EVALUATION OF THERMAL STRATIFICATION EFFECTS

ON THE

SHUTDOWN COOLING LINE

FOR

ARKANSAS NUCLEAR ONE, UNIT 2

AUGUST, 1993

Prepared by

ABB Combustion Engineering Nuclear Services
Windsor, CT

ABB Combustion Engineering Report No. A-MECH-ER-009, Rev. 00

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FAX REQUEST

SENT TO: BARRY LUBIN

COMPANY: ABB/CE

DATE: 5/6/93

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FROM: JOHN MARTIN

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NUMBER OF PAGES INCLUDING COVER SHEET: 10

COMMENTS/REPLY:

ORIGINALS WILL BE FED-EX'D TONIGHT

1.0 INTRODUCTION

ANO2 informed ABB-CE Nuclear Services that top-to-bottom wall temperature differences of 345°F were being recorded at Location 1 during the current mid-cycle cooldown of ANO2 (see Figures 1 and 2).

Based on a request by ANO2, an evaluation of the effect of this stratification on the stresses and fatigue life of the SDC line was performed. The objective of this evaluation was to support a return to power of ANO2 from this mid-cycle outage (2R9) and operation at least until the next scheduled outage in mid-1994 (2R10).

This request focused in three specific areas:

1. Identification of regions for subsequent NDE examinations and justification for the need for such examinations before the next scheduled outage.

2. Identification and justification for additional thermocouple placements to obtain further data on the magnitude and distribution of the top-to-bottom wall temperature differences.

3. Evaluation of the stress levels and fatigue usage due to the recorded temperature differences.

The proposed program (Reference) included two Tasks:

Task 1 Preliminary Evaluation: a letter report supporting return to power, with reliance on current NDE and thermocouple data. This letter report was based on an engineering-assured, preliminary stress and fatigue evaluation. (A copy of the letter report is included as Appendix A.)

Task 2 Final Evaluation: this report, which was generated to formally document the Quality Assured analyses that were performed and the conclusions that were reached.

2.0 PROGRAM

The objective of the program was to support the return to power. This can be achieved by demonstrating that stress levels are acceptable and that the fatigue life of the line has not been significantly shortened by the presence of stratification.

Examination for evidence of cracks (NDE), and placement of additional thermocouples are both related to the evaluation of stress and fatigue. NDE is necessary at locations of high stress and/or high fatigue and the distribution and magnitude of wall temperature influences the location and magnitude of the stresses.

The fatigue usage factor is a function of the magnitude of the stresses and the number of stress cycles the line has experienced, both since the entering initial service and since the last NDE of the SDC line in outage 2R8. The value of usage factor will indicate the design margin remaining in the line, and the rate at which fatigue damage is being accumulated. With a small increase in usage factor since the last NDE, it is reasonable to assume that significant damage to the line will not occur before the next scheduled outage.

The evaluation is based on the maximum temperature difference of 350°F and assumes that the entire horizontal portion of the line from Elbow B to Elbow F (see Figure 1) experiences the maximum temperature difference.

2.1 THERMAL STRESS ANALYSIS

The thermal stress analysis is documented in the recorded calculation in Appendix B. Forces, moments, support loads, displacements and stresses for the stratified conditions were calculated using the SUPERPIPE computer code, based on the following set of assumptions:

1. Tributary lines of .50",1.0" and 3" were ignored.

2. The model was terminated at the first elbow beyond support H15.

3. Spring hangers were assumed not to have reached their travel limits.

4. Line temperatures were assumed, as follows:

   Case a: Stratified Flow

   A-B 560°F, Uniform
   B-F 560°F Top, 210°F Bottom
   F-G 80°F, Uniform

   Case b: Uniform Expansion

   A-G 500°F Uniform

The uniform expansion case was included as a possible enveloping case for other thermal loading conditions which may have been part of the original design basis.

5. The influence of thermal stratification can be included using the results for line rotation extrapolated from the ANO2 surge line analysis.

The temperature distribution assumed in the analysis is based on measurements taken at ANO2 (e.g. Figure 2). For the shutdown cooling line, being closed at the valve, the variation in top to bottom difference in wall temperature is due to changes in secondary flows ("turbulent penetration") in the lines. Preliminary indications are that the fluid is thermally stratified without the presence of any interface; region of rapid changes in the temperature distribution of the fluid. This differs from the surge line in which changes in operating conditions results in the propagation of fluid relative to a stationary layer. Based on the absence of this hot to cold fluid interface variations in fluid and thus wall temperatures at the interface location ("striping") has been neglected.

The thermal stress analysis determined that the highest stressed location for the stratified conditions was the first elbow directly below the Hot Leg (Figure 1: Elbow B); this determination was based upon the relative ranking provided by the SUPERPIPE computer code.

2.2 STRESS AND FATIGUE EVALUATION

The stress and fatigue evaluation is documented in the recorded calculation in Appendix C. The evaluation calculated stress ranges which resulted from the thermally stratified conditions in conjunction with the two design basis transients which contributed most significantly to the usage factor of the elbow. These stress ranges were then compared to ASME Code allowable and it was determined that the ranges were within the limits provided by the Code. Additionally, a fatigue usage factor of 0.073 was calculated for Elbow B. This number is the sum of two values: 1) 0.044, the design basis usage factor for the location and 2) 0.029, which accounts for 350°ΔT thermal stratification in the SDC Line during 68 Heatup-Cooldown cycles and an estimated 436 Power Reduction, Reactor trip, and Loss of Coolant Flow transients.

A fatigue usage factor of 0.113 was calculated for the stress-limiting elbow for an additional 10 Heatup-Cooldown cycles and 1000 additional Power Reduction, Reactor trip, and Loss of Coolant Flow transients.

It was noted in the fatigue analysis that the stress-limiting location did not have the highest usage factor for the entire SDC Line. The location on the Line with the highest usage factor (0.398) was evaluated for the effects of the additional cycles. It was determined that the usage factor for this location would become 0.467 (by applying the increase in fatigue for the stress-limiting elbow to this location). Thus, for either the stress-limiting location or the fatigue-limiting location, the resulting usage factor is well below the ASME Code limit of 1.0.

This analysis has been completed based on the largest variation in wall temperature observed to date being less than 350°F. The maximum temperature difference possible in the first horizontal run is directly proportional to the Hot Leg temperature (-565°F) less the ambient temperature in the first horizontal run (-150°F is the lower temperature observed at the bottom thermocouple). While it is possible that a larger ΔT could be experienced, it is not expected to have significant effect on the total usage factor and thus the number of additional cycles. This is based on the low usage factor observed to date (and near future) and due to significant conservatism used in this analysis (i.e., using rigid support stiffness, maximum ΔT used for even minor power reductions, SDC first horizontal run considered stratified the entire length, etc.).

Both the thermal stress analysis and the stress and fatigue evaluation were performed according to Section III of the 1986 ASME Boiler and Pressure Vessel Code. The use of the 1986 Code is based on the recommendation in NRC Bulletin 88-11 on Pressurizer Surge Line Thermal Stratification to use the latest ASME Section III requirements for high cycle fatigue. The use of the 1986 Code is consistent with the analyses submitted to the NRC as part of the response to NRCB 88-11 on "Pressurizer Surge Line Flow Stratification Evaluation " (CEN-NPSD 546-P,Rev 1-P) by the Combustion Engineering Owners Group.

3.0 CONCLUSIONS

Design Analyses were completed that evaluated the effect of top-to-bottom wall temperature differences of 345°F on the SDC line recorded May 4, 1993 during the reduction in power for the 2P-93-1 mid-cycle outage. These analyses support the conclusions that:

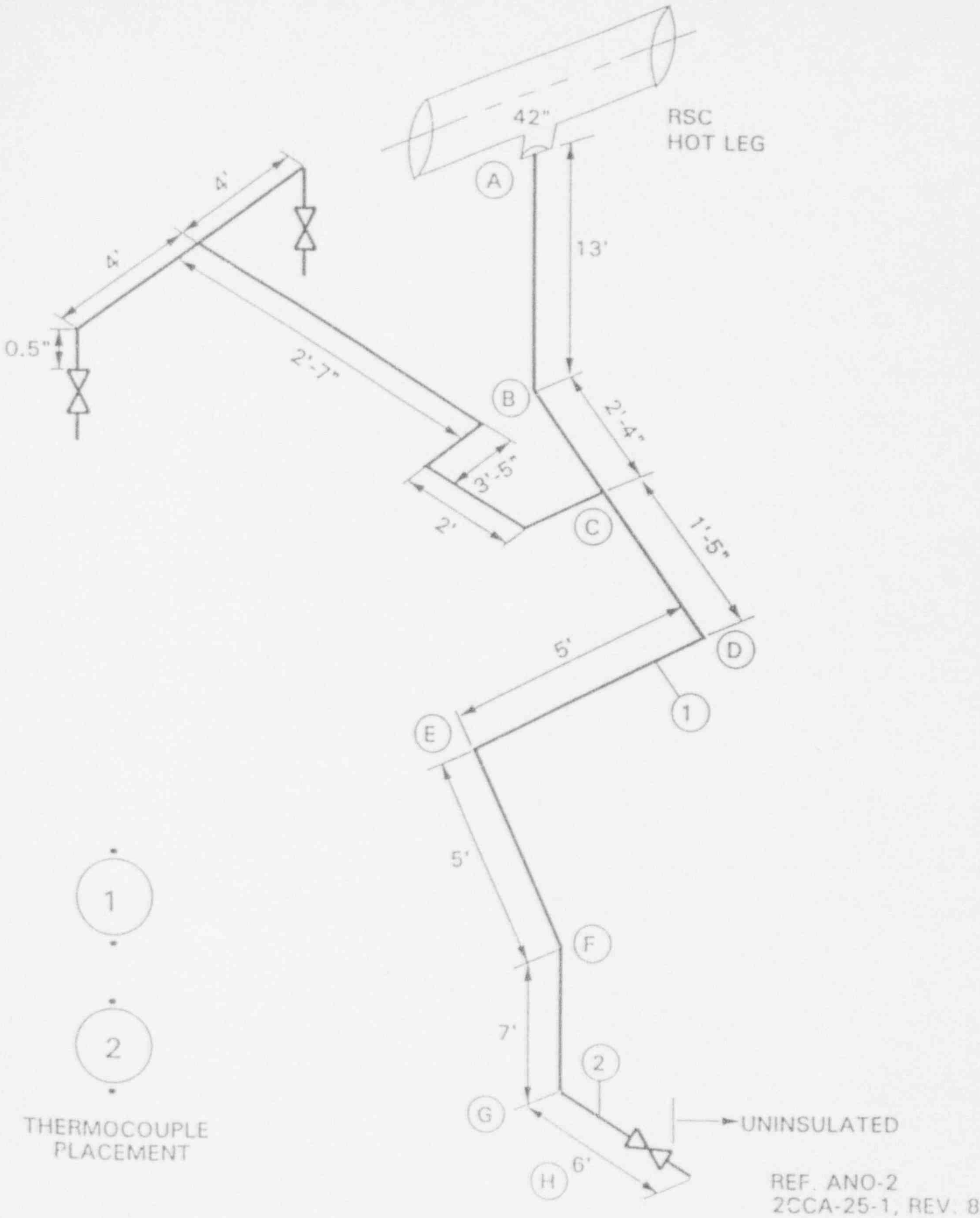
1. Based on the 1986 ASME Code, the accumulated fatigue usage factor is below the Code limit of 1.0. Furthermore, the anticipated number of additional thermal cycles will not increase the total usage factor above the ASME Code limit of 1.0.

2. The highest stress levels due to thermal stratification are calculated in the elbows closest to the hot leg which were subject to NDE during the 2R8 outage. The increase in fatigue life usage will not exceed the ASME limit for a limited number of additional thermal cycles. Thus, the present NDE results can be used as evidence of the present status of these components and the SDC line should not require additional NDE prior to a Return to Power.

3. The addition of more thermocouples to the SDC line prior to the 2R10 outage is not necessary. Additional thermocouples would provide information on the extent of stratification within the line and would allow a refinement of the stress analysis, leading to a possible reduction in calculated stress levels. However, based on the present conservative assumptions, the fatigue usage factor is sufficiently low that additional margin would not be needed for a significant number of additional thermal cycles.

4.0 REFERENCE

C-E Proposal No. 93-241-63A, "Evaluation of Thermal Stratification Effects in the Shutdown Cooling Line on Return to Power of Arkansas Nuclear One-Unit 2," dated May, 1993.



SDC LINE MEASUREMENT LOCATIONS - ANO-2

FIGURE 1


ANO Shutdown Cooling Transient
TOP
BOTTOM
Temperature (F)
Elapsed Time (minutes)
100
200
300
400
500
600
0
500
1000
1500
2000
2500
3000

FIGURE 2

APPENDIX A

to

ABB-CE Report No. A-MECH-ER-009, Rev.00

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May 11, 1993
A-MECH-93-012

Mr. Rick Lane, Manager
Mechanical, Civil and Structural Design
Entergy Operations, Inc.
Route 3, Box 137G
Russellville, AR 72801

SUBJECT: Return to Power of Arkansas Nuclear One-Unit 2 from Outage 2P-93-1

Dear Mr. Lane:

Attached is a report provided by ABB-Combustion Engineering summarizing the effort to-date in support of the Return to Power and operation from outage 2P-93-1, of Arkansas Nuclear One-Unit 2. The work represents the preliminary evaluation of the stress and fatigue life in the Shutdown Cooling line following the recording of top-to-bottom differences of wall temperatures of up to 345°F during cooldown.

This work supports the following conclusions:

1. Based on the 1986 ASME Code the accumulated fatigue usage factor is below the Code limit of 1.0. Furthermore, a number of additional thermal cycles will not increase the total usage factor above the ASME Code limit of 1.0.

2. The highest stress levels due to thermal stratification are calculated in the elbows closest to the hot leg which were subject to NDE during the 2R8 outage. The increase in fatigue life usage will not exceed the ASME limit for a limited number of additional thermal cycles. Thus, the present NDE results can be used as evidence of the present status of these components and the SDC line should not require additional NDE prior to a Return to Power.

3. The addition of more thermocouples to the SDC line prior to the 2R10 outage is not necessary. Additional thermocouples would provide information on the extent of stratification within the line and would allow a refinement of the stress analysis, leading to a possible reduction in calculated stress levels. However, based on the present conservative assumptions, the fatigue usage factor is sufficiently low that additional margin would not be needed for a significant number of additional thermal cycles.

Combustion Engineering, Inc. 1000 Prospect Hill Road Post Office Box 500 Telephone (203) 688-1911 Fax (203) 285-9512

This evaluation, while being engineering assured, should be considered preliminary until completion of formal Quality Assurance in compliance with ABB Combustion Engineering Nuclear Services QAM-100 procedures. This final report will be completed as a program being proposed to ANO2.

Should there be any questions on these results, please call me at 203-285-4996.

