray System (APSS) inlet tee (See Figure 1). The top-to-bottom temperature difference is approximately 65 degrees. There is no evidence of cycling due to check valve oscillation.

[2]Figure 3 represents temperature data taken during RCS heatup in Unit 3. The monitoring node point is at Location 7 downstream and adjacent to check valve V431 (See Figure 1). The maximum top-to-bottom temperature difference is approximately 105°F. There is no evidence of cycling due to check valve oscillation. As the fluid (steam) temperature cools, the delta-T decreases.

[3]Figure 4 and 4a represent temperature data taken during RCS heatup in Unit 3. The monitoring node point in Figure 4 is Location 8 adjacent to the APSS inlet tee (See Figure 1). The top-to-bottom temperature difference is approximately 60°F. In Figure 4a the same time and temperature data is depicted with the temperature profile at TC21 located upstream of check valve V431. There is no evidence of check valve cycling or valve leakage. The data also depicts auxiliary spray initiation as identified by the rapid drop in temperature representing APSS valve actuation. This type of thermal transient is specified in the Arizona Public Service Company valve actuation.

during plant heatup and cooldown with the Reactor Coolant Pumps (RCPs) secured. Under these conditions, APSS piping downstream of check valve V431 would be filled with steam from the pressurizer steam space. The data did not reflect large fluctuations in temperature which would be representative of a leaking control valve and oscillating check valve. Consequently, it is not clear from the data as to whether the observed temperature differences represent thermal stratification due to in-leakage, thermocouple bias, insulation effects or a pressurizer steam convective cooling phenomenon.

APSS temperature monitoring data from earlier PVNGS fatigue test programs were also reviewed by APS. Similar delta-T values were observed during Natural Circulation testing performed in Unit 1 in 1986 (See Figure 5)[4]. Although large temperature differences were observed between the pressurizer steam space and the auxiliary pressurizer spray flow (600°F vs. 100°F), the piping delta-T was approximately 100°F during periods of no spray flow. Additional data from a Unit 2 monitoring program during post-core hot functional testing provides comparative information (See Figure 6)[5].

The occurrence of in-leakage from the charging system should be evidenced by a much greater delta-T. In CE

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[4]Figure 5 represents temperature data taken during the Unit 1 RCS Natural Circulation testing in January 1986. Thermocouples TC5 and TC6 are located downstream of check valve V431. TC1 and TC2 are located near check valve V244 on the main spray line (See Figure 5a). Since the Reactor Coolant Pumps (RCPs) have tripped due to Loss of Offsite Power (LOP) the main and auxiliary spray lines are filled with steam from the pressurizer steam space. Auxiliary spray flow initiation and cessation is depicted by the rapid change in temperature in the APSS piping. The auxiliary spray temperature is approximately 100°F. During periods of no APSS flow a top-to-bottom temperature of 75°F exist. However, as shown in Figure 7, a much larger delta-T would be expected for a partially filled pipe. Therefore, it is concluded that in-leakage is not present and the delta-T may be due to insulation effects or convective cooling.

[5]Figure 6 represents temperature data taken during postcore hot functional testing in Unit 2. TC55 and TC57 are top and bottom thermocouples located downstream of check valve V431. TC51 and TC53 are top and bottom thermocouples located upstream of the check valve. Once again there is no evidence of leakage cycling.

NPSD-261, "Pressurizer Spray System Thermal Fatigue Evaluation" prepared for the Combustion Engineering Owners Group (CEOG), the effects of throttled auxiliary spray flow were evaluated. The reduced flow produced a steam/water stratified flow condition with a top to bottom temperature difference of 600°F (See Figure 7)[6]. Since the flow rates associated with valve leakage would also be insufficient to fill the APSS piping, the effects of in-leakage from the charging system would be expected to yield similar results. Further assessment of the existing heatup and cooldown data, as well as data reduction of normal operation data is ongoing and is expected to be completed by July 31, 1992. The results of this effort will serve as the basis for a bounding ASME Code Stress Analysis to determine the long term effects of the observed top-to-bottom temperature differences.

Continuous In-Leakage Monitoring

The evaluation criteria provided by the Staff in Reference A, states that provisions should be made to either eliminate the source of in-leakage or provide continuing assurance by a long term monitoring program. As stated previously, it is APS' position that the results from APSS monitoring programs do not clearly indicate the presence of valve in-leakage from the charging system. As a result, APS has evaluated the need for permanent temperature or pressure monitoring of the APSS piping. By review of the system design and the test results of the PVNGS Unit 3 monitoring program, APS concludes that implementation of a permanent APSS temperature or pressure monitoring system is not required.

The decision for not installing permanent resistance temperature detectors and associated computer monitoring equipment is supported by the valve component design, ASME Section XI testing and leakage detection capability via pressurizer heater usage. The APSS control valves HV-203 and HV-205 are pilot operated solenoid valves (See Figure 1). The design of the valves provides increased sealing effectiveness against in-leakage with a higher upstream pressure (See Figure 8). The temperature monitoring programs instituted by APS confirmed that leakage past

[6]Figure 7 is reprinted from Combustion Engineering Owners Group (CEOG) report CE NPSD-261 and is representative of thermal stratification in auxiliary pressurizer spray piping observed during the CE test program.

these valves is not occurring. Consequently, the potential for future leakage is dependent on valve degradation since the design application of these valves has been demonstrated. The APSS control valves and check valve V431 are operability tested as required by Technical Specification 3/4.4.3.2. Testing is required within 48 hours after entering Mode 5. Therefore, valve degradation should be detected and corrected via approved surveillance test procedures.

Additionally, testing at PVNGS has demonstrated that small leaks in either main or auxiliary spray valves have large impacts on pressurizer heater usage. For example, efforts to reduce main spray valve leakage (addition of pressure regulators, change in booster relays, different packing configuration) resulted in reductions of heater usage of 45%. As a result, valve degradation resulting in leakage from the charging system to the RCS (pressurizer) may be recognized by increases in pressurizer heater usage.

APS acknowledges that these items do not provide full and direct identification of a valve degradation. Therefore, additional programs such as valve internal inspections, leak rate testing or portable temperature monitoring will be evaluated by APS. Since selection of additional monitoring programs to provide continued assurance of APSS operability are largely dependent on knowledge of the process conditions, it is anticipated that a decision on the implementation of additional long-term surveillance activities will be completed by December 31, 1992.

Fatigue Monitoring

Since the issuance of CEOG Report CE NPSD-261, "Pressurizer Spray System Thermal Fatigue Evaluation" in December 1984, APS has been actively involved in defining the effects of thermal cycling and thermal stratification of the main and auxiliary pressurizer spray system. Continuous fatigue monitoring as well as several comprehensive transient monitoring programs have been conducted to quantify the thermal loading on the APSS piping and pressurizer spray nozzle.

Technical Specification Table 5.7-2 presents a method for tracking thermal fatigue accumulation in the pressurizer spray nozzle as it undergoes spray initiation. Therefore, every initiation of the main and auxiliary pressurizer spray is tracked and recorded. The cumulative effect of

each transient is then calculated in accordance with approved PVNGS Station Manual Procedures. To date, the fatigue cumulative usage factors for each PVNGS unit indicate that spray system thermal fatigue is accumulating at a rate faster than originally expected. Several reasons may account for the higher usage factors:

1) The number of plant heatups and cooldowns generally occur at a higher rate early in plant life due to startup and power ascension testing programs.

2) The number of auxiliary pressurizer spray actuations per plant shutdown assumed in the original design basis analysis was underestimated for actual plant operation. After an extensive monitoring program conducted in 1986, an APS study concluded that the actual number of spray actuations increased by a factor of five when compared to the design basis. Consequently, the cyclic use of auxiliary pressurizer spray was determined to be the limiting transient for the APSS piping and pressurizer spray nozzle. An APS calculation was performed in 1987 to account for the increased number of transients and assure 40-year design life for the APSS piping.

3) The PVNGS Technical Specifications require the administration of a correction factor which is applied to the auxiliary pressurizer spray flow to account for heat transfer losses in the spray fluid (See Table 5.7-2 in the PVNGS Technical Specifications). The correction factor accounts for the fact that the in-line temperature instrument (T-229) is located approximately 175 feet upstream of the APSS spray inlet to the pressurizer. This correction factor is applied to all spray transients without consideration of the existing plant situation or actual hydraulic conditions. For example, if the temperature of the spray flow is recorded at T-229 as 90°F, it would be adjusted to 30°F in accordance with the PVNGS Technical Specifications and used in the calculation of the fatigue cumulative usage factor. Consequently, the fatigue cumulative usage factor is artificially high due to this very conservative factor.

To determine the actual effects of thermal stratification and thermal cycling in the APSS piping as well as evaluate the need for physical modifications, an accurate end-of-life prediction for the APSS piping must be developed.

Accounting for the actual number and severity of APSS transients is required for the development of a more realistic fatigue cumulative usage factor. In order to accomplish this effort, APS has compared the results of the PVNGS Unit 3 APSS monitoring program with a classical heat transfer analysis to determine a more appropriate spray temperature correction factor. APS then intends to generate a Technical Specification Change to Table 5.7-2 for future logging of spray transients and calculation of the fatigue cumulative usage factor in accordance with the Reactor Coolant System Transient and Operational Cycles Station Manual Procedure. APS will submit the Technical Specification Amendment and supporting documentation by October 23, 1992. Subsequently, the new temperature adjustment factor will be applied to all the recorded APSS spray transients and a revised fatigue cumulative usage factor will be calculated. This information will serve as a fatigue analysis baseline for combining the effects of thermal stratification and developing a 40-year usage factor prediction.

Fatigue Analysis

APS intends to use the results of the Unit 3 monitoring program as well as the results of earlier data acquisition programs to redefine the transients associated with the APSS piping. The redefined transients will be incorporated into a revised ASME Code stress analysis to determine the acceptability of the piping for the 40-year plant life. Since the preliminary temperature monitoring results do not clearly indicate the presence of in-leakage thermal stratification, additional monitoring at PVNGS or research in conjunction with generic efforts at the CEOG or Electric Power Research Institute (EPRI) may be required to define the process parameters. A determination of the hydraulic conditions (i.e., water/steam, water/water, convective steam cooling) is required for calculating the bending moment in the pipe due to a stratified flow condition. However, a bounding thermal stratification analysis assuming worst case bending moments associated with the top-to-bottom temperature differences observed in the Unit 3 monitoring program and an assumed hydraulic condition will be developed by APS to serve as a baseline in determining the need for future corrective actions. This analysis will be completed by October 30, 1992.

ATT-4
SHT 10 OF 25



Application of New Screening Criteria

A number of additional concerns has been identified by the nuclear industry which further complicate the screening criteria that was provided in the Attachment to Reference B, and suggest that further evaluation of piping systems connected to the RCS be conducted. Specifically, the issues of turbulent penetration, natural convection in both unisolable and isolable piping, and thermal striping have been identified as possible contributors to thermal gradient effects. To address these issues, APS is developing an additional evaluation that parallels the research work of the Westinghouse/EPRI Thermal Stratification, Cycling and Striping (TASCS) Program. The TASCS research is aimed at developing further screening criteria to address the phenomena stated above. Additionally, APS is considering participation in the CEOG generic monitoring and evaluation program which deals with ABB-CE's investigation into the same phenomena in response to the concerns specified in NRC Bulletin 88-08. Data collected by ABB-CE in support of the generic effort may serve as a basis for PVNGS due to plant similarities. Systems identified as susceptible to thermal stratification by the new screening criteria will be included in the APS evaluation program and the associated thermal stresses will be considered.

Summary

APS has instituted a program of temperature and fatigue monitoring for the APSS piping identified as susceptible to in-leakage thermal stratification as defined in NRC Bulletin 88-08. The APS program is comparable with the evaluation criteria submitted by the Staff in Reference A. Specific similarities and differences with the staff provided evaluation criteria are identified in Enclosure 1. Although top-to-bottom temperatures in excess of 50°F have been detected, it is APS' position that additional research is required to determine the cause of the observed delta-T values. The bounding thermal stratification analysis to be performed by APS, will determine the long term effects of the top-to-bottom temperature differences observed in the PVNGS monitoring program. Since the Staff recommended modifications (i.e., additional block valves, reduction in upstream pressure source or check valve relocation) would not resolve a steam convective cooling phenomenon, no physical or operational modifications are planned at this time. APS is continuing to define the transients associated with the APSS piping to assure the cumulative fatigue usage factor meets ASME Code criteria for 40-year plant life. Any new transients will be factored into the PVNGS fatigue monitoring program for the pressurizer spray system.