Sincerely,
ABB COMBUSTION ENGINEERING
NUCLEAR SERVICES

Barry T. Lubin
Supervisor, Fatigue Evaluation Services

xc: M.S. McDonald(ABB-CE)
R.W. Bradshaw(ABB-CE)
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W. Greeson(ANO2)
J. Martin(ANO2)

SUMMARY AND CONCLUSIONS IN EVALUATION OF THERMAL STRATIFICATION IN THE SHUTDOWN COOLING LINE ON THE RETURN TO POWER OF ARKANSAS NUCLEAR ONE-UNIT 2

BACKGROUND: On May 4, 1992, ANO2 informed Nuclear Services that top-to-bottom wall temperature differences of approximately 345°F had been recorded during the power reduction for the mid-cycle outage of ANO2. These values are above the 300°F differential temperature previously recorded at Location 1 (shown in the attached Figure). Temperatures at Location 2 were close to ambient (80°F) and were uniform around the line. In addition, it was noted that these temperature differences were related to reductions in power, increasing in magnitude with larger percent reductions in power.

A request was made by ANO2 to provide assistance in evaluating the effect of this stratification on the stresses and fatigue life of the SDC line. The objective of this evaluation was to support a Return to Power of ANO2 from this mid-cycle outage (2P-93-1) and to support operation for a limited number of additional thermal cycles.

This request focused in three specific areas:

1. Evaluation of the stress levels and fatigue usage due to the recorded temperature differences, with allowances for additional future thermal cycles.

2. Identification of regions for NDE examinations.

3. Identification of locations for additional thermocouple placements.

The purpose of this report is to document this preliminary evaluation and the conclusion that the presence of thermal stratification in the shutdown cooling line has not, and will not, for an additional number of thermal cycles, cause the SDC line to exceed ASME code limits on fatigue, and that ANO2 can return to power and operate safely.

STRESS ANALYSIS: The purpose of the stress analysis was two-fold: to determine the locations of the maximum stress for identifying NDE locations and to calculate the fatigue usage factor for the line, from the initial plant criticality to the end of the current fuel cycle.

This analysis was done using the SUPERPIPE code, utilizing experience gained in analysis of pressurizer surge lines. The analysis conservatively assumed that: the SDC line is anchored at the RCS nozzle, top-to-bottom wall temperature differences are assumed constant over the upper horizontal portion of the line (Figure;B-F), with a temperature difference of 350°F, while the remainder of the line is taken at a uniform temperature of 560°F in the vertical section below the RCS nozzle (Figure;A-B) and 80°F at the vertical run before (Figure; F-G) and horizontal run (Figure;G-H) before

and after the isolation valve. The effect of the thermal stra   is accounted for using results for line rotation based on the surge line analys... ...e for a top-to-bottom temperature difference of 350°F.

A fatigue usage factor of 0.13 was computed for the limiting elbow (Figure; Elbow B) based on an estimated number of cycles during which stratification in the SDC line is assumed to have occurred since initial criticality.

In addition, to support continued safe operation, future thermal cycles must be accounted for. For the number of cycles specified below, an incremental increase in usage factor of 0.12 would occur, resulting in a total usage factor of .25, which is below the ASME code allowable of 1.0.

Based on this analysis, continued operation can proceed for the number of SDC thermal stratification cycles within the SDC line wall temperature differences listed below. Measured wall temperature differences greater than 350°F will require a re-evaluation of stresses and of the usage factor.

Wall Temperature Difference	Number of Cycles
> 350°F	Re-evaluation of usage factor
200°F - 350°F	1000 SDC thermal stratification cycles
< 200°F	Unlimited SDC thermal stratification cycles

These calculations, done for the elbow below the hot leg nozzle (Figure; Elbow b) which showed the highest stress levels due to thermal stratification, were based on methods and procedures required in Section III of the 1986 ASME Boiler and Pressure Vessel Code. The use of the 1986 Code is based on the recommendation in NRC Bulletin 88-11 on Pressurizer Surge Line Thermal Stratification to use the latest ASME Section III requirements for high cycle fatigue. The use of the 1986 Code is consistent with the analyses submitted to the NRC as part of the response to NRCB 88-11 on "Pressurizer Surge Line Flow Stratification Evaluation " (CEN-NPSD 546-P,Rev 1-P) by the Combustion Engineering Owners Group.

These results support the conclusion that the margin in fatigue life of the SDC line is sufficiently high to allow the plant to return to and continue safe operation.

NON-DESTRUCTIVE EXAMINATION: The results of the SUPERPIPE analysis show that the maximum stress locations are at the elbows closest to hot leg nozzle.

Based on information provided by ANO2, Non-Destructive Examinations at these locations and the weldolet region at the hot leg injection line junction, were performed

during outage 2R8. The results showed no evidence of flaws indicative of cracks. In addition, the UT techniques utilized in this ISI were enhanced in accordance with recommendations in NRC Bulletin 88-08, Supplement 2. The inspection included enhanced UT of welded regions, visual inspection of the weldolet and UT inspections of base metal in the elbows.

Results of the fatigue analysis indicate that the additional loss of fatigue life from the 2R8 through 2P-93-1 outages and for the additional thermal cycles specified above will be minor. Thus the NDE results taken during the 2R8 outage should be a sufficient indication as to the condition of the high stress regions until the next scheduled outage.

ADDITIONAL THERMOCOUPLE LOCATIONS: The current SUPERPIPE analysis conservatively assumes that the top-to-bottom difference in wall temperature is uniform over the entire upper horizontal section of the SDC line. A more local distribution in the effect of the stratification would result in a reduction in stress values but is not expected to change the location of the maximum stresses.

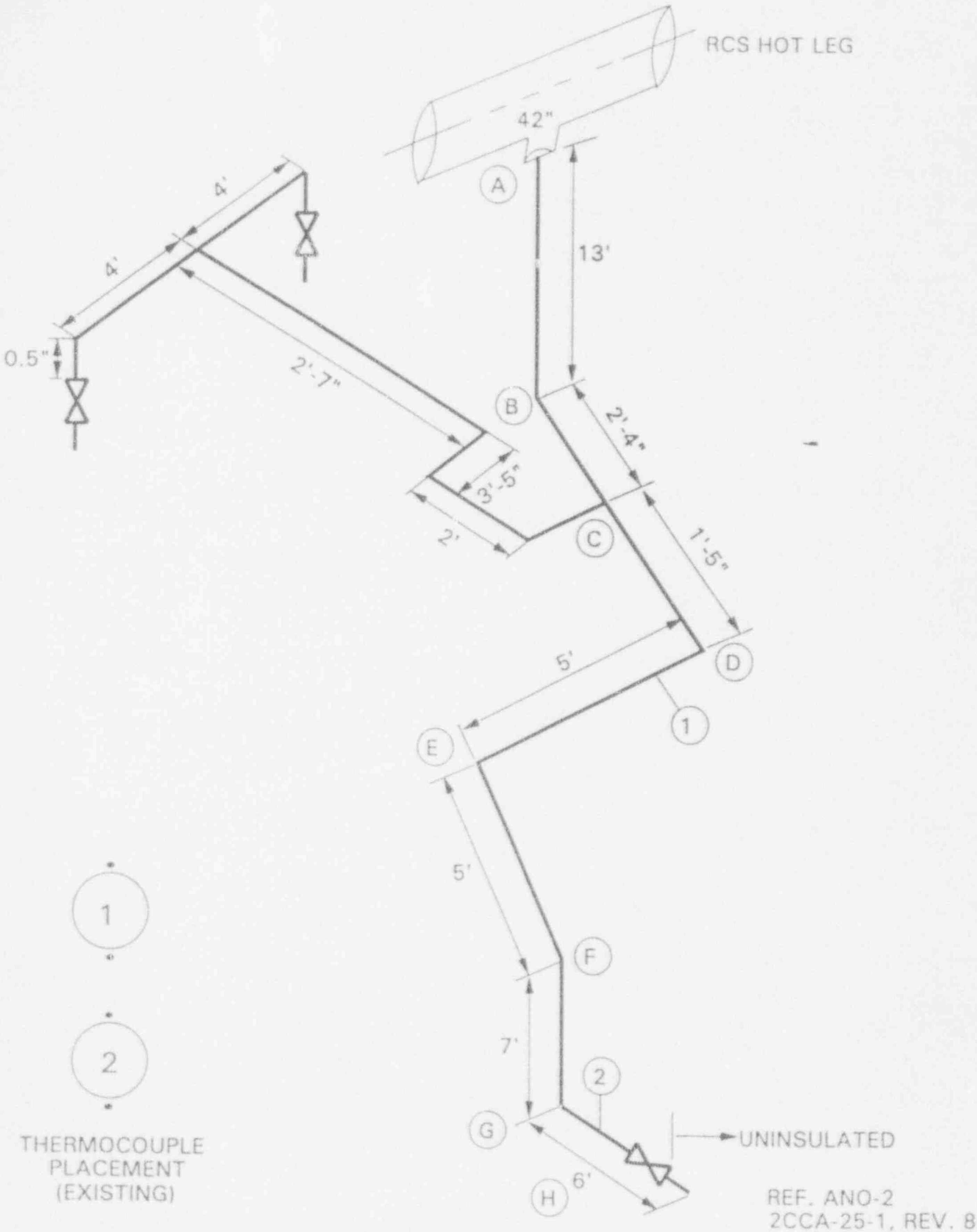
The usage factor based on the stresses calculated with the current assumptions, and based on the 1986 ASME Code, have a sufficient margin below the ASME code limit such that only a limited benefit would be gained from using a more accurate, less conservative, distribution on wall temperature difference.

CONCLUSIONS: The following conclusions are based on this evaluation:

1. The accumulated fatigue usage factor of 0.13 is well below the ASME Code limit of 1.0. Furthermore, the additional conservative increase in usage factor of 0.12 for a number of additional thermal cycles will not increase the total usage factor above the ASME Code limit.

2. The highest stress levels due to thermal stratification are calculated at elbows closest to the hot leg which were subject to NDE during the 2R8 outage. The increase in fatigue usage factor will not exceed the ASME Code limits for the recommended number of additional thermal cycles. Thus, the current NDE results can be used as evidence of the present status of these components without additional NDE prior to a return to power.

3. The addition of more thermocouples to the SDC line prior to the 2R10 outage is not necessary. Additional thermocouples would provide information on the location of stratification within the line and a refinement of the stress analysis leading to a reduction in calculated stress levels. However, based on the present conservative assumptions the fatigue usage factor is below the ASME Code limit therefore this additional margin will not be needed for a significant number of additional thermal cycles.



SDC LINE MEASUREMENT LOCATIONS - ANO-2

APPENDIX B

to

ABB-CE Report No. A-MECH-ER-009, Rev.00

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Calculation 42 Pages

Contract 2002243,2

Appendix 5 Pages

Microfiche 5

Calculation Number MISC-ME-C-164

Revision 01

Title THERMAL ANALYSIS OF THE ANO2 SHUTDOWN COOLING LINE, INCLUDING EFFECTS OF THERMAL FLOW STRATIFICATION

Author S.C. AUSTIN / S.C. Austin

Date 7-29-93

Calculation contains safety related design information: Yes ✓ No ___

VERIFICATION STATUS: COMPLETE

The design information contained in this document has been verified to be correct by means of Design Review.

Name G. PIERFEDEKI Signature [signature] Date 7/29/93
Independent Reviewer

This calculation contains no assumptions requiring further verification.

Approved by D.F. BAISLEY (SUPV SYSTEMS ANALYSIS) / [signature] Date 7/29/93

Distribution K.A. EMERY, D.A. PECK*, M.S. McDONALD*, B.T. LUBIN, P.I. HAMMER

* (COVER SHEET ONLY)

Summary Purpose: CORRECT INPUT ERROR IN RUN #5 OF REV 00 (DISPLACEMENT OF SUPPORT H9 WAS INPUT AS 8.793" INSTEAD OF 8.8793")

Method and Results of Review:

The method of design review was used for verification of this calculation. The results are satisfactory for the purpose stated above.

MISC-ME-C-16-1 — 01
Calculation Number — Rev.

2
Page Number

RECORD OF REVISIONS

No.	Date	Sections Involved	Prepared By	Approvals
00	6/21/93	ALL-ORIGINAL ISSUE	C.R. SCHMIDT	D.F. BAISLEY G.A. PIERFEDEICI
01	7/29/93	ALL Pages Reissued, but only pages with change bars were revised.	S.C. AUSTIN	D.F. BAISLEY G.A. PIERFEDEICI

Table of Contents

PURPOSE - To analyze the ANO2 shutdown cooling (SDC) line with the Superpipe computer code and determine loads and Equation 10 & 12 (Ref. 5) stress ranges resulting from the analysis of the following two cases: 1) an arbitrarily selected bounding case involving only linear thermal expansion, and 2) a thermal flow stratification case in which stratification occurs in a portion of the SDC line. These cases are outlined in the discussion section and the body of the calculation.

DISCUSSION - The basic SDC line geometry was based on Ref. 1 & 2 (see pp. 25-26). The 8" line off of the SDC line in the vicinity of support H9 was added to the model at a later point in the analysis (see pp. 34-35). This geometry was based on Ref. 8. See Ref. 10 for a description of the method used for analyzing thermal flow stratification. See p. 34 for a diagram of the computer model. A listing of the input file used in the final iteration run of the final analysis is contained in the appendix.

Ref. 6 transmitted preliminary results generated by computer runs #1 & 2, in which flow stratification of delta 340 deg F was assumed along the first horizontal plane run off of the hot leg. The rest of the line was only subjected to linear thermal expansion (see p.32). This analysis, the preliminary analysis, was run with the basic SDC line geometry described above. Subsequently, the model and the stratification case were

modified per pp. 35-36. Computer runs #4, 5, the final analysis, were made. The initial vertical section of the line off of the hot leg was at a temperature of 560 deg F, followed by the stratified section of the SDC line, which was subjected to a delta T of 350 deg F, while the remainder of the line was held at a constant temperature of 80 deg F. Additionally, the vertical hanger (H1 & H2) stiffnesses were changed to 1600 and 1200 #/in, respectively, and, as noted above, the 8" line off of the SDC line was added to the model. Therefore, runs #4-5 reflect the most accurate available model data, and the most complete SDC line modeling. It should be noted that the addition of the 8" line to the overall model did not significantly alter the results of the analysis, and that the change of vertical hanger stiffnesses from 1500 #/in to their final values had a negligible effect on the analysis results. Additionally, the stratification case input that was used initially was the more severe of the two overall thermal inputs used, when considering both the stra- and unstratified portions of the line. In all of the computer runs made, the linear expansion only case was a constant 500 deg F, which is a conservative overall temperature to apply to the SDC line.