ATT-4
SHT 11 OF 25



A summary of the actions items to be completed by APS are summarized as follows:

| TASK | ACTION | DATE |
|---|---|---|
| Temperature Monitoring | Complete assessment of Unit 3 monitoring data | July 31, 1992 |
| Continuous In-Leakage Monitoring | Evaluate need for additional long-term surveillance activities | December 31, 1992 |
| Fatigue Monitoring | Submit Technical Specification Change to Table 5.7-2 | October 23, 1992 |
| Fatigue Analysis | Bounding thermal stratification stress analysis | October 30, 1992 |

If you should have any questions, please contact Michael E. Powell of my staff at (602) 340-4981.

Sincerely,

WFConway

WFC/JMQ/jmq

Enclosure
Figures 1-7

cc: J. B. Martin
D. H. Coe
A. C. Gehr
A. H. Gutterman
C. M. Trammell

ENCLOSURE 1
PALO VERDE NUCLEAR GENERATING STATION (PVNGS) COMPARISON WITH EVALUATION CRITERIA FOR RESPONSES TO NRC BULLETIN 88-08 ACTION 3

4.0 ACCEPTABLE ACTIONS

(1) The Auxiliary Pressurizer Spray System (APSS) is a safety grade system required for pressurizer pressure control during a Reactor Coolant System (RCS) Natural Circulation. Therefore, redesign of the system to reduce the upstream charging system pressure is not considered feasible. Additionally, reduction in upstream pressure will not correct a convective cooling phenomenon.

(2) This corrective action is not applicable to the in-leakage concerns associated with the APSS. This modification corrects the conditions identified in Supplement 3 of NRC Bulletin 88-08.

(3) Arizona Public Service (APS) has installed temperature monitoring instrumentation for detection of piping thermal cycling due to valve leakage.

A. Type and location of sensors.

a. Temperature sensors are thermocouples. For monitoring APSS piping temperature differences, the thermocouples are considered to be sufficiently accurate. During a pressurizer spray line monitoring program conducted in 1986-1987, thermocouple accuracy was compared to a temporary in-line Resistance Temperature Detector (RTD). The thermocouple results were considered to be accurate for depiction of the fluid conditions. The remaining evaluation of the NRC criteria specifies thermocouples in lieu of RTD.

b. The thermocouples should be located between the first elbow (elbow closest to the Reactor Coolant System (RCS)), and the first check valve (check valve closest to the RCS). This corrective action is not applicable to the in-leakage concerns associated with the APSS. This is a Supplement 3 requirement concerned with outleakage and the effects of turbulent penetration.

c. The thermocouples are installed 12 inches from the Auxiliary Pressurizer Spray System (APSS) 'tee' connection. (See Figure 1).

d. The thermocouples are located within 7 - 10 inches of the welds.

e. At each pipe cross section, one thermocouple is positioned on the top of the pipe, on the bottom of the pipe and midway between the top and the bottom on the exterior of the pipe.

B. Determination of baseline temperature histories.

Temperature data was recorded in one minute intervals during the Unit 3 second operating cycle including RCS heatup, cooldown and normal operation.

a. The maximum top-to-bottom temperature difference was 115°F, which exceeded 50°F.

b. The top and bottom temperature time histories were in-phase.

c. Peak-to-peak temperature fluctuations did not exceed 60°F.

C. Monitoring time intervals.

a. Monitoring was performed at the following times:

1. RCS heatup and cooldown.

2. Normal Operation during Unit 3 Cycle 2. APS is not conducting further temperature monitoring at six-month intervals. Several options to a permanent monitoring system are being considered by APS. Additional test monitoring at PVNGS or participation in the Combustion Engineering Owners Group (CEOG) Generic Program will be evaluated based on completion of fatigue assessment.

b. Temperature data was recorded in one minute intervals during the entire RCS heatup and cooldown and extended periods during normal operation.

D. Exceedance Criteria.

Actions should be taken to modify piping sections or to correct valve leakage if the following conditions occur:

a. The maximum temperature difference between the top and bottom of the pipe exceeds 50°F. However the data is not indicative of valve leakage. Additional evaluations are required to ascertain thermal hydraulic conditions.

b. Top and bottom temperature histories are in-phase and the peak-to-peak fluctuations of the top or bottom temperatures do not exceed 60°F. Therefore, this is not a concern.

c. Top and bottom temperature histories are not out-of-phase and the bottom peak-to-peak temperature fluctuations do not exceed 50°F. Therefore, this is not a concern.

d. Temperature data reflected earlier baseline information and, therefore, system degradation is not a concern.

(4) APS agrees that the use of pressure monitors is not the preferred method of determining in-leakage, and therefore, pressure monitors were not considered for implementation at PVNGS.