Because some of the SDC line supports contain gaps in places (i.e., H9A & H9B), the final support configuration was arrived at iteratively in both the preliminary and final analyses. This

was done by assuming an initial set of open and closed support gaps and altering this configuration during successive computer runs until the final configuration led to a set of consistent support loads. If a vertical support gap should have been closed but was not during a particular iteration, the support was made rigid in the next iteration and the support point in the model was moved a distance equal to the gap size. More particularly, the support point was moved in the (+) direction if the support topped out and in the (-) direction if the support should have bottomed out during the iteration. This was done by altering the support point displacement in the stratified flow input section of the computer run input file. If, on the other hand, a gap previously taken to be closed opened, the support was given a negligible spring rate (1 #/in), and the support point displacement was restored to the original value in the next iteration.

For the preliminary analysis, run #2 reflects the final support configuration, and for the final analysis, run #5 reflects the final support configuration, for the stratification cases. For the 500° uniform case, runs 1 or 2 may be used for preliminary results, and run no. 4 should be used for the final.

It should be noted that although loads and stress range values are available from the analyses run, only loads should be used to assess piping stresses in an absolute sense. Getting accurate stress ranges (i.e. equn. 10 & 12 results) requires consideration of all loading conditions in the original design basis for the subject line acting in combination with flow stratification. This analysis does not examine the necessary prerequisite conditions. However, a comparison of the magnitudes of the equn. 10 & 12 results along the SDC line can be used to determine locations at which the stresses are likely to be most severe.

ASSUMPTIONS -

1) The downward (-) vertical gap size at supports H9A & H9B is equal to 1/2". Inspection of the Ref. 3 support drawing shows that this is a reasonable assumption, and the final results indicate that the downward motion at these supports is much < the assumed limit.

2) The effects of 3" and smaller lines off of the 14" SDC line are negligible, and therefore these lines do not need to be included in the model. Comparison of runs #2 & 5, in which the model does not and does have the 8" line included indicates essentially the same behavior. Therefore, the inclusion of significantly smaller lines would have

a negligible effect on the results.

3) The horizontal plane clearance at the H16 guide (Ref. 2) is sufficiently large to allow for no contact. This assumption is valid because the partial stratification case run herein is unlikely to cause a significantly larger movement at this location of the SDC line than some of the linear thermal expansion cases for which the support has been designed. Further, it is likely that the stratification analyzed is less severe than the actual stratification experienced.

4) The end of the model is fixed in all directions but axial translation. The true end condition of the portion of the overall SDC line modeled for this analysis is somewhere between free in axial translation and completely fixed, with the more reasonable approximation being the one used in this analysis. Run #3 was made with the end completely fixed, and the resulting final support configuration along the rest of the model remained the same, indicating that using either end condition produces essentially the same results.

5) Vertical hangers H1 & H2 had an assumed stiffness of 1500 #/in in the preliminary analysis. Subsequent undocumented data indicated that the stiffnesses were 1600 and 1200 #/in, respectively. These values were used in the final analyses. All of the other active supports were assumed to be rigid. The fact that the

changes made to the hanger stiffnesses in this calculation's runs had a negligible effect on the results indicates that the final values used will produce results that are within the accuracy requirements of this analysis. Similarly, inspection of the support drawings validates the assumption that the other supports are rigid, since they only need to approach being rigid when compared to the stiffness of the SDC line in order for the analysis to produce sufficiently accurate results.

6) It was assumed that neither of the vertical spring hangers bottomed or topped out in the final support configurations. In general, experience with surge lines has shown that the maximum hanger displacements encountered in this analysis (-.342", +.376") are not sufficiently large to cause the vertical hangers to top or bottom out. Therefore, the assumption is validated.

RESULTS - The results are contained on pp. 11 - 21. They consist of tabulated SDC line forces and moments in the Superpipe local coordinate system along with a SDC line diagram defining the local coordinate systems for the straight piping sections in the model. Units are inches and pounds. Therefore, the results on the straight pipe side of a straight piping/elbow interface are the results that

are consistent with the local coordinate system diagram. It should also be noted that to be totally consistent, the signs of the loads at the DCP "coming out" of an elbow (e.g., DCP 5B) should be reversed, while the signs of the loads "going into" an elbow/piping juncture (e.g., 5A) should remain as is. For example, the correct set of loads for 5A & 5B for the final analysis stratified flow case (see p. 19) are as follows:

LOC	MX	MY	MZ
5A	-117040.800	-189294.33	-1444998.50
5B	-126963.57	+204188.69	+1687133.50

Results are presented for the constant 500 deg F and the partial stratified flow cases for both the preliminary and final analyses. The results reported in this calculation are thermal only loads.

The 500 deg F case (THMN) results are for information only since there is no real basis for the computer code input for this case. Flow stratification results (SFL1) should be selected from run #2 & 5 outputs in the most conservative manner. It is recommended that the larger of the results be selected on a location by location and component of load by component of load basis.

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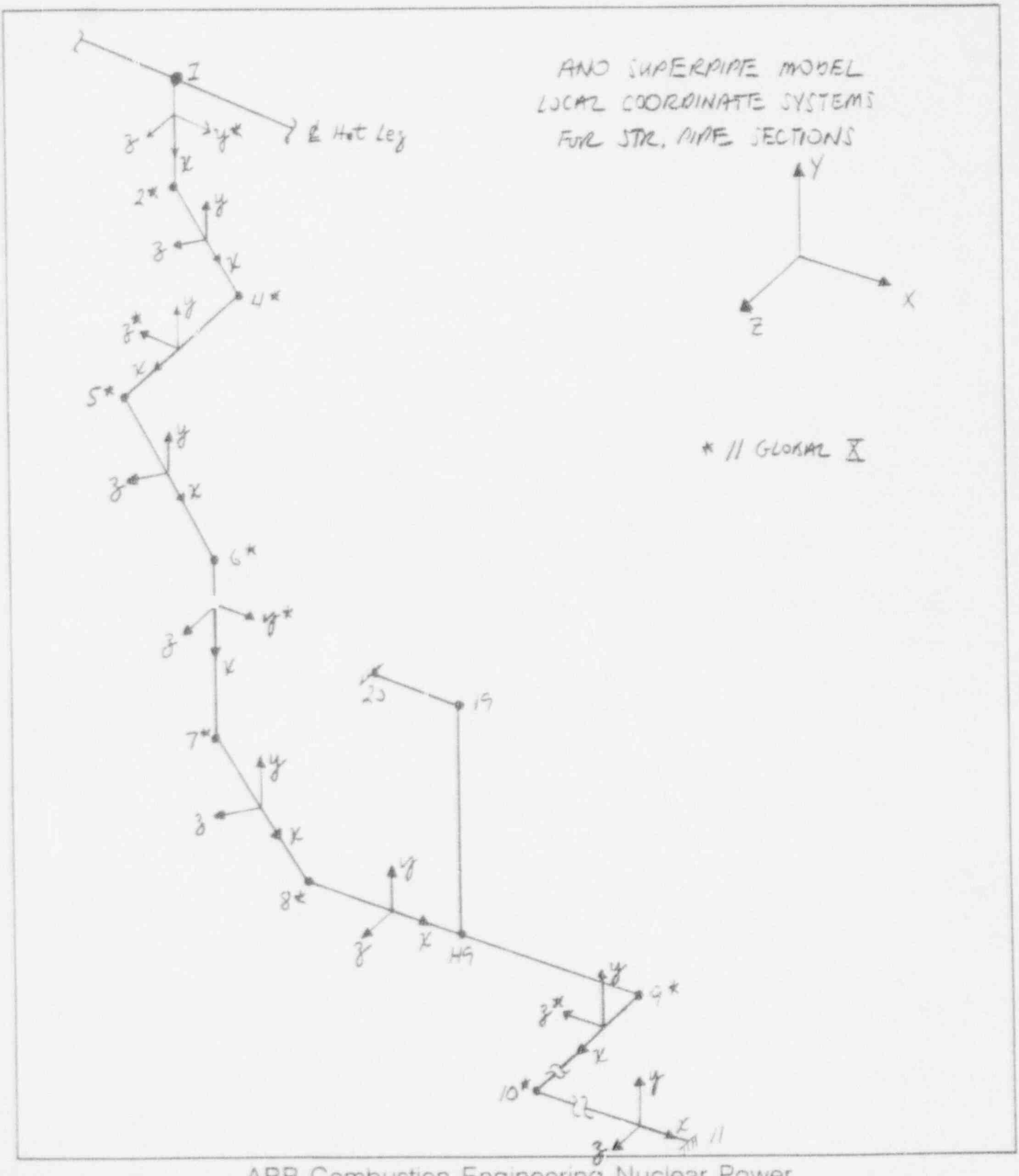
MISC-ME-C-134 00
Calculation Number Rev.

11
Page Number



ARKANSAS POWER & LIGHT SHUTDOWN COOLING LINE - PRELIMINARY ANALYSIS RESULTS
500 DEG F CONSTANT TEMP CASE

LOAD CASE NO. 3 (THMN), FORCES AND MOMENTS IN LOCAL COORDINATES

RUN GROUP	SOP MMB	DCP NAME	AXIAL FORCE (LB)	Y FORCE (LB)	Z FORCE (LB)	XX MOMENT (LB.IN)	YY MOMENT (LB.IN)	ZZ MOMENT (LB.IN)
PRN1								
	1	1	1705.00	0.00	644.17	226941.08	164980.05	-34202.02
	2		1705.00	0.00	644.17	226941.08	188225.67	-34202.02
	3		1705.00	0.00	644.17	226941.08	211471.39	-34202.02
	4		1705.00	0.00	644.17	226941.08	234717.11	-34202.02
	5L	2A	1705.00	0.00	644.17	226941.08	257962.92	-34202.02
	5R	2A	1705.00	-455.49	-455.49	226941.08	-158222.84	206591.81
	6L	2B	455.49	1705.00	-455.49	168594.50	216569.42	178140.34
	6R	2B	455.49	-1705.00	455.49	168594.50	-216569.41	-178140.34
	7	3	455.49	-1705.00	455.49	168594.50	-212927.02	-164506.03
	8L	4A	455.49	-1705.00	455.49	168594.50	-209235.56	-150688.25
	8R	4A	455.49	-455.49	-1705.00	168594.48	150688.27	-209235.56
	9L	4B	644.17	0.00	-1705.00	24032.65	198314.92	-204939.50
	9R	4B	644.17	-1705.00	0.00	24032.64	-204939.50	-198314.92
	10		644.17	-1705.00	0.00	24032.65	-204939.52	-157547.94
	11L	5A	644.17	-1705.00	0.00	24032.64	-204939.50	-116780.79
	11R	5A	644.17	0.00	1705.00	24032.65	-116780.79	204939.50
	12L	5B	455.49	455.49	1705.00	88199.11	-38130.77	200643.42
	12R	5B	455.49	-1705.00	455.49	88199.11	-200643.42	-38130.77
	13L	H2	455.49	-1705.00	455.49	88199.11	-184188.47	23463.39
	13R	H2	455.49	-1760.00	455.49	88199.11	-184188.47	23463.39
	14L	6A	455.49	-1760.00	455.49	88199.11	-182212.91	31096.82
	14R	6A	455.49	-1760.00	455.49	88199.11	-182212.89	31096.82
	15L	6B	1760.00	455.49	455.49	175298.48	95113.52	50899.38
	15R	6B	1760.00	0.00	644.17	175298.47	31264.13	103246.73
	16	H3	1760.00	0.00	644.17	175298.47	52218.02	103246.73
	17	H4	1760.00	0.00	644.17	175298.47	57805.73	103246.73
	18L	7A	1760.00	0.00	644.17	175298.47	65488.82	103246.73
	18R	7A	1760.00	-455.49	-455.49	175298.50	-119314.04	-26698.87
	19L	7B	455.49	1760.00	-455.49	129685.70	164926.83	-56402.71
	19R	7B	455.49	-1760.00	455.49	129685.69	-164926.81	56402.71
	20L	H1	455.49	-1760.00	455.49	129685.69	-157428.34	85376.48
	20R	H1	455.49	-1499.00	455.49	129685.69	-157428.34	85376.48
	21	VA1A	455.49	-1499.00	455.49	129685.69	-144093.38	129261.14
	22		455.49	-1499.00	455.49	129685.69	-133721.75	163393.56
	23	VA1B	455.49	-1499.00	455.49	129685.69	-123350.09	197526.14
	24L	8A	455.49	-1499.00	455.49	129685.69	-123324.63	197609.88
	24R	8A	455.49	455.49	1499.00	129685.70	197609.89	123324.63
	25L	8B	0.00	644.17	1499.00	-58026.82	255568.23	112952.99
	25R	8B	0.00	-1499.00	644.17	-58026.84	-112952.99	255568.25
	26	H5	0.00	-1499.00	644.17	-58026.84	-111345.48	259309.02
	27	H9A	0.00	-1499.00	644.17	-58026.84	-107154.70	269061.16

FROM RUN #2

MISC-ME-C-164
p. 12
R00

ARKANSAS POWER & LIGHT SHUTDOWN COOLING LINE - PRELIMINARY ANALYSIS RESULTS
500 DEG F CONSTANT TEMP CASE

LOAD CASE NO. 3 (THMN), FORCES AND MOMENTS IN LOCAL COORDINATES (CONTD.)

RUN GROUP	SOP MMB	DCP NAME	AXIAL FORCE (LB)	Y FORCE (LB)	Z FORCE (LB)	XX MOMENT (LB.IN)	YY MOMENT (LB.IN)	ZZ MOMENT (LB.IN)
PRN1 (CONTD.)								
	28L	H9	0.00	-1499.00	644.17	-58026.84	-96677.75	293441.53
	28R	H9	0.00	17642.99	644.17	-58026.84	-96677.75	293441.53
	29L	H9B	0.00	17642.99	644.17	-58026.84	-86200.81	6489.44
	29R	H9B	0.00	-93.28	644.17	-58026.84	-86200.81	6489.44
	30	VA2A	0.00	-93.28	644.17	-58026.84	-63151.54	9827.01
	31		0.00	-93.28	644.17	-58026.84	-48483.84	11950.91
	32	VA2B	0.00	-93.28	644.17	-58026.84	-33816.10	14074.83
	33L	H17	0.00	-93.28	644.17	-58026.84	-16354.52	16603.29
	33R	H17	0.00	196.19	622.14	-58026.84	-16354.52	16603.29
	34L	9A	0.00	196.19	622.14	-58026.84	-2188.24	12135.92
	34R	9A	0.00	-622.14	196.19	-58026.83	-12135.93	-2188.24
	35L	9B	622.14	0.00	196.19	7668.56	-53559.47	11978.04
	35R	9B	622.14	196.19	0.00	7668.56	11978.04	53559.47
	36	H21	622.14	196.19	0.00	7668.56	11978.04	52921.28
	37		622.14	196.19	0.00	7668.56	11978.04	45518.26
	38		622.14	196.19	0.00	7668.56	11978.04	38115.19
	39		622.14	196.19	0.00	7668.56	11978.04	30712.13
	40		622.14	196.19	0.00	7668.56	11978.04	23309.07
	41	H16	622.14	196.19	0.00	7668.56	11978.04	15905.97
	42L	10A	622.14	196.19	0.00	7668.56	11978.04	12076.80
	42R	10A	622.14	0.00	-196.19	7668.56	12076.80	-11978.04
	43L	10B	0.00	622.14	-196.19	-7609.44	3201.20	-26144.33
	43R	10B	0.00	196.19	622.14	-7609.44	26144.33	3201.20
	44		0.00	196.19	622.14	-7609.44	48827.14	-3951.87
	45		0.00	196.19	622.14	-7609.44	71510.08	-11104.98
	46		0.00	196.19	622.14	-7609.44	94193.00	-18258.08
	47	H15	0.00	196.19	622.14	-7609.44	116876.01	-25411.21
	48		0.00	196.19	622.14	-7609.44	136809.91	-31697.40
	49		0.00	196.19	622.14	-7609.44	156743.88	-37983.63
	50		0.00	196.19	622.14	-7609.44	176677.88	-44269.84
	51		0.00	196.19	622.14	-7609.44	196611.84	-50556.06
	52	11	0.00	196.19	622.14	-7609.44	216545.94	-56842.31

MISC-ME-C-164 p.13 R00

ARKANSAS POWER & LIGHT SHUTDOWN COOLING LINE - PRELIMINARY ANALYSIS RESULTS
340 DEG F DELTA T STRATIFIED FLOW CASE

LOAD CASE NO. 4 (SFL1). FORCES AND MOMENTS IN LOCAL COORDINATES

RUN GROUP	SOP MMB	DCP NAME	AXIAL FORCE (LB)	Y FORCE (LB)	Z FORCE (LB)	XX MOMENT (LB.IN)	YY MOMENT (LB.IN)	ZZ MOMENT (LB.IN)
PRN1								
	1	1	9126.64	0.00	439.72	113314.08	2088512.00	-1519044.00
	2		9126.64	0.00	439.72	113314.08	2104652.75	-1519044.00
	3		9126.64	0.00	439.72	113314.08	2120793.75	-1519044.00
	4		9126.64	0.00	439.72	113314.08	2136934.25	-1519044.00
	5L	2A	9126.64	0.00	439.72	113314.08	2153075.50	-1519044.00
	5R	2A	9126.64	-310.93	-310.93	113314.10	-448327.81	2596580.50
	6L	2B	310.93	9126.64	-310.93	455529.47	106112.43	2392395.75
	6R	2B	310.93	-9126.64	310.93	438837.25	-102224.10	-2304730.00
	7	3	310.93	-9126.64	310.93	438837.25	-99787.63	-2233213.50
	8L	4A	310.93	-9126.64	310.93	438837.25	-97318.38	-2160734.25
	8R	4A	310.93	-310.93	-9126.64	438837.28	2160734.50	-97318.38
	9L	4B	439.72	0.00	-9126.64	-1157920.13	1694179.25	-94444.66
	9R	4B	439.72	-9126.64	0.00	-1157920.25	-94444.66	-1694179.25
	10		439.72	-9126.64	0.00	-1157920.38	-94444.67	-1480342.50
	11L	5A	439.72	-9126.64	0.00	-1157920.25	-94444.66	-1266504.88
	11R	5A	439.72	0.00	9126.64	-1157920.13	-1266505.00	94444.66
	12L	5B	310.93	310.93	9126.64	17136.08	-1570332.00	91570.95
	12R	5B	310.93	-9126.64	310.93	17136.07	-91570.95	-1570332.00
	13L	H2	310.93	-9126.64	310.93	17136.07	-80563.98	-1247249.63
	13R	H2	310.93	-9691.00	310.93	17136.07	-80563.98	-1247249.63
	14	6A	310.93	-9691.00	310.93	17136.07	-79242.50	-1206062.38
	15L	6B	9691.00	310.93	310.93	74617.33	21761.24	-1066532.25
	15R	6B	9691.00	0.00	439.72	72478.49	747481.56	-717588.63
	16	H3	9691.00	0.00	439.72	72478.49	761096.13	-717588.63
	17	H4	9691.00	0.00	439.72	72478.49	764726.75	-717588.63
	18L	7A	9691.00	0.00	439.72	72478.49	769718.81	-717588.63
	18R	7A	5591.00	-310.93	-310.93	72478.48	-36861.54	1051685.13
	19L	7B	310.93	9691.00	-310.93	43600.43	65739.59	848389.25
	19R	7B	310.93	-9691.00	310.93	42396.02	-63923.61	-824953.25
	20L	H1	310.93	-9691.00	310.93	42396.02	-59186.11	-677297.06
	20R	H1	310.93	-9677.31	310.93	42396.02	-59186.11	-677297.06
	21	VA1A	310.93	-9677.31	310.93	42396.02	-50761.17	-415083.19
	22		310.93	-9677.31	310.93	42396.02	-44208.45	-211139.47
	23	VA1B	310.93	-9677.31	310.93	42396.02	-37655.71	-7194.95
	24L	8A	310.93	-9677.31	310.93	42396.02	-37639.63	-6694.64
	24R	8A	310.93	310.93	9677.31	42396.01	-6694.66	37639.63
	25L	8B	0.00	439.72	9677.31	-25021.51	169454.95	31086.90
	25R	8B	0.00	-9677.31	439.72	-25021.51	-31086.90	169454.94
	26	H5	0.00	-9677.31	439.72	-25021.51	-30071.29	191806.41
	27L	H9A	0.00	-9677.31	439.72	-25021.51	-27423.58	250076.14
	27R	H9A	0.00	-9677.24	439.72	-25021.51	-27423.58	250076.14

FROM RUN #2

MJC-ME-C-164 p.14 R00

ARKANSAS POWER & LIGHT SHUTDOWN COOLING LINE - PRELIMINARY ANALYSIS RESULTS
340 DEG F DELTA T STRATIFIED FLOW CASE

LOAD CASE NO. 4 (SFL1). FORCES AND MOMENTS IN LOCAL COORDINATES (CONTD.)

RUN GROUP	SOP MMB	DCP NAME	AXIAL FORCE (LB)	Y FORCE (LB)	Z FORCE (LB)	XX MOMENT (LB.IN)	YY MOMENT (LB.IN)	ZZ MOMENT (LB.IN)
PRN1 (CONTD.)								
	28L	H9	0.00	-9677.24	439.72	-25021.51	-20804.32	395749.47
	28R	H9	0.00	468466.31	439.72	-25021.51	-20804.32	395749.47
	29L	H9B	0.00	468466.31	439.72	-25021.51	-14185.06	-6656163.50
	29R	H9B	0.00	-68642.08	439.72	-25021.51	-14185.06	-6656163.50
	30	VA2A	0.00	-68642.08	439.72	-25021.51	377.31	-4382943.00
	31		0.00	-68642.08	439.72	-25021.51	9644.25	-2936350.50
	32	VA2B	0.00	-68642.08	439.72	-25021.51	18911.23	-1489752.50
	33L	H17	0.00	-68642.08	439.72	-25021.51	29943.33	232384.92
	33R	H17	0.00	758.94	-131.12	-25021.51	29943.33	232384.92
	34L	9A	0.00	758.94	-131.12	-25021.51	27180.14	216390.75
	34R	9A	0.00	131.12	758.94	-25021.49	-216390.75	27180.14
	35L	9B	-131.12	0.00	758.94	200396.56	-9027.32	24416.96
	35R	9B	-131.12	758.94	0.00	200396.55	24416.96	9027.32
	36	H21	-131.12	758.94	0.00	200396.55	24416.96	6742.44
	37		-131.12	758.94	0.00	200396.55	24416.96	-19762.08
	38		-131.12	758.94	0.00	200396.55	24416.96	-46266.72
	39		-131.12	758.94	0.00	200396.55	24416.96	-72771.37
	40		-131.12	758.94	0.00	200396.55	24416.96	-99276.00
	41	H16	-131.12	758.94	0.00	200396.55	24416.96	-125780.80
	42L	10A	-131.12	758.94	0.00	200396.55	24416.96	-139490.09
	42R	10A	-131.12	0.00	-758.94	200396.56	-139490.09	-24416.96
	43L	10B	0.00	-131.12	-758.94	155484.30	184402.38	-21653.77
	43R	10B	0.00	758.94	-131.12	155484.30	21653.77	184402.38
	44		0.00	758.94	-131.12	155484.30	17229.40	158792.75
	45		0.00	758.94	-131.12	155484.30	12805.01	133183.02
	46		0.00	758.94	-131.12	155484.30	8380.62	107573.26
	47	H15	0.00	758.94	-131.12	155484.30	3956.22	81963.42
	48		0.00	758.94	-131.12	155484.30	68.04	59457.43
	49		0.00	758.94	-131.12	155484.30	-3820.16	36951.32
	50		0.00	758.94	-131.12	155484.30	-7708.36	14445.21
	51		0.00	758.94	-131.12	155484.30	-11596.55	-8060.88
	52	11	0.00	758.94	-131.12	155484.30	-15484.77	-30567.09

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MISC-ME-C-164
R01

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From Run # 4

LOAD CASE NO. 3 (THRM), FORCES AND MOMENTS IN LOCAL COORDINATES

RUN GROUP	SOP MMI	DCP NAME	AXIAL FORCE (LB)	Y FORCE (LB)	Z FORCE (LB)	XX MOMENT (LB.IN)	YY MOMENT (LB.IN)	ZZ MOMENT (LB.IN)
PRN1								
	1	1	6103.82	7883.55	9174.38	-21852.02	-790568.56	1092803.88
	2		6103.82	7883.55	9174.38	-21852.02	-459498.00	808314.75
	3		6103.82	7883.55	9174.38	-21852.02	-128426.05	523824.59
	4		6103.82	7883.55	9174.38	-21852.02	202645.86	239334.34
	5L	2A	6103.82	7883.55	9174.38	-21852.02	533719.13	-45157.02
	5R	2A	6103.82	-12061.78	-912.76	-21852.01	-345465.56	409327.25
	6L	2B	12061.78	6103.82	912.76	366249.16	-42635.59	544990.63
	6R	2B	12061.78	-6103.82	912.76	366249.16	42635.57	-544990.63
	7	3	12061.78	-6103.82	912.76	366249.16	49934.56	-496180.44
	8L	4A	12061.78	-6103.82	912.76	366249.16	57331.77	-446713.53
	8R	4A	12061.78	-912.76	-6103.82	366249.16	446713.53	57331.77
	9L	4B	9174.38	7883.55	-6103.82	-16189.21	476574.34	-8414.60
	9R	4B	9174.38	-6103.82	-7883.55	-16189.21	-8414.60	-476574.34
	10		9174.38	-6103.82	-7883.55	-16189.21	-196911.95	-330630.69
	11L	5A	9174.38	-6103.82	-7883.55	-16189.21	-385410.09	-184686.30
	11R	5A	9174.38	-7883.55	6103.82	-16189.22	-184686.31	385410.09
	12L	5B	12061.78	912.76	6103.82	78437.74	-43763.38	451156.44
	12R	5B	12061.78	-6103.82	912.76	78437.73	-451156.44	-43763.37
	13L	H2	12061.78	-6103.82	912.76	78437.73	-418182.66	176740.59
	13R	H2	12061.78	-5999.77	912.76	78437.73	-418182.66	176740.59
	14L	6A	12061.78	-5999.77	912.76	78437.73	-414223.88	202762.58
	14R	6A	12061.76	-5999.77	912.76	78437.74	-414223.88	202762.58
	15L	6B	5999.77	12061.78	912.76	400368.16	92293.43	110740.79
	15R	6B	5999.77	7883.55	9174.38	400368.19	-13044.25	143566.88
	16	H3	5999.77	7883.55	9174.38	400368.19	285386.78	-112875.02
	17	H4	5999.77	7883.55	9174.39	400368.19	364968.34	-181259.52
	18L	7A	5999.77	7883.55	9174.38	400368.19	474393.09	-275288.22
	18R	7A	5999.77	-12061.78	-912.76	400368.19	-140788.39	530104.75
	19L	7B	12061.78	5999.77	-912.76	161571.97	379584.63	668137.38
	19R	7B	12061.78	-5999.77	912.76	161571.95	-379584.63	-668137.38
	20L	H1	12061.78	-5999.77	912.76	161571.95	-364558.53	-569367.19
	20R	H1	12061.78	-5504.67	912.76	161571.95	-364558.53	-569367.19
	21	VA1A	12061.78	-5504.67	912.76	161571.95	-337836.81	-408213.31
	22		12061.78	-5504.67	912.76	161571.95	-317053.34	-282871.66
	23	VA1B	12061.78	-5504.67	912.76	161571.95	-296269.72	-157529.47
	24L	8A	12061.78	-5504.67	912.76	161571.95	-296218.72	-157221.98
	24R	8A	12061.78	912.76	5504.67	161571.97	-157221.98	296218.72
	25L	8B	7883.55	9174.38	5504.67	188709.58	91706.02	201079.97

ARKANSAS POWER & LIGHT SAFETY INJECTION - STRATIFIED FLOW <ark.1b.rev>
ADD 8-INCH LINE REPRESENTATION
USE TEMPS IN BTL LETTER TO ANO 5/11/93
AND EXACT SPRING STIFFNESSES

LOAD CASE NO. 3 (THMN), FORCES AND MOMENTS IN LOCAL COORDINATES (CONTD.)