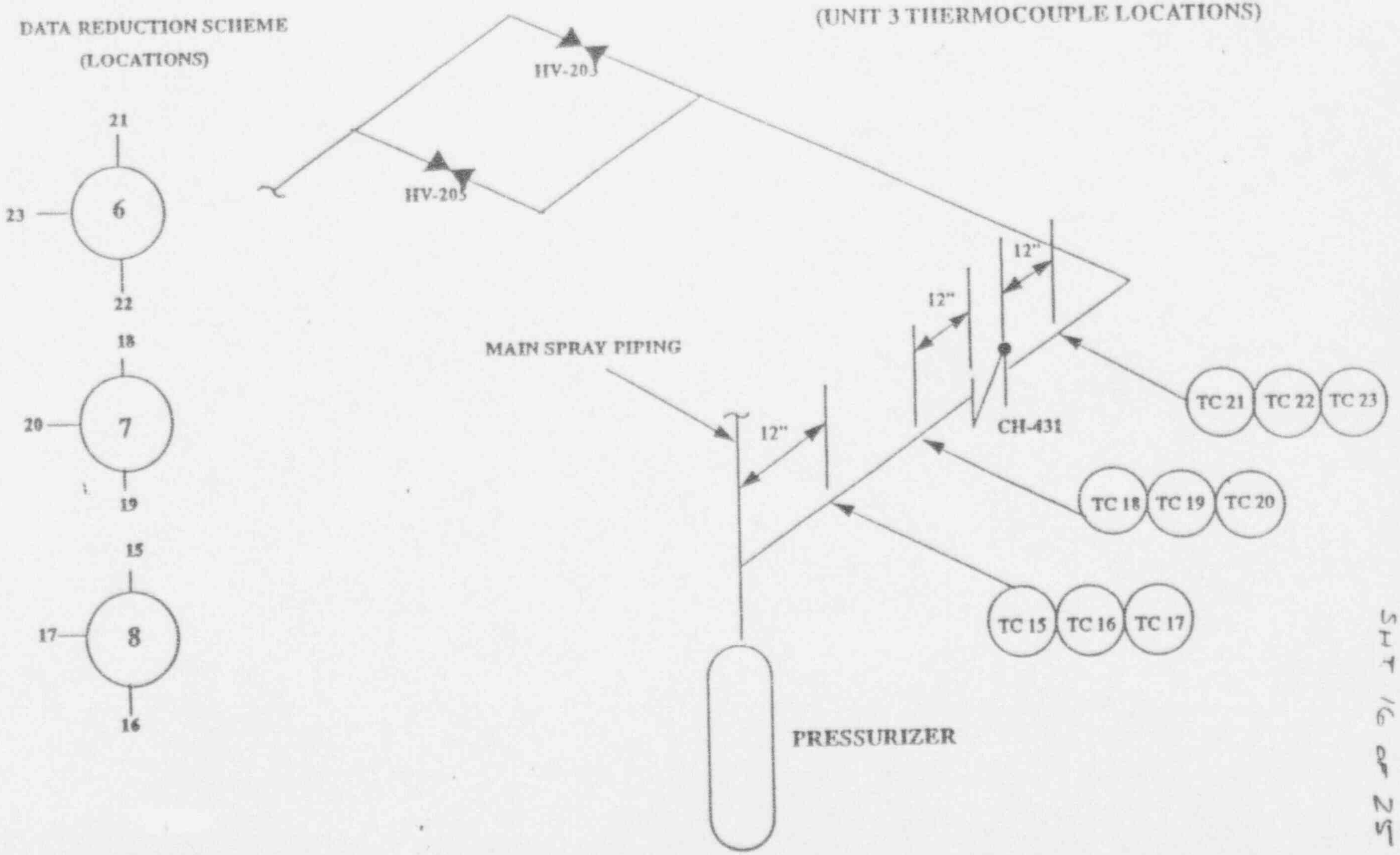
ATT-4
SHT 15 OF 25

| | | |
|---|---|---|
| bcc: | J. N. Bailey | (1966) |
| | E. C. Simpson | (1962) |
| | R. J. Stevens | (1502) |
| | M. E. Powell | (1515) |
| | J. R. Provasoli | (1515) |
| | J. A. Bailey | (1875) |
| | M. F. Hodge | (1796) |
| | M. A. Radspinner | (1796) |
| | K. M. Sweeney | (1796) |
| | J. W. Fisher | (1702) |
| | H. R. Miyahara | (1702) |
| | J. S. Summy | (6004) |
| | M. J. Winsor | (6002) |
| | M. A. Friedlander | (6099) |
| | D. B. Hansen | (6086) |
| | R. W. Page | (1938) |
| | Source Document Library | (6715) |

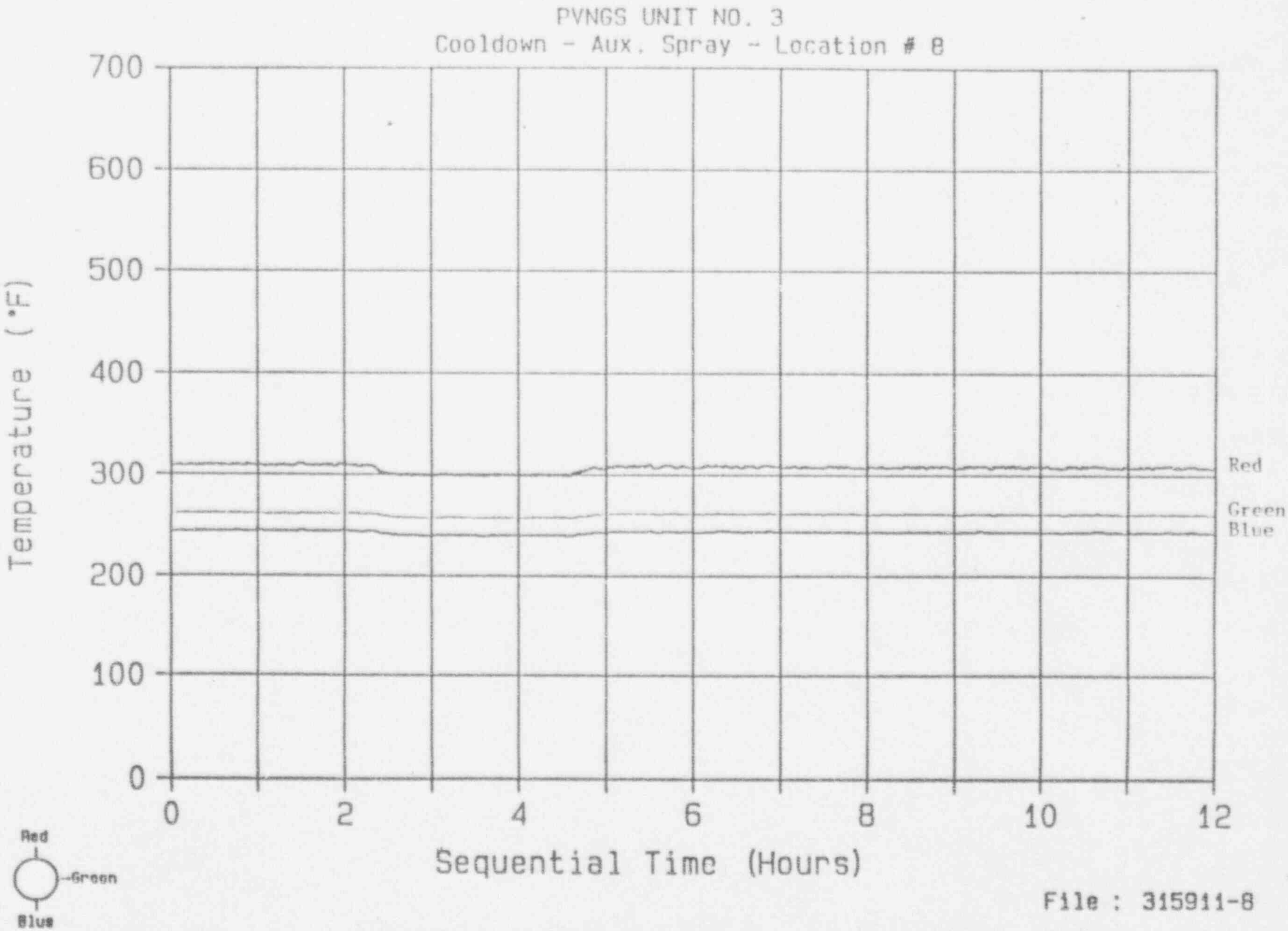
FIGURE 1

PVNGS 88-08 TEMPERATURE MONITORING PROGRAM

(UNIT 3 THERMOCOUPLE LOCATIONS)




ATT-4
SHT 16 of 25




ATT-4
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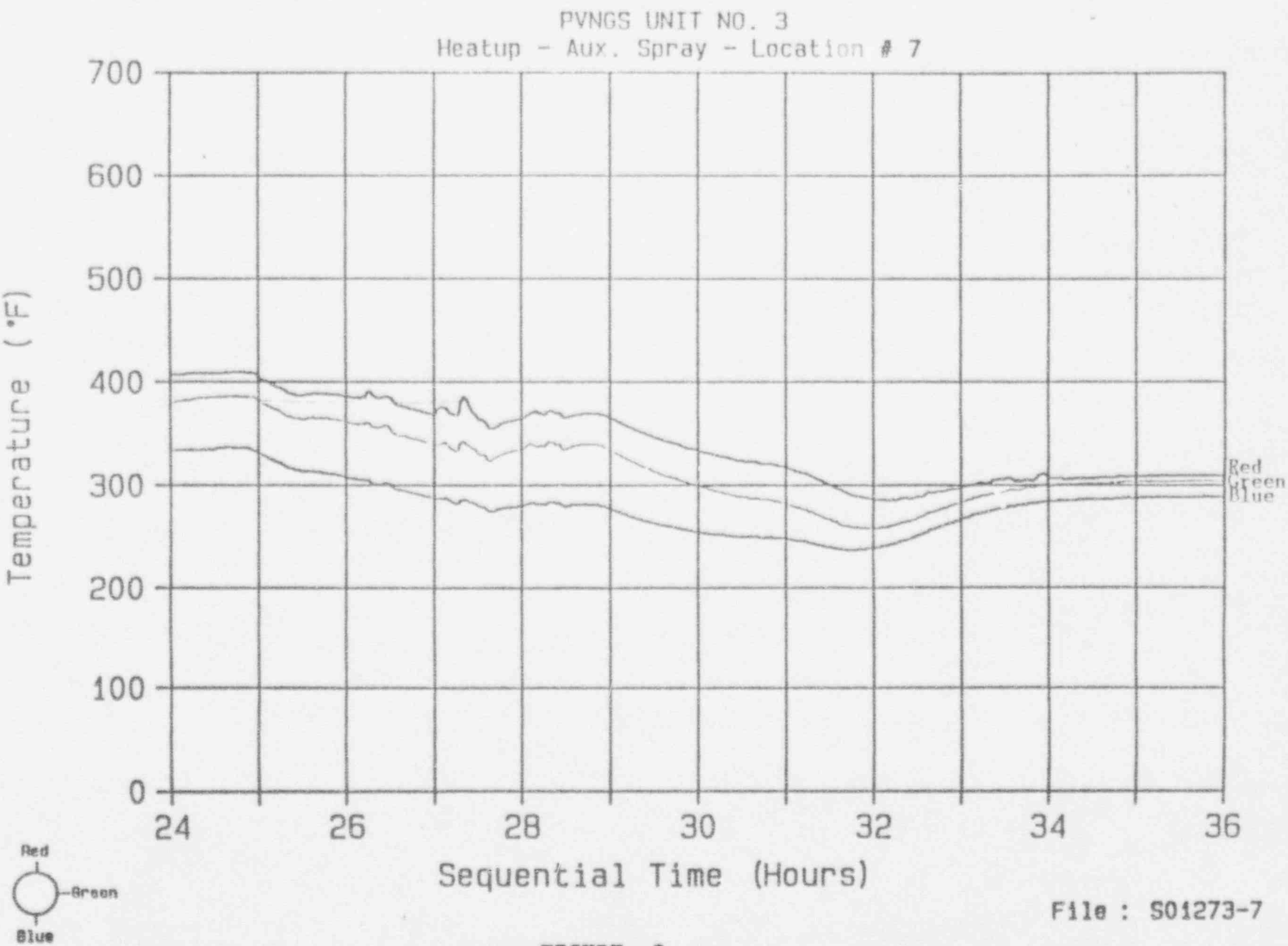
**FIGURE 2**