RUN GROUP	SGP MMB	DCP NAME	AXIAL FORCE (LB)	Y FORCE (LB)	Z FORCE (LB)	XX MOMENT (LB.IN)	YY MOMENT (LB.IN)	ZZ MOMENT (LB.IN)
PRN1 (CONTD.)								
	25R	8B	7883.55	-5504.67	9174.38	188709.56	-201079.97	91706.02
	26	H5	7883.55	-5504.67	9174.38	188709.56	-178185.19	105442.98
	27L	H9A	7883.55	-5504.67	9174.38	188709.56	-118498.98	141254.95
	27R	H9A	7883.55	-5504.66	9174.38	188709.56	-118498.98	141254.95
	28L	H9	7883.55	-5504.66	9174.38	188709.56	30716.53	230784.80
	28R	H9	0.00	4192.05	1058.25	-119681.19	-147557.61	553174.8[illegible]
	29L	H9B	0.00	4192.05	1058.25	-119681.19	-130345.81	484993.7[illegible]
	29R	H9B	0.00	4192.05	1058.25	-119681.19	-130345.81	484993.7[illegible]
	30	VA2A	0.00	4192.05	1058.25	-119681.19	-92479.85	334995.50
	31		0.00	4192.05	1058.25	-119681.19	-68383.38	239542.31
	32	VA2B	0.00	4192.05	1058.25	-119681.19	-44286.81	144088.70
	33L	H17	0.00	4192.05	1058.25	-119681.19	-15600.47	30453.69
	33R	H17	0.00	397.80	618.26	-119681.19	-15600.47	30453.69
	34L	9A	0.00	397.80	618.26	-119681.19	-1522.52	21395.83
	34R	9A	0.00	-618.26	397.80	-119681.20	-21395.84	-1522.52
	35L	9B	618.26	-0.00	397.80	12337.96	-110623.34	12555.44
	35R	9B	618.26	397.80	0.00	12337.96	12555.44	110623.32
	36	H21	618.26	397.80	0.00	12337.96	12555.44	109329.35
	37		618.26	397.80	0.00	12337.96	12555.44	94319.23
	38		618.26	397.80	0.00	12337.96	12555.44	79309.07
	39		618.26	397.80	0.00	12337.96	12555.44	64298.90
	40		618.26	397.80	0.00	12337.96	12555.44	49288.72
	41	H16	618.26	397.80	0.00	12337.96	12555.44	34278.46
	42L	10A	618.26	397.80	0.00	12337.96	12555.44	26514.57
	42R	10A	618.26	0.00	-397.80	12337.96	26514.57	-12555.44
	43L	10B	0.00	618.26	-397.80	-17456.71	3280.09	-26633.40
	43R	10B	0.00	397.80	618.26	-17456.71	26633.40	3280.09
	44		0.00	397.80	618.26	-17456.71	49174.79	-11223.21
	45		0.00	397.80	618.26	-17456.71	71716.29	-25726.58
	46		0.00	397.80	618.26	-17456.71	94257.78	-40229.96
	47	H15	0.00	397.80	618.26	-17456.71	116799.35	-54733.38
	48		0.00	397.80	618.26	-17456.71	136608.97	-67479.03
	49		0.00	397.80	618.26	-17456.71	156418.64	-80224.75
	50		0.00	397.80	618.26	-17456.71	176228.34	-92970.45
	51		0.00	397.80	618.26	-17456.71	196038.05	-105716.16
	52	11	0.00	397.80	618.26	-17456.71	215847.83	-118461.94

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ARKANSAS POWER & LIGHT SAFETY INJECTION - STRATIFIED FLOW <ark.lb.rev>
ADD 8-INCH LINE REPRESENTATION
USE TEMPS IN BPL LETTER TO ANO 5/11/93
AND EXACT SPRING STIFFNESSES

LOAD CASE NO. 3 (THMN), FORCES AND MOMENTS IN LOCAL COORDINATES (CONTD.)

RUN GROUP	SUP MMB	DCP NAME	AXIAL FORCE (LB)	Y FORCE (LB)	Z FORCE (LB)	XX MOMENT (LB.IN)	YY MOMENT (LB.IN)	ZZ MOMENT (LB.IN)
PRN2								
	53	H9	5229.40	7883.55	-8116.13	164415.38	284416.91	297327.91
	54		5229.40	7883.55	-8116.13	164415.38	86925.04	105495.48
	55		5229.40	7883.55	-8116.13	164415.38	-110567.44	-86337.58
	56L	H7	5229.40	7883.55	-8116.13	164415.38	-308060.50	-278171.19
	56R	H7	5229.40	-15497.11	-8116.13	164415.38	-308060.50	-278171.19
	57L	19A	5229.40	-15497.11	-8116.13	164415.38	-397337.91	-107702.92
	57R	19A	5229.40	-15497.11	-8116.13	164415.39	-397337.88	-107702.92
	58	19B	15497.11	5229.40	-8116.13	494731.44	67021.84	15509.63
	59	20	15497.11	5229.40	-8116.13	494731.44	34557.32	-5407.98

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ARKANSAS POWER & LIGHT SAFETY INJECTION - STRATIFIED FLOW <ark.1b.rev>
ADD 8-INCH LINE REPRESENTATION
USE TEMPS IN BTL LETTER TO ABB 5/11/93
AND EXACT SPRING STIFFNESSES: H9B BILIN, H9A INACTIVE

LOAD CASE NO. 4 (SFL1). FORCES AND MOMENTS IN LOCAL COORDINATES

From Run #5

RUN GROUP	SOP MMB	DCP NAME	AXIAL FORCE (LB)	Y FORCE (LB)	Z FORCE (LB)	XX MOMENT (LB.IN)	YY MOMENT (LB.IN)	ZZ MOMENT (LB.IN)
PRNJ								
	1	1	10298.33	3803.20	6899.24	82801.05	1285893.38	-927278.81
	2		10298.33	3803.20	6899.24	82801.05	1538934.25	-1066767.38
	3		10298.33	3803.20	6899.24	82801.05	1791975.75	-1206256.38
	4		10298.33	3803.20	6899.24	82801.05	2045017.38	-1345745.39
	5L	2A	10298.33	3803.20	6899.24	82801.05	2298060.00	-1485235.50
	5R	2A	10298.33	-7567.76	-2189.23	82801.05	-574753.94	2675193.50
	6L	2B	7567.77	10298.33	-2189.23	625418.25	32136.75	2612001.25
	6R	2B	7567.76	-10298.33	2189.23	602089.69	-30938.06	-2514571.50
	7	3	7567.76	-10298.33	2189.23	602089.69	-13808.94	-2433[illegible]1.75
	8L	4A	7567.76	-10298.33	2189.23	602089.69	3550.67	-2352333.50
	8R	4A	7567.77	-2189.23	-10298.33	602089.63	2352333.50	3550.67
	9L	4B	6899.24	3803.20	-10298.33	-1170408.13	1926854.50	-11343.68
	9R	4B	6899.24	-10298.33	-3803.20	-1170408.00	-11343.68	-1926854.38
	10		6899.24	-10298.33	-3803.20	-1170408.13	-100318.82	-1685927.00
	11L	5A	6899.24	-10298.33	-3803.20	-1170408.00	-189294.33	-1444998.50
	11R	5A	6899.24	-3803.20	10298.33	-1170408.13	-1444998.50	189294.33
	12L	5B	7567.77	2189.23	10298.33	126963.51	-1687133.50	204188.69
	12R	5B	7567.76	-10298.33	2189.23	126963.57	-204188.69	-1687133.50
	13L	H2	7567.76	-10298.33	2189.23	126963.57	-126806.40	-1323120.13
	13R	H2	7567.76	-10517.21	2189.23	126963.57	-126806.40	-1323120.13
	14L	6A	7567.76	-10517.21	2189.23	126963.57	-117516.04	-1278488.50
	14R	6A	7567.77	-10517.21	2189.23	126963.57	-117516.02	-1278488.50
	15L	6B	10517.21	7567.76	2189.23	84999.74	159479.86	-1234680.88
	15R	6B	10517.21	3803.20	6899.24	80213.49	930310.00	-717471.25
	16	H3	10517.21	3803.20	6899.24	80213.49	1137531.00	-831701.81
	17	H4	10517.21	3803.20	6899.24	80213.49	1192790.13	-862163.25
	18L	7A	10517.21	3803.20	6899.24	80213.49	1268771.13	-904047.81
	18R	7A	10517.21	7567.76	2189.23	80213.52	-257898.41	1536415.00
	19L	7B	7567.77	10517.21	-2189.23	303926.41	34185.48	1474403.63
	19R	7B	7567.76	-10517.21	2189.23	303926.41	-34185.49	-1474403.63
	20L	H1	7567.76	-10517.21	2189.23	303926.41	-908.17	-1314537.00
	20R	H1	7567.76	-10325.35	2189.23	303926.41	-908.17	-1314537.00
	21	VA1A	7567.76	-10325.35	2189.23	303926.41	58270.69	-1035423.81
	22		7567.76	-10325.35	2189.23	303926.41	104298.59	-818336.19
	23	VA1B	7567.76	-10325.35	2189.23	303926.41	150326.69	-601247.75
	24L	8A	7567.76	-10325.35	2189.23	303926.41	150439.61	-600715.13
	24R	8A	7567.76	2189.23	10325.35	303926.41	-600715.13	-150439.61
	25L	8B	3803.20	6899.24	10325.35	576094.56	-56356.96	-229588.69

ARKANSAS POWER & LIGHT SAFETY INJECTION - STRATIFIED FLOW <ark lb.rev>
ADD 8-INCH LINE REPRESENTATION
USE TEMPS IN BTL LETTER TO ANO 5/11/93
AND EXACT SPRING STIFFNESSES; H9B BILIN, H9A INACTIVE

LOAD CASE NO. 4 (SELI). FORCES AND MOMENTS IN LOCAL COORDINATES (CONTD.)

RUN GROUP	SGP MMB	DCP NAME	AXIAL FORCE (LB)	Y FORCE (LB)	Z FORCE (LB)	XX MOMENT (LB.IN)	YY MOMENT (LB.IN)	ZZ MOMENT (LB.IN)
PRN1 (CONTD.)								
	25R	8B	3803.20	-10325.35	6899.24	576094.56	229588.69	-56356.95
	26	H5	3803.20	-10325.35	6899.24	576094.56	245486.09	-32564.97
	27L	H9A	3803.20	-10325.35	6899.24	576094.56	286930.34	29460.17
	27R	H9A	3803.20	-10325.28	6899.24	576094.56	286930.34	29460.17
	28L	H9	3803.20	-10325.28	6899.24	576094.56	390540.91	184522.03
	28R	H9	0.00	474125.00	-2874.70	-115191.33	337925.22	106223.08
	29L	H9B	0.00	474125.00	-2874.70	-115191.33	294753.94	-7014038.50
	29R	H9B	0.00	-72710.89	-2874.70	-115191.33	294753.94	-7014038.50
	30	VA2A	0.00	-72710.89	-2874.70	-115191.33	199777.13	-4611749.00
	31		0.00	-72710.89	-2874.70	-115191.33	139337.47	-3083022.75
	32	VA2B	0.00	-72710.89	-2874.70	-115191.33	78897.56	-1554290.38
	33L	H17	0.00	-72710.89	-2874.70	-115191.33	6945.43	265625.63
	33R	H17	0.00	1112.68	-26.89	-115191.33	6945.43	265625.63
	34L	9A	0.00	1112.68	-26.89	-115191.33	6380.16	242231.83
	34R	9A	0.00	26.89	1112.68	-115191.33	-242231.84	6380.16
	35L	9B	-26.89	0.00	1112.68	218838.03	-91797.55	5814.89
	35R	9B	-26.89	1112.68	0.00	218838.05	5814.89	91797.55
	36	H21	-26.89	1112.68	0.00	218838.05	5814.89	88455.56
	37		-26.89	1112.68	0.00	218838.05	5814.89	49688.91
	38		-26.89	1112.68	0.00	218838.03	5814.88	10922.06
	39		-26.89	1112.68	0.00	218838.05	5814.89	-27844.78
	40		-26.89	1112.68	0.00	218838.05	5814.89	-66611.62
	41	H16	-26.89	1112.68	0.00	218838.05	5814.89	-105378.70
	42L	10A	-26.89	1112.68	0.00	218838.05	5814.89	-125430.51
	42R	10A	-26.89	0.00	-1112.68	218838.05	-125430.48	-5814.89
	43L	10B	0.00	26.89	-1112.68	148824.30	195444.25	-5249.62
	43R	10B	0.00	1112.68	-26.89	148824.30	5249.62	195444.25
	44		0.00	1112.68	-26.89	148824.30	4344.51	157986.52
	45		0.00	1112.68	-26.89	148824.30	3439.41	120528.57
	46		0.00	1112.68	-26.89	148824.30	2534.30	83070.63
	47	H15	0.00	1112.68	-26.89	148824.30	1629.19	45612.59
	48		0.00	1112.68	-26.89	148824.30	833.77	12694.33
	49		0.00	1112.68	-26.89	148824.30	38.36	-20224.07
	50		0.00	1112.68	-26.89	148824.30	-757.06	-53142.47
	51		0.00	1112.68	-26.89	148824.30	-1552.48	-86060.87
	52	11	0.00	1112.68	-26.89	148824.30	-2347.90	-118979.44

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ARKANSAS POWER & LIGHT SAFETY INJECTION - STRATIFIED FLOW <ark 1b.rev>
ADD 8-INCH LINE REPRESENTATION
USE TEMPS IN BTL LETTER TO ANO 5/11/93
AND EXACT SPRING STIFFNESSES; H9B BILIN; H9A INACTIVE

LOAD CASE NO. 4 (SFL1). FORCES AND MOMENTS IN LOCAL COORDINATES (CONTD.)

RUN GROUP	SOP MNB	DCP NAME	AXIAL FORCE (LB)	Y FORCE (LB)	Z FORCE (LB)	XX MOMENT (LB.IN)	YY MOMENT (LB.IN)	ZZ MOMENT (LB.IN)
PRN2								
	53	H9	-705.30	3803.20	-9773.93	52553.72	690471.69	-78206.74
	54		-705.30	3803.20	-9773.93	52553.72	452640.13	-170750.98
	55		-705.30	3803.20	-9773.93	52553.72	214807.77	-263295.53
	56L	H7	-705.30	3803.20	-9773.93	52553.72	-23025.27	-355840.34
	56R	H7	-705.30	-17598.58	-9773.93	52553.72	-23025.27	-355840.34
	57L	19A	-705.30	-17598.58	-9773.93	52553.72	-130538.52	-162255.94
	57R	19A	-705.30	-17598.58	-9773.93	52553.71	-130538.50	-162255.94
	58L	19B	17598.58	-705.30	-9773.93	247825.67	-64733.45	57390.69
	58R	19B	17598.58	-705.30	-9773.93	247825.67	-64733.45	57390.69
	59	20	17598.58	-705.30	-9773.93	247825.67	-103829.18	60211.91

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REFERENCES

1) AP&L Dwg 2CCA-25-1, Rev 9, Large Pipe Isometric - Safety Injection System

2) Bechtel Dwg 2GCB-5-4, Rev 06, Isometric - Containment Building Safety Injection

3) Entergy Operations Dwg 2CCA-25-H9, Rev 09, Hanger Detail, SI System

4) Bechtel Dwg H-20-517, Rev 08, Pipe Support, Reactor Building SI

5) ASME Boiler and Pressure Vesel Code, Section III, Class 1 Components, Division 1, Subsection NB, 1986 Division, and Appendicies.

6) ABB Letter ME-93-067, G.A. Pierfedeici to B.T. Lubin, Preliminary Stress Analysis of ANO2 Shutdown Cooling Line with Thermal Stratification, dated 6/8/93.

7) ABB Letter A-MECH-93-012, B.T. Lubin to R. Lane, Return to Power of Arkansas Nuclear One - Unit 2 from Outage 2P-93-1, dated 5/11/93

8) Bechtel Dwg 2CCA-25-2, Rev 6, Large Pipe Isometric - Safety Injection System

9) Calc MISC-ME-C-057, Rev 00, Stress Analysis of Surge Lines for CEOG Task 587, Including Effects of Stratified Flow, dated 8/7/89

10) Calc MISC-ME-C-057, Rev 02, dated 5/13/91

11) Beer. F.P. and Johnston, E.R., "Vector Mechanics for Engineers - Statics and Dynamics", McGraw-Hill Book Co., 1962

12) Calc K-ME-C-021, Rev 01, Surge Line Routing, Support System, and Stress Analysis for YGN 3 & 4, Including Effect of Stratified Flow, dated 12/9/88

13) Tube Turns, "Pipe Fitters Manual", Chemtron Corp., 1977

COMPUTER CODE REFERENCES

NAME	PF ID/VERSION	COMPUTER USED
Superpipe	spipe / Vers 22E	HP9000/400T (Desktop)

COMBUSTION ENGINEERING

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COMPUTER REFERENCE LOG   * = MFRO XXXX

CALC REF #	DESCRIPTION	JOBNAME*	TAPE OR PFN CREATED	DATE	M/FILM OR M/FICHE
1	SOC 0340 CASE WITH FREE ROTATION @ H9	XXXX = HB80	—	6/9/93	M/FICHE
2	SOC 0340 CASE WITH RESTRICTED ROTATION @ H9	ITB3	—	↓	↓
3	RUN #2 W/ END FIXED	JWOI	—	↓	↓
4	SOC 0350 CASE W/ H9 ACTIVE, H9A & H9B INACTIVE	L9FX	—	↓	↓
5	SOC 0350 CASE WITH H9B NONLINEARIZED, H9 ACTIVE & H9A INACTIVE	MFRR 254B	—	7/29/93	↓

I. Model Geometry (Ref. 1+2) - PRELIMINARY + FINAL MODELS

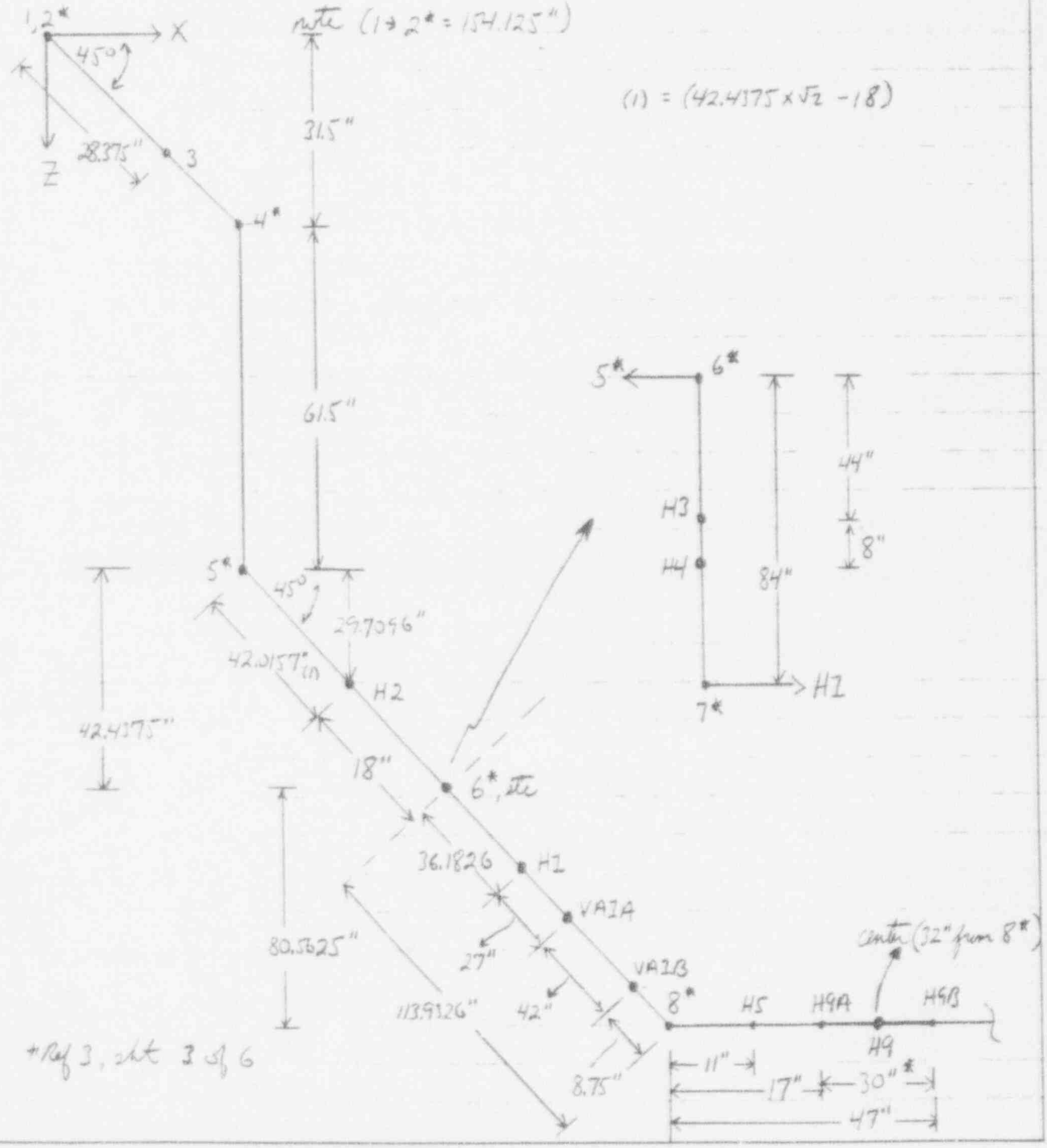

ABB
ASEA BROWN BOVERI

MISC-ME-C-164 — Calculation Number — 00 — Rev.

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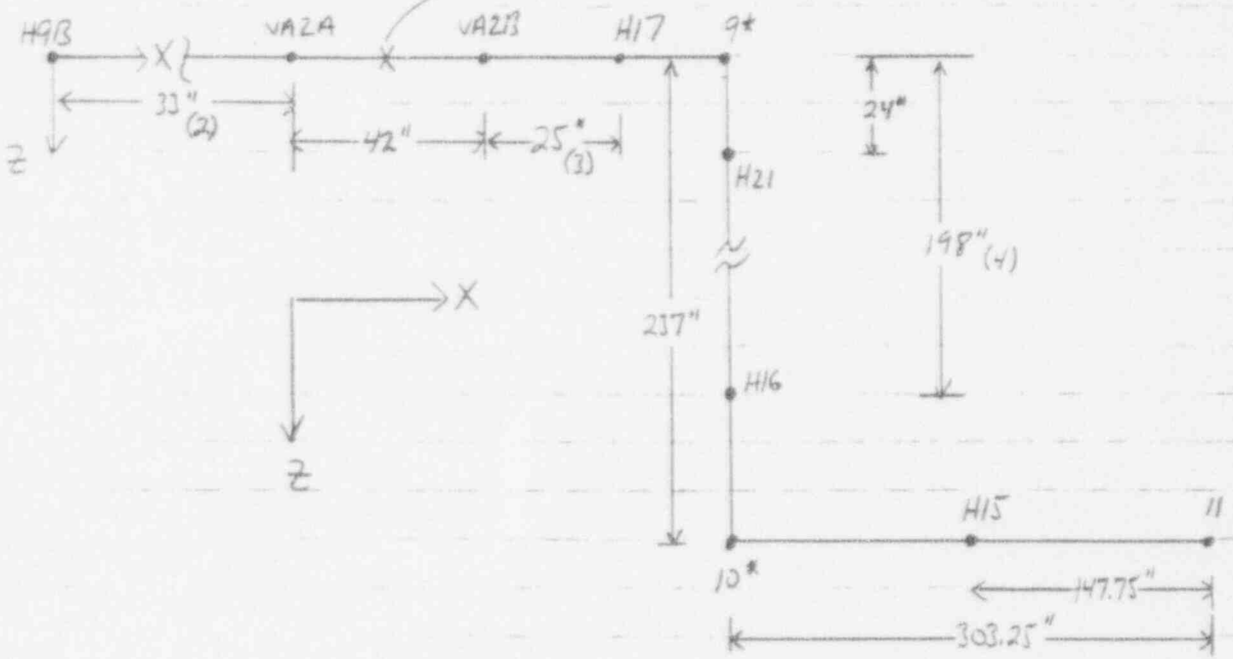
I. Model Geometry (Cont'd)



(2) = 29 + 19 − 15 ← d from center of H9 to H9B

(3) = 5'7" − 3'6"

(4) = 19'9" − 3'3"

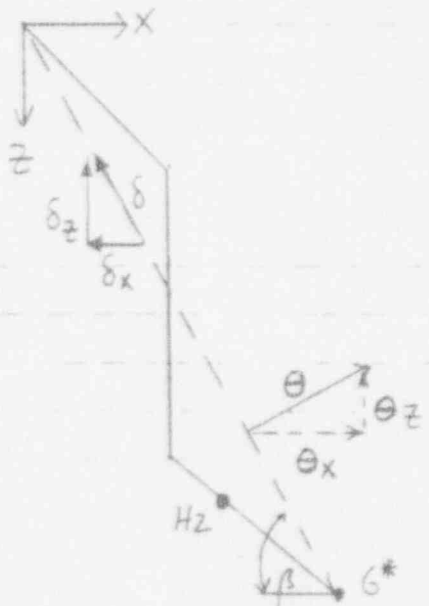
II. Stratified Flow Input (for runs # 1 → 3 - Δ340°F SF)

$LX_1 = LX_{2^* \to 6^*} = 31.5 + 42.4375 = 73.9375$
$LZ_1 = LZ_{2^* \to 6^*} = LX + 61.5 = 135.4375$
} stratified portion of horizontal run $L_1 = 154.305$

$LX_2 = LX_{6^* \to 11} = 80.5625 + 32 + 69 + 46 + 42 + 303.25 = 572.8125$

$LZ_2 = LZ_{6^* \to 11} = 80.5625 + 237 = 317.5625"$ $L_2 = 654.9505$

(I) Calculate SF offsets to 2nd vertical drop (7*)



$\beta = \tan^{-1} \frac{LZ_1}{LX_1} = 61.369°$

Find K:

$K_{12"} = .00026$ when $\Delta T = 320°F$ ← Ref. 12, p. 57

for 14" @ same ΔT,

$K_{14"} = .00026 \times \frac{OD_{12}}{OD_{14}}$

$= .00026 \times \frac{12.75}{14} = .000237$ ← Ref. 13, p. 66

since $K \propto \frac{\alpha \Delta T}{D}$

Add 10% for conservatism ⇒ .00026

Ratio to find $K_{14"}$ @ $\Delta T = 340 = \frac{340}{320} \times .00026$

$= .000277$

At 6*:

$\delta y_1 = -\frac{1}{2} K L_1^2 = -3.2977"$

$\delta x_1 = -K H l_{x_1}$, where $H = 84"$

$= -1.7204"$

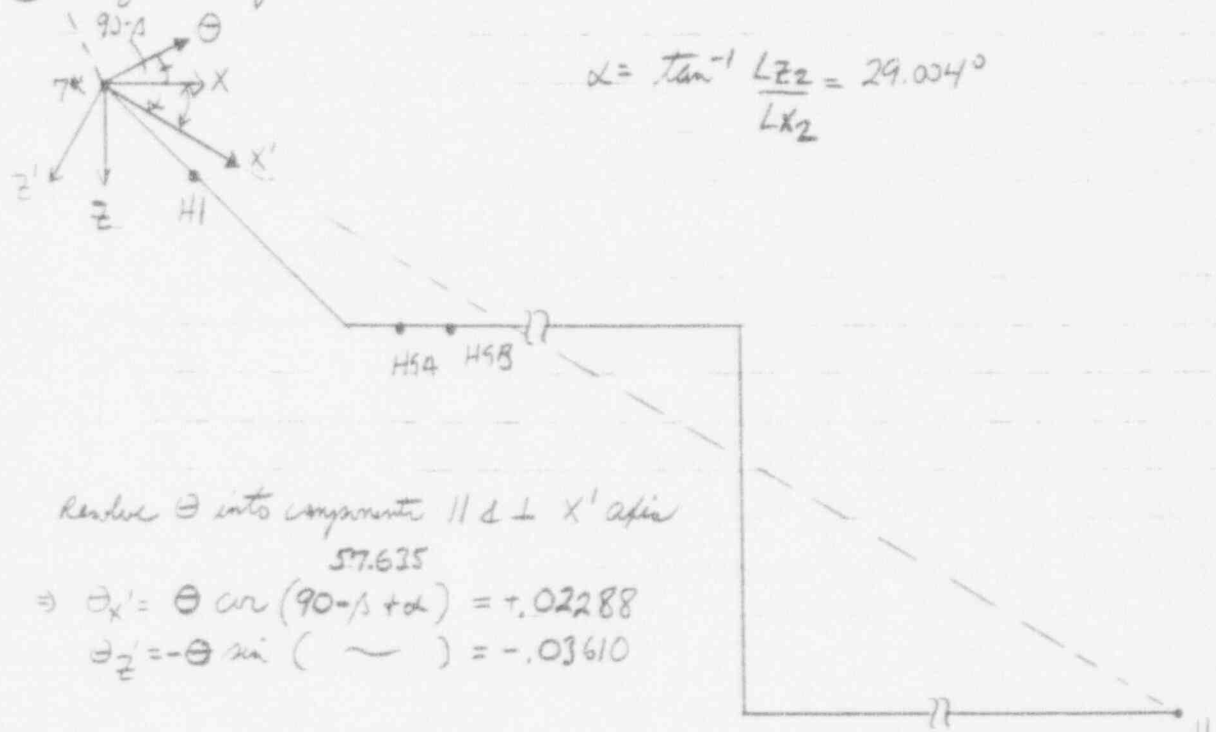
$\delta z_1 = -K H l_{x_1} = -3.1514"$

$\theta x_1 = +K l_{z_1} = +.03752$ rad

$\theta z_1 = -K l_{x_1} = -.02048$ rad

$\theta = K L_1 = .042743$ rad

(II) Rigid body rotation to the end (11).