File : S01273-7

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**FIGURE 3**


File : S11229-8

FIGURE 4

PVNGS UNIT NO. 3
Heatup - Aux. Spray - Locations 6 & 8

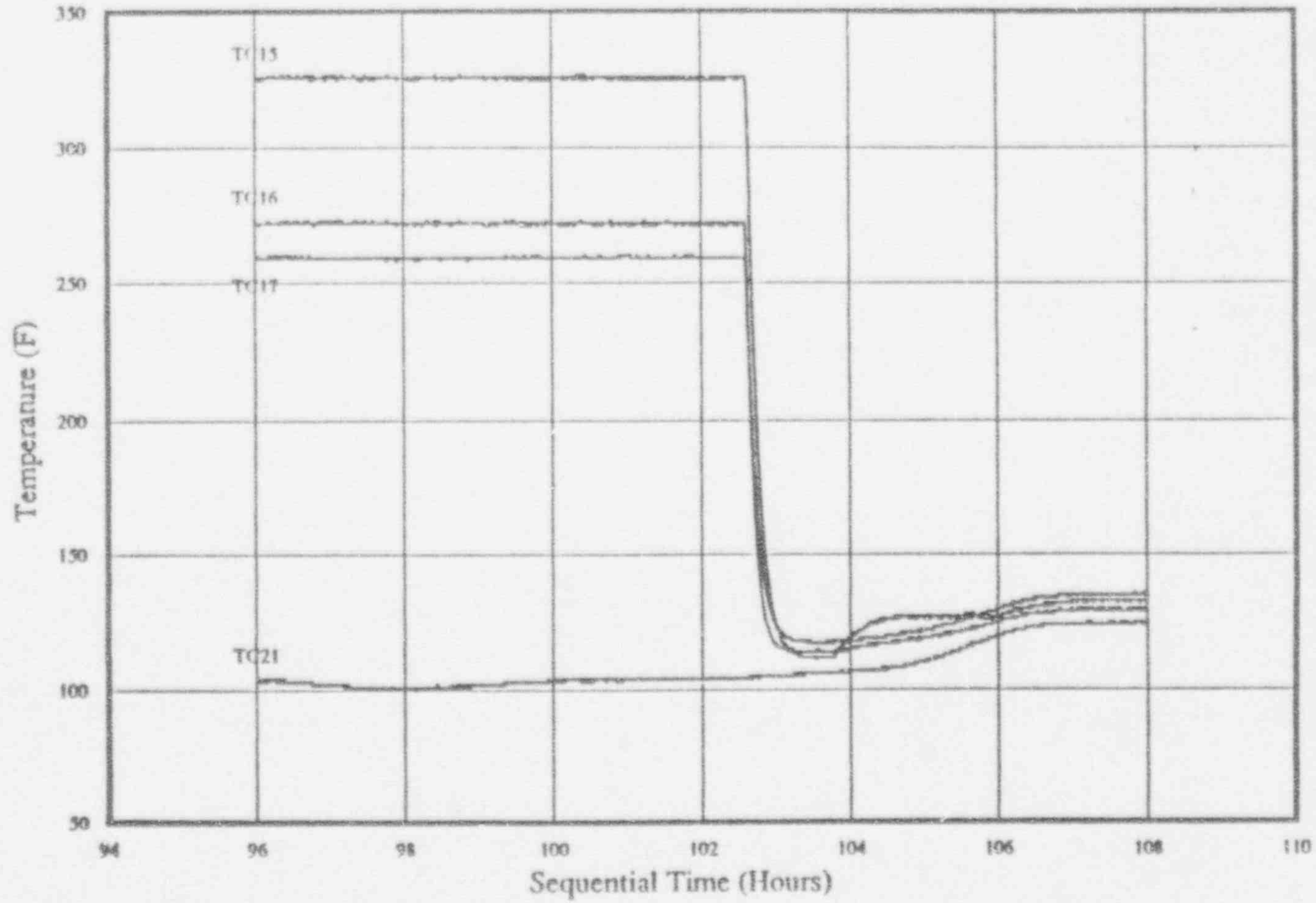


FIGURE 4a

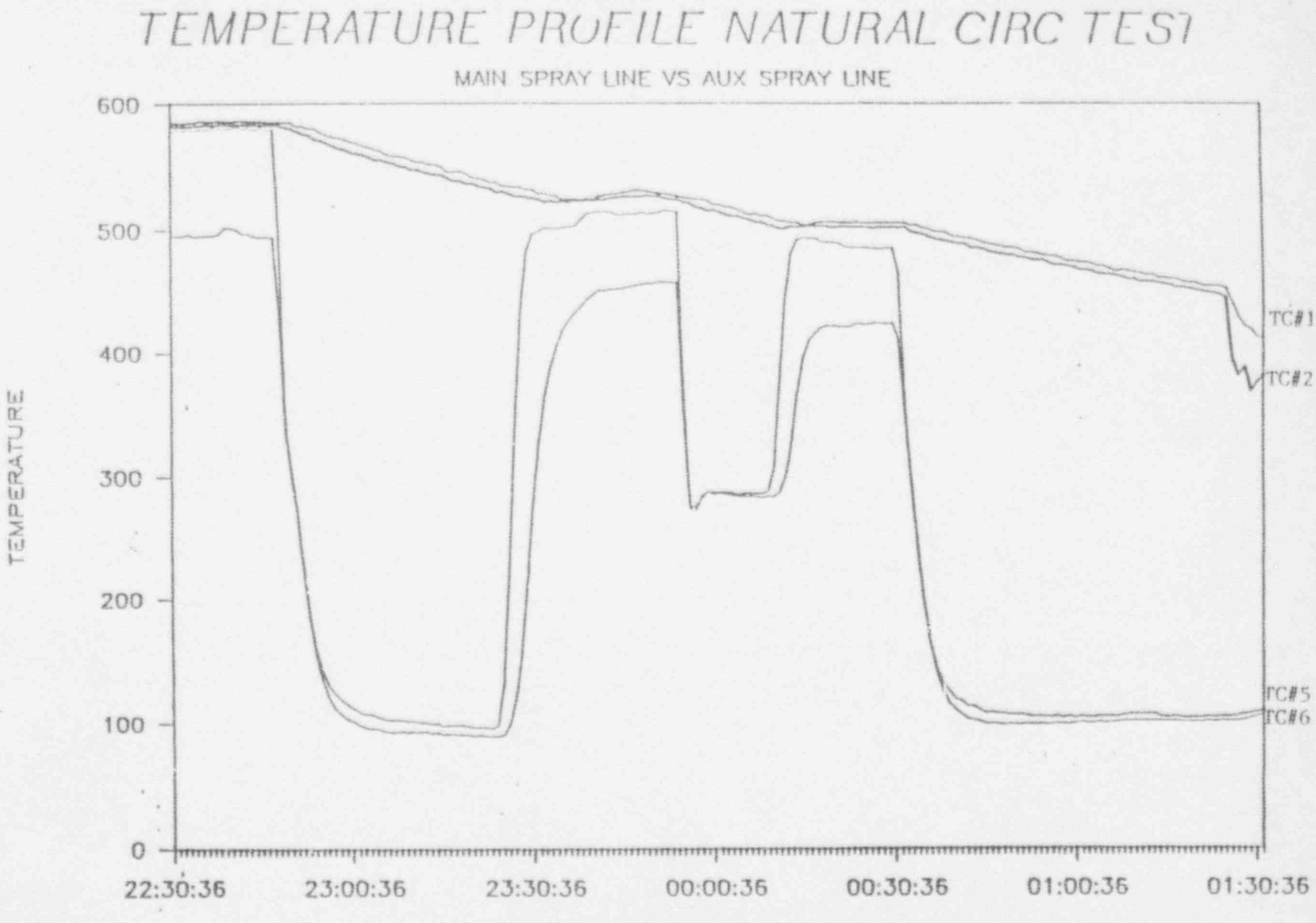


FIGURE 5

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# THERMOCOUPLE LOCATIONS

## UNIT 1 NATURAL CIRCULATION TEST

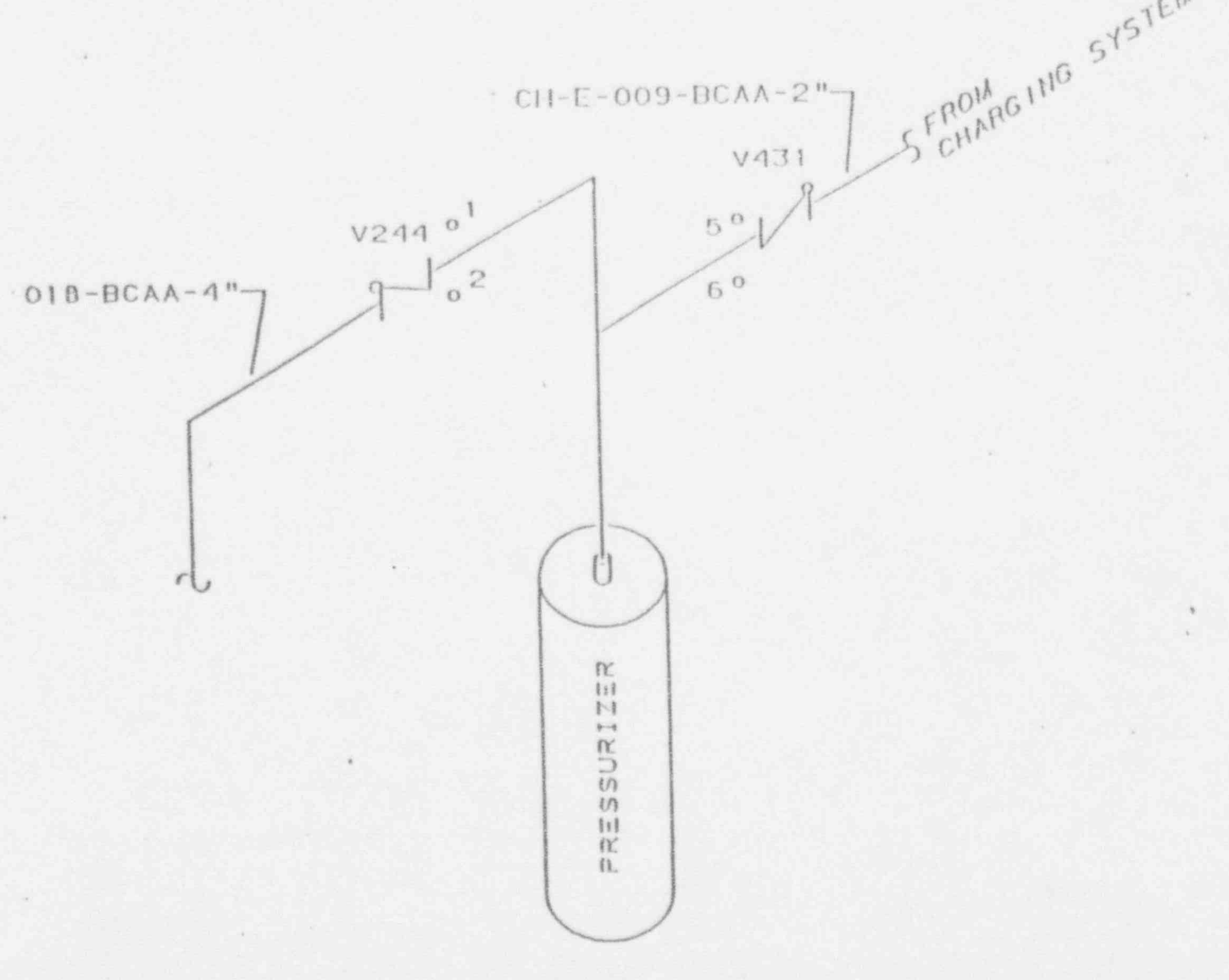


FIGURE 5a

# STRATIFIED FLOW IN AUXILIARY SPRAY LINE

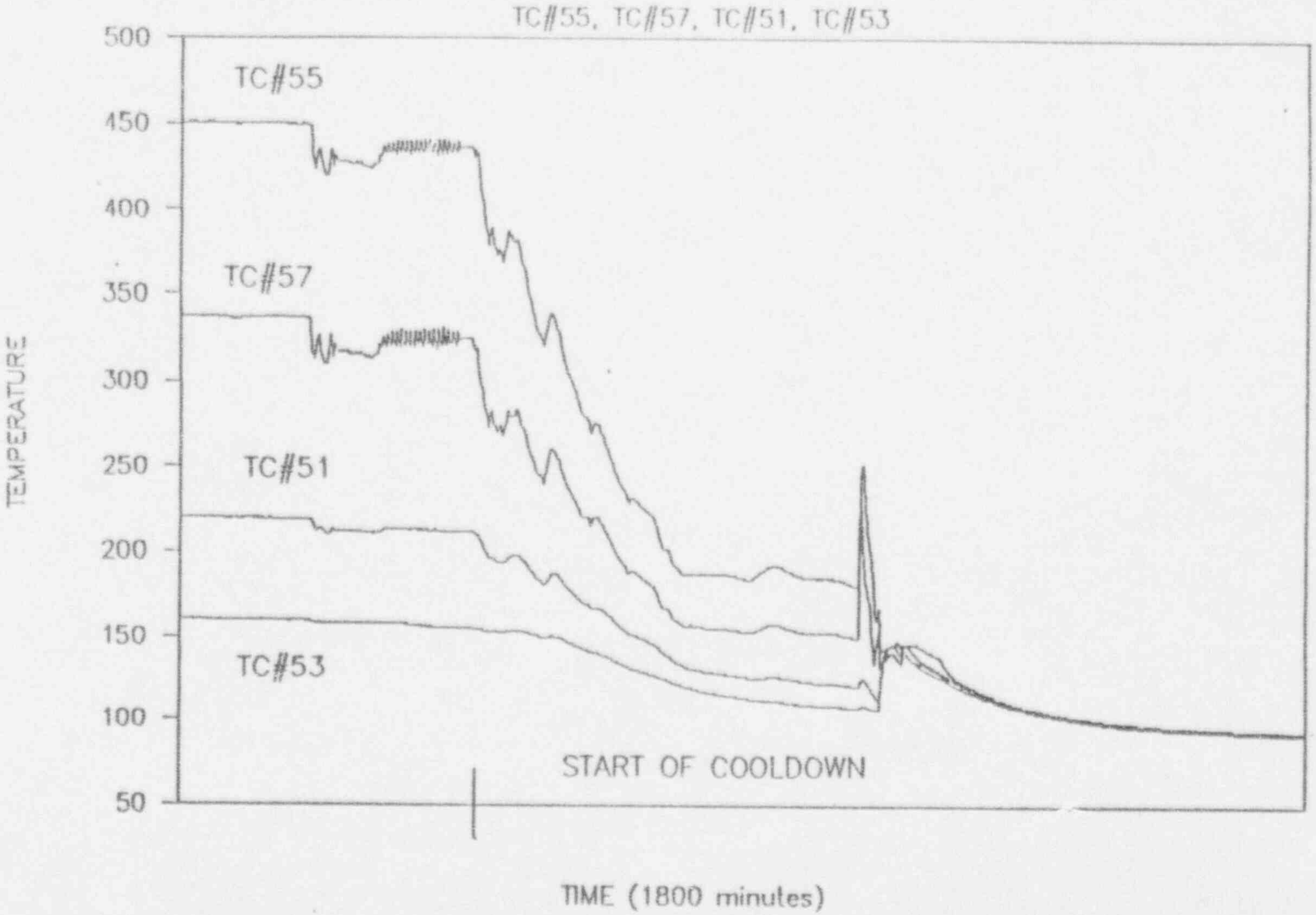


FIGURE 6