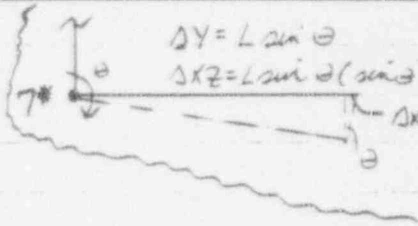
$\alpha = \tan^{-1} \frac{L_{Z2}}{L_{X2}} = 29.004°$

Resolve θ into components ∥ & ⊥ X' axis

57.635

$\Rightarrow \theta_{x'} = \theta \cos(90-\beta+\alpha) = +.02288$

$\theta_{z'} = -\theta \sin(\sim) = -.03610$



$\delta y_2 = -L_2\,\theta_z' = -28.6437''$

$\delta y_T = \delta y_1 + \delta y_2 = -26.9414''$

The equal and opposite motion to be applied to 11 are:

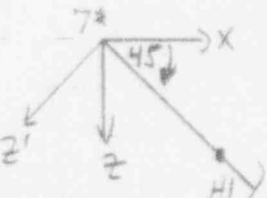
$\delta x = +1.7204$ $\qquad\theta_x = -.03752$

$\delta y = +26.9414$ $\qquad\theta_z = +.02048$

$\delta z = +3.1514$

Find δy values for supports:

Loc	δy
H2	$= +\tfrac{1}{2} K L_{H2}^2$, where $L_{H2} = [(31.5+29.71)^2 + (31.5+29.71+61.5)^2]^{1/2} = 137.1292''$ $\boxed{= +2.6044''}$
H1	do rigid body rotation from 7*



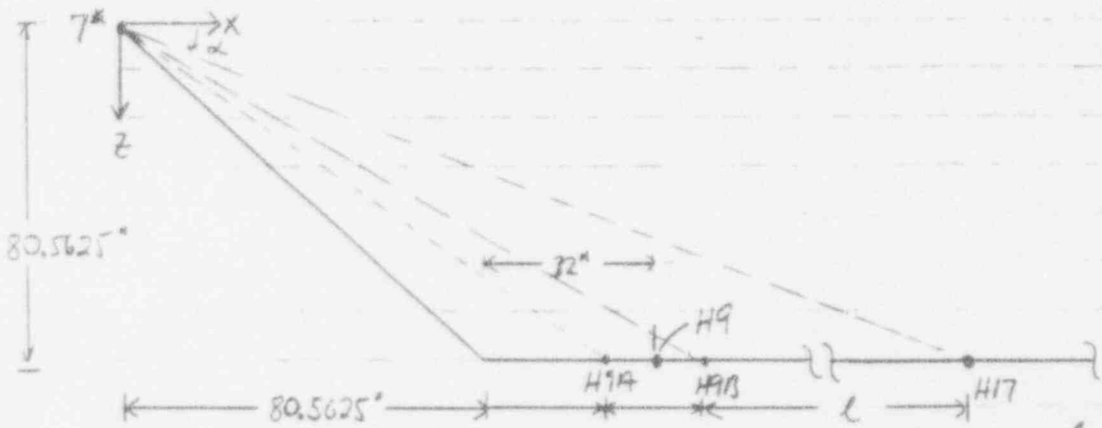
$\alpha = 45$

$\theta_z' = -\theta \sin(28.631 + \alpha) = -.04101$

$\delta y_2 = -(36.1826)\,\theta_z' = +1.4838$

$\boxed{\Rightarrow \delta y_T = +4.7815}$

H9, H9A, H9B + H17



$l = 69 + 46 + 42$
$= 157"$

for H9A, $\alpha = \tan^{-1} 80.5625/(80.5625 + 32 - 15) = 39.547^\circ$

$\theta_{z'} = -\theta \sin(68.179) = -.03968$

$\delta Y_2 = -(80.5625^2 + 97.5625^2)^{1/2} \theta_{z'} = +5.0205"$

$\Rightarrow \delta Y_T = +8.3182$

for H9A, $\alpha = 32.275^\circ$

$\theta_{z'} = -.03735$

$\delta Y_2 = -(80.5625^2 + 127.5625^2)^{1/2} \theta_{z'} = +5.6351"$

$\Rightarrow \delta Y_T = +8.9128"$

for H9, $\alpha = \tan^{-1} 80.5625/(80.5625 + 32) = 35.5918^\circ$
$\theta_{z'} = -\theta \sin(28.631 + \alpha) = 0.03849$
$\delta Y_2 = -(80.5625^2 + 112.5625^2)^{1/2} \theta_{z'} = 5.3279 \Rightarrow \delta Y_T = +8.6256$

H17 $\theta = .042743$

$\alpha = \tan^{-1} 80.5625/(127.5625+157) = 15.8074°$

$\theta_z' = -\theta \sin(28.631+\alpha) = -.029926$

$\delta Y_Z = -295.7467\, \theta_z' = +8.8505 \Rightarrow \boxed{\Delta Y_T = +12.1482}$

use δZ from p. 28 $= \boxed{+3.1514"}$

note - H17 has 1/16" gaps in the ±Z direction, 1/16" in +Y and 0" in -Y. It will be treated as a 0 gapped support in the analysis.

III. BOUNDARY CONDITIONS (FOR RUNS #1-3, Δ340°F SF RUNS)

CASE 1 - 500°F LINEAR CASE

ratio generic values @ 563°F - $\Delta X_G = -.88349"$, $\Delta Y_G = +.38441"$, $\Delta\theta_{Z_G} = +.001219$ rad } REF. 10, p. 048

$$\Rightarrow \Delta X = \Delta X_G \left(\frac{500-70}{563-70}\right) =$$

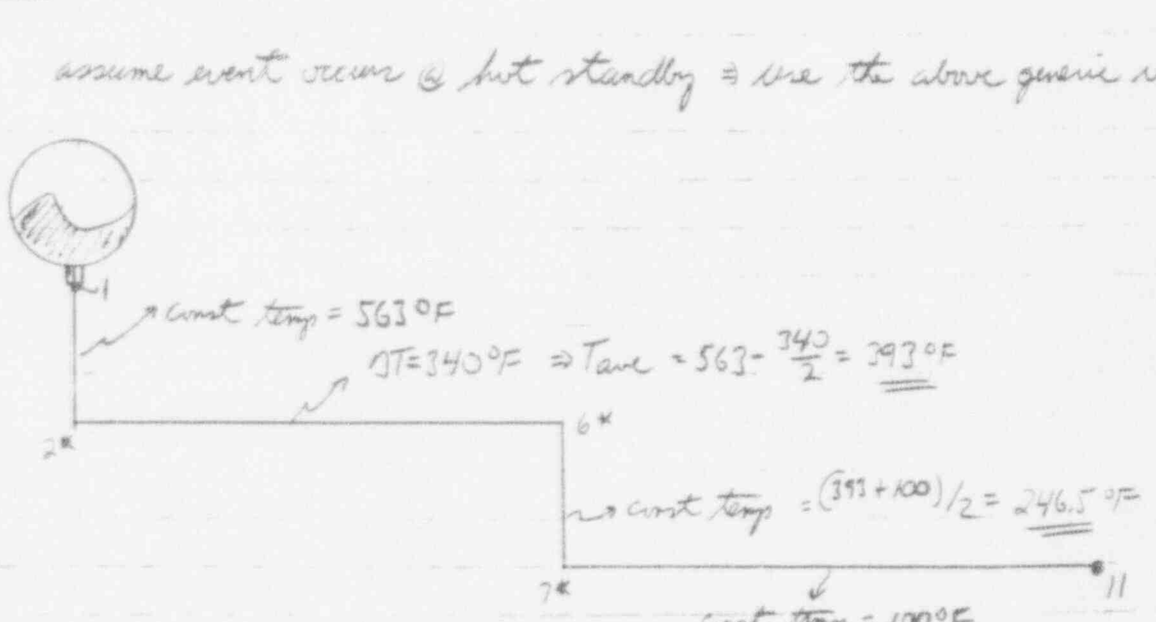
$$= .872211\,\Delta X_G = -.7706$$

$$\Delta Y = +.3353$$

$$\Delta\theta_Z = +.001063$$

CASE 2 - 340ΔT SF Case

assume event occurs @ hot standby ⇒ use the above generic values

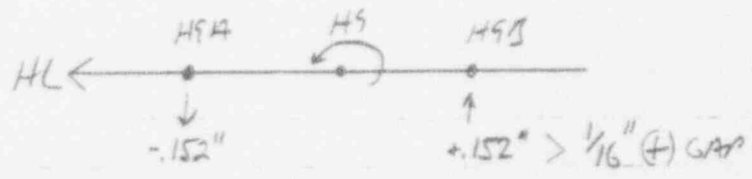


IV. PRELIMINARY ANALYSIS SUMMARY

Run #1 -

H9, H1, H2, H17 ACTIVE

RESULTS -



⇒ BILINEARIZE H9B + RERUN : $\delta y_{H9B} = 8.9328 + 1/16 = +8.9953"$

Run #2 -

RESULTS - OK, H9 has (-) load
H9B has (+) load

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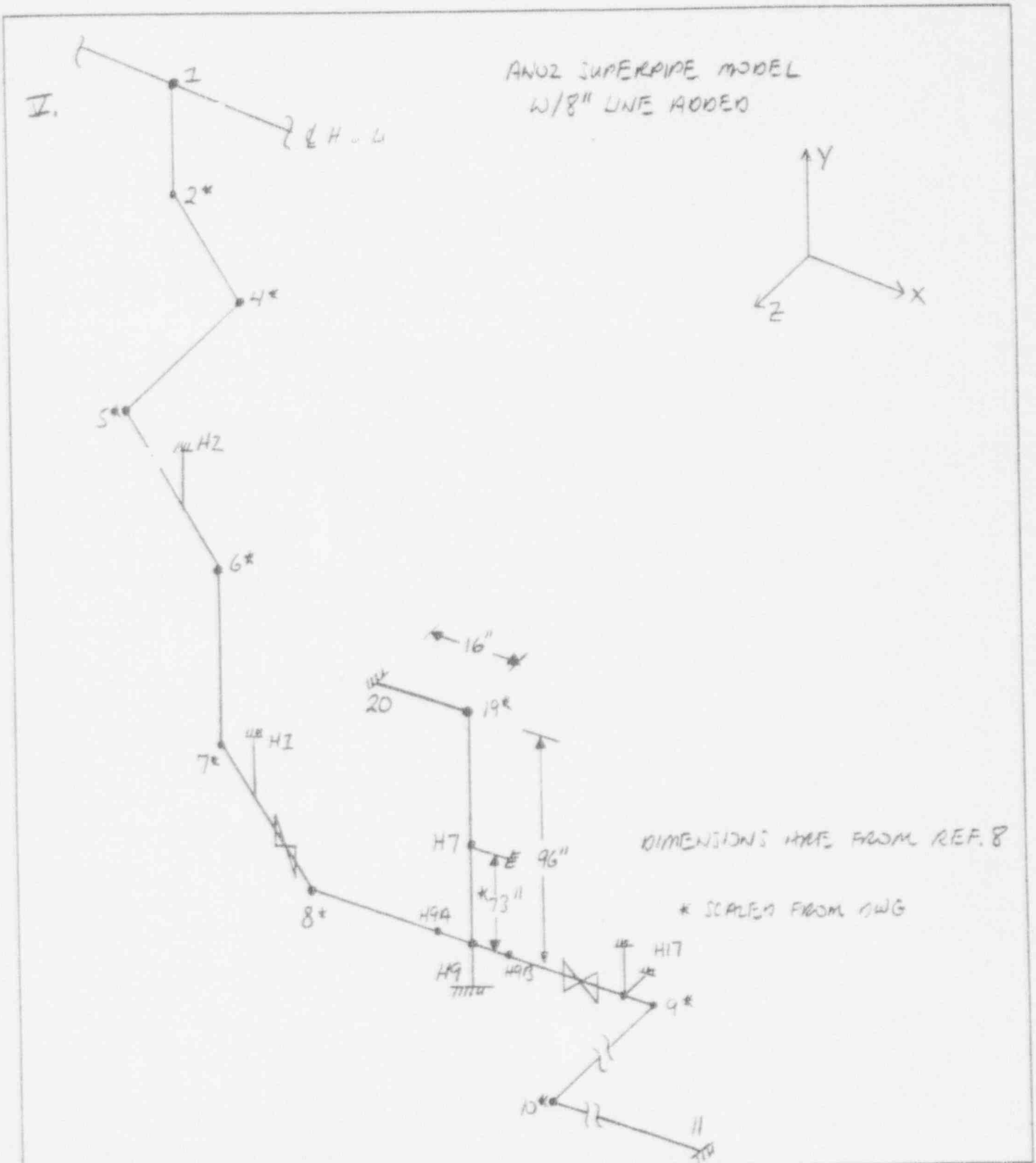

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Re-run with 8" line included, Ref. 7 Temperatures, and exact spring stiffnesses

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VI. CHANGES FOR FINAL ANALYSIS

1. PER REF. 7, use the following temperatures:

S.P. Model Nodes	ΔT	T_{TOP}	T_{BOTTOM}	T_{AVE}
1 to 2B	0	560	560	560
2B to 6B	350	560	210	385
6B to 7B	0	80	80	80
7B to 11	0	80	80	80

2. Per ANO to PH telecon, the exact spring hanger stiffnesses are:

H1 1600 lb/in

H2 1200 lb/in.

On the 8" line:

H6 is a snubber - ignore for thermal loadings

H7 rigid strut (N-S direction)

H8 spring hanger (520 lb/in.)

3. Add a section of the 8" Sch 140 line as shown in the figure on p. 34.

VII Calculate S.F. input displacements at H7X and anchor at 20

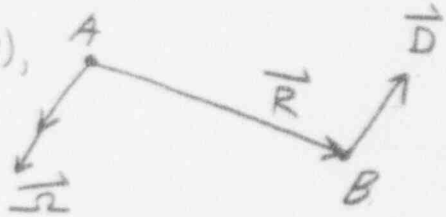
These displacements are due only to rigid body motion from point 6* to points H7 and 20.

at 6*: (see p. 28)

$\Delta Y = -3.3''$ $\theta_X = +.03752$ $\theta_Z = -.02048$

Use the vector cross product to calculate the effect of rigid body rotation at H7 and 20:

$\vec{D} = \vec{\Omega} \times \vec{R}$ (Beer & Johnston (Ref. 11), EQ. 15.5, p. 567)



$\vec{D}$ = displacement vector at point A due to rigid body rotation

$\vec{\Omega}$ = rotation vector at A

$\vec{R}$ = position vector, B relative to A

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At H7:

$$\vec{\Omega} = \begin{Bmatrix} \Omega_x \\ \Omega_y \\ \Omega_z \end{Bmatrix} = \begin{Bmatrix} +.03752 \\ 0.0 \\ -.02048 \end{Bmatrix}$$

(H7, 6*) → See pp. 41-42 for coordinates

$$\vec{R} = \begin{Bmatrix} R_x \\ R_y \\ R_z \end{Bmatrix} = \begin{Bmatrix} 186.5 - 73.938 \\ -165.125 - (-154.125) \\ 216.0 - 135.438 \end{Bmatrix} = \begin{Bmatrix} 112.562 \\ -11.0 \\ 80.562 \end{Bmatrix}$$

↑ H7 ↑ 6*

$$\vec{\Omega} \times \vec{R} = \begin{Bmatrix} \Omega_y R_z - \Omega_z R_y \\ \Omega_z R_x - \Omega_x R_z \\ \Omega_x R_y - \Omega_y R_x \end{Bmatrix}$$

(Beer & Johnson, Eq. 3.9, p. 58)

$$\vec{D}_{H7} = \begin{Bmatrix} -.2255 \\ -5.328 \\ -0.413 \end{Bmatrix}$$

Need to apply D_x only, with reverse sign, but scaled by ΔT ratios

$+.2255 \times \frac{350}{340} = \underline{.2321 \text{ in.}}$

At anchor 20:

$$\vec{R} = \begin{Bmatrix} R_x \\ R_y \\ R_z \end{Bmatrix} = \begin{Bmatrix} 170.5 - 73.938 \\ 142.125 - (-154.125) \\ 216.0 - 135.438 \end{Bmatrix} = \begin{Bmatrix} 96.562 \\ 12.0 \\ 80.562 \end{Bmatrix}$$

(arrows above columns: 20, 6**)

$$\vec{D}_{20} = \vec{\Omega} \times \vec{R} = \begin{Bmatrix} 0.246 \\ -5.000 \\ 0.450 \end{Bmatrix}$$

Add −3.3 to ΔY (since ΔY = −3.3 at 6**)

$$\Delta Y = -5.000 - 3.3 = -8.300$$

Scaling by the ΔT ratio and reversing signs, the deflections and rotations to be applied are:

	X	Y	Z
SUPT HNG7	+.2321	—	—
SUPT AN20	-.2532	+8.5451	-.4632
SUPR AN20	-.03862	0.0	+.02108

note - The boundary conditions on p. 32 are also used for runs #4-6.

VIII. FINAL ANALYSIS SUMMARY

The above changes were made in RUN #4. In this run, H9 was made active, and H9A & H9B were made inactive. The results showed a (-) load @ H9, and a (+) ΔY @ H9B > 1/16".

So, RUN #5 was made with H9 + H9B active.

δy @ H9B was adjusted for the 1/16" gap ⇒

$$\delta y_{H9B} = \left(\frac{350}{340}\right) 8.9328 + 1/16'' = 9.2580''$$

(Note - for the final analysis runs, all S.F. equivalent displacements were scaled by 350°/340° from the values of RUN #1)

The RUN #5 results were: ① H9B had a (+) load ⇒ OK, ② H9A had a (-) ΔY ⇒ OK, ③ H9 had a (-) load ⇒ OK

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IX. ARKANSAS POWER & LIGHT SHUTDOWN COOLING LINE COORDINATES

CONTROL POINT COORDINATES, AS COMPUTED AND STORED

RUN NAME	POINT NAME	POINT TYPE	GLOBAL COORDINATES X (IN)	Y (IN)	Z (IN)
PRN1					
	1		0.000	0.000	0.000
	2A	TNP	0.000	-133.125	0.000
	2*	TIP	0.000	-154.125	0.000
	2B	TNP	14.849	-154.125	14.849
	3		20.064	-154.125	20.064
	4A	TNP	25.349	-154.125	25.349
	4*	TIP	31.500	-154.125	31.500
	4B	TNP	31.500	-154.125	40.198
	5A	TNP	31.500	-154.125	84.302
	5*	TIP	31.500	-154.125	93.000
	5B	TNP	37.651	-154.125	99.151
	H2		61.210	-154.125	122.710
	6A	TNP	64.038	-154.125	125.538
	6*	TIP	73.938	-154.125	135.438
	6B	TNP	73.938	-168.125	135.438
	H3		73.938	-198.125	135.438
	H4		73.938	-206.125	135.438
	7A	TNP	73.938	-217.125	135.438
	7*	TIP	73.938	-238.125	135.438
	7B	TNP	88.787	-238.125	150.287
	H1		99.522	-238.125	161.022
	VA1A		118.614	-238.125	180.114
	VA1B		148.313	-238.125	209.813
	8A	TNP	148.349	-238.125	209.849
	8*	TIP	154.500	-238.125	216.000
	8B	TNP	163.198	-238.125	216.000
	H5		165.500	-238.125	216.000
	H9A		171.500	-238.125	216.000
	H9	BRP	186.500	-238.125	216.000
	H9B		201.500	-238.125	216.000
	VA2A		234.500	-238.125	216.000
	VA2B		276.500	-238.125	216.000
	H17		301.500	-238.125	216.000
	9A	TNP	322.500	-238.125	216.000
	9*	TIP	343.500	-238.125	216.000
	9B	TNP	343.500	-238.125	237.000

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CONTROL POINT COORDINATES, AS COMPUTED AND STORED (CONTD.)

RUN NAME	POINT NAME	POINT TYPE	GLOBAL COORDINATES X (IN)	Y (IN)	Z (IN)
PRN1 (CONTD.)					
	H21		343.500	-238.125	240.000
	H16		343.500	-238.125	414.000
	10A	TNP	343.500	-238.125	432.000
	10*	TIP	343.500	-238.125	453.000
	10B	TNP	364.500	-238.125	453.000
	H15		499.000	-238.125	453.000
	11		646.750	-238.125	453.000
PRN2					
	H9	BRP	186.500	-238.125	216.000
	H7		186.500	-165.125	216.000
	19A	TNP	186.500	-154.125	216.000
	19*	TIP	186.500	-142.125	216.000
	19B	TNP	174.500	-142.125	216.000
	20		170.500	-142.125	216.000

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APPENDIX - RUN #5 INPUT FILE LISTING

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```
ARKANSAS POWER & LIGHT SHUTDOWN COOLING LINE - STRATIFIED FLOW    <ark.2f.rev>
               ADD 8-INCH LINE REPRESENTATION
                   USE TEMPS IN BTL LETTER TO ANO 5/11/93
*                      AND EXACT SPRING STIFFNESSES; H9B BILIN;      H9A INACTIVE
 NOFL                                                          H9 ACTIVE
C
C
 EXEW STAT COMB DESC
C
C USE NEXT CARD FOR DATA CHECK ONLY
C
CCHEK                DESC E-80
C
C CARD B4- UNITS (BLANK FOR DEFAULT)

C
C SECT. C1% TITLE OF GEOMETRY SET
 ARK     2    0 E-80      XPRN         ARK SHUTDOWN COOLING LINE
C
C SECT. D1A% PIPE RUN NAME & TITLE
 PRN1 CLS1          ARK SAFETY INJ  14-INCH LINE
    1                  DIR 0.0
   2*  TIP   21.0      OFF            -154.125                1
    3                  STL 28.375                             2*   4*
   4*  TIP   21        OFF 31.5                 +31.5         2*
   5*  TIP   21        OFF                      61.5          4*
   H2                  STL  18.00                             6*   5*
   6*  TIP   14        OFF  42.4375             +42.4375      5*
   H3                  OFF             -44.                   6*
   H4                  OFF             -52.                   6*
   7*  TIP   21        OFF             -84.                   6*
   H1                  STL  27.                             VA1A   7*
 VA1A                  STL  42.                             VA1B   7*
 VA1B                  STL  8.75                              8*   7*
   8*  TIP   21        OFF  80.5625             80.5625       7*
   H5                  STL  11.                               8*   9*
  H9A                  STL  17.                               8*   9*
   H9  BRP             STL  32.                               8*   9*
  H9B                  STL  47.                               8*   9*
 VA2A                  STL  33.                              H9B   9*
 VA2B                  STL  42.                             VA2A   9*
  H17                  OFF  25.                             VA2B
   9*  TIP   21        OFF  189.                              8*
  H21                  OFF                       24.0         9*
  H16                  OFF                      198.0         9*
```

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```
 STRP  8S140
 BELB  8S140
 BELB  14S140
                MASS 13.333     1.724    1.288     60.
 BELB  14S20
                MASS 13.333     1.724    1.288     60.
 VALV  VALVE         20.0       4.0
*FGBW  FGBW
C
C CARDS F% MATERIAL PROPERTIES
C
C    SA403 WP316
*SA312 TP316
 STRP STRP  14S140   SA312 TP316      2A
 FGBW FGBW  FGBW
 BELB BELB  14S140   SA312 TP316      2B
 FGBW FGBW
 STRP STRP                            4A
 FGBW FGBW
 BELB BELB  14S140                    4B
 FGBW FGBW
 STRP STRP                            5A
 FGBW FGBW
 BELB BELB                            5B
 FGBW FGBW
 STRP STRP                            6A
 FGBW FGBW
 BELB BELB  14S140                    6B
 FGBW FGBW
 STRP STRP                            7A
 FGBW FGBW
 BELB BELB                            7B
 FGBW FGBW
 STRP STRP                          VA1A
 FGBW FGBW
 VAL1 VALV  VALVE    SA312 TP316    VA1B
 STRP STRP                            8A
 FGBW FGBW
 BELB BELB  14S140                    8B
 FGBW FGBW
 STRP STRP                           H9A
 HAN9 VALV                           H9B
 STRP STRP                          VA2A
 VAL2 VALV                          VA2B
 STRP STRP  14S20                     9A
 FGBW FGBW
 BELB BELB  14S20                     9B
 STRP STRP                           10A
 FGBW FGBW
 BELB BELB                           10B
 FGBW FGBW
*STRP STRP                            11
 STRP STRP  8S140    SA312 TP316     19A
 BELB BELB  8S140    SA312 TP316     19B
*STRP STRP                            20
C
C SECT. H% LUMPED WEIGHTS
*
```

```
C
C  SECT. I% SUPPORTS
 HOTL    1 ANCH
 HNG1   H1 HANG        1600.0                                            Y
 HNG2   H2 HANG        1200.0                                            Y
 HNG9   H9 HANG                                                          Y
 HN9A  H9A HANG           1.0                                            Y
C
C   H9B BILINEARIZED
 HN9B  H9B HANG                                                          Y
 H17Y  H17 HANG                                                          Y
 H17Z  H17 HANG                                                          Z
 ENDS   11 ANCH                                                U
 HNG7   H7 HANG                                                          X
*AN20   20 ANCH
C
C CARD J% OUTPUT POINTS
 SOPS                 36.
*DOPS                 36.
C
C SECT. L% STATIC ANALYSES
 EXP0 THRM NOPR                               ZERO-LOAD
 AUTE
 FFPR         0.
*RUNL      70.        70.
 EXPN THRM NOPR                               THERMAL - 500 DEG CONST TEMP
 AUTE
 FFPR      2250.
 RUNL PRN1     500.    70.                       1   11
 SUPT HOTL -.7706    +.3353       0.
*SUPR HOTL                     +.00106
 EXP1 THRM PRIN                               THERM EXPN-STRATIFIED CASE
 AUTE
 FFPR       2250.
 RUNL PRN1     560.    70.                       1   2B
 RUNL PRN1     385.    70.                      2B   6B
 RUNL PRN1      80.    70.                      6B   7B
 RUNL PRN1      80.    70.                      7B   11
 SUPT HOTL -.8835    +.3844       0.
*SUPR HOTL                     +.00122
 STR1 THRM PRIN                               STRATIFIED FLOW INPUT
 FFPR      2250.
 TEME PRN1     560.    70.                       1   2B
 TEME PRN1     385.    70.                      2B   6B
 TEME PRN1      80.    70.                      6B   7B
 TEME PRN1      80.    70.                      7B   11
C
C  THESE ARE SCALED BY 350/340
 SUPT HNG2           +2.6810
 SUPT HNG1           +4.9221
 SUPT HNG9           +8.8793
 SUPT HN9A           +8.5629
C
C DEL-Y H9B = 9.1955 + 1/16"
 SUPT HN9B           +9.2580
 SUPT H17Y           +12.5055
 SUPT H17Z                     +3.2441
 SUPT ENDS+1.7710    +27.7338  +3.2441
```

```
 SUPR ENDS-.03862     0.0     +.02108
 SUPT HNG7+0.2321
 SUPT AN20-0.2532    +8.5451  -0.4632
*SUPR AN20-.03862     0.0     +.02108
*GRAV GRAV NOPR                           DUMMY WEIGHT LOADING
 TEME       650.       650.
 MASS     1.0       1.0        1.0
 FFPR       2250.
*GRAV
C
C SECT. RA- COMB OPTION (PRINT COMB'S FOR SUPPORT LOADS & DISPS)
C
C ALSO DEFINE LOAD CASES FOR DESIGN CHECK
 GRA1 GRAV NOPR            GRAV   1.0
 THM0 EXPN NOPR            EXP0   1.0
 THMN EXPN PRNX            EXPN   1.0
*SFL1 EXPN PRNX       DSUM EXP1   1.0     STR1       1.0
C
C SECT. T% CLASS 1 DESIGN CHECKING
C
C SECT. T1% CONTROL CARD
*CL1A       DETL       OLDC NEWP NEWT
C
C SECT. T5% PRESSURE DISTRIBUTIONS
 PRD0                  PRESSURE DISTRIBUTION FOR PD/2T (ZERO LOAD)
*                    0.
 PRDD                  PRESSURE DISTRIBUTION FOR PD/2T (DESIGN PRESSURE)
*               2500.
 PRD1                  PRESSURE DISTRIBUTION FOR 440-120 CASE
*                410.
*PRD2                  PRESSURE DISTRIBUTION FOR 653 CASES
*               2250.
C
C SECT. T6% TEMPERATURE DISTRIBUTIONS
*TMD1                 TEMPERATURE DISTRIBUTION FOR SM DETERMINATION
*               700.
C
C SECT. T7% DEFINE LOAD SETS FOR EQ 9. DESIGN CONDITION
*DES  DCON PRDD TMD1 GRA1                               DES PRES+WEIGHT
C
C SECT. T8A% CONTROL CARD FOR NB3653 CONDITIONS
    0   .1 2.4   100 3.0 2.4   0.1                         NB3653
C
C T9- LOAD SETS FOR NB3653 CONDITIONS.
C
C USED TO DETERMINE STRESS RANGES.
 ZERO       1000       PRD0 TMD1       THM0                ZERO-LOAD
 SFL_       1000       PRD2 TMD1       SFL1                340 DELTA T CASE
*T500       1000       PRD2 TMD1       THMN                500 DEG CASE
```

APPENDIX C

to

ABB-CE Report No. A-MECH-ER-009, Rev.00

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Contract 2002243-1

Calculation 19 Pages

Appendix A12 Pages

Microfiche N/A

Calculation Number A-MECH-CALC-023

Revision 00

Title Preliminary Stress and Fatigue Analysis of Thermal Stratification in the ANO2 Shutdown Cooling Line 2CCA-25-14"

Author P.I. Hammer Paul I. Hammer

Date 8/11/93

Calculation contains safety related design information: Yes X No ___

VERIFICATION STATUS: COMPLETE

The Safety-Related design information contained in this document has been verified to be correct by means of:

✓ Design Review using Checklist(s) 2 of QAM-101.

___ Alternate Analysis - Copy attached.

___ Verification Testing - Test Report No. ______

Robert C. Wheeler Robert C. Wheeler 8/11/93

Independent Reviewer: Name/Signature/Date

Approved by B.T. Lubin (Supervisor - Fatigue Evaluation Services)

Date 8/12/93

Distribution B. Boya (2), G. Perfedaici

Summary Purpose