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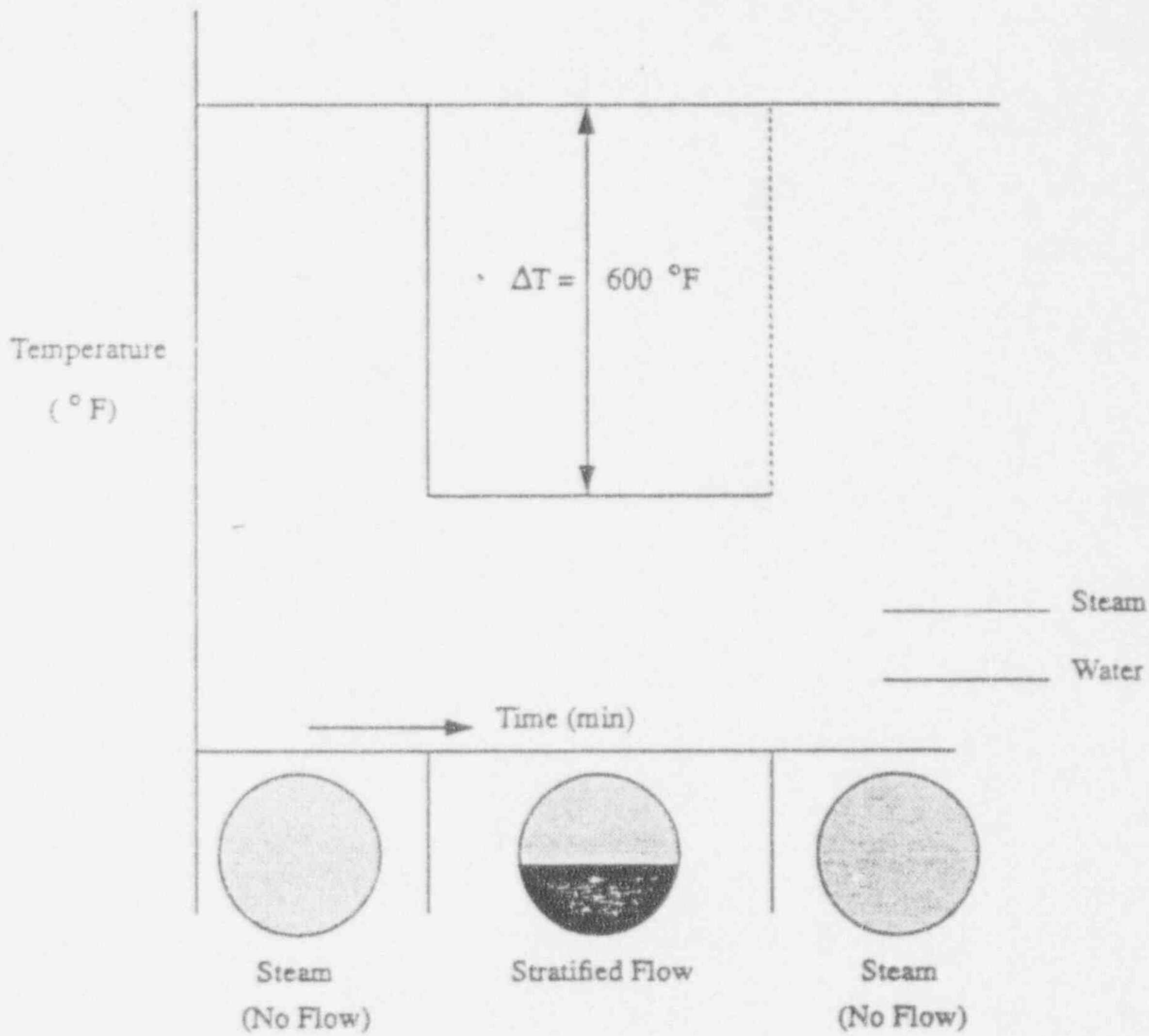
## SPRAY LINE TRANSIENT
## STRATIFIED FLOW AT ΔT=600 °F




PLANT OPERATION CAUSING TRANSIENT

1) Plant Cooldown

A) Throttling of Auxiliary Spray during Natural Circulation

FIGURE 7

Reprinted from CE NPSD-261

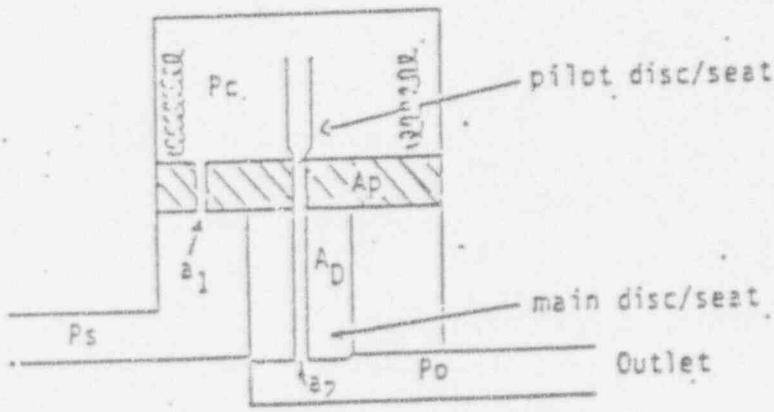
# CLOSURE FORCES OF PILOT OPERATED SOLENOID VALVE

The closure forces on a pilot operated solenoid valves in ASME Paper, Spurious Opening of Hydraulic Assisted, Pilot-Operated Valves - An Investigation of the Phenomenon. The forces acting on the valve are described as follows:

$$P_c A_p + F_o + K_x + M\, d^2x/dt^2 - D\, dx/dt$$

where $F_o$ = spring preload
$K_x$ = spring force
M = mass
D = drag
$A_p$ = area of main piston

When the solenoid coil is de-energized during closing, the spring force seats the pilot disc, closing the pilot orifice. Upstream pressure (Ps) enters the chamber through the supply orifice. This pressure force (Pc) combined with spring force moves the main disc to the closed position.




a1 = supply orifice
a2 = pilot orifice

FIGURE 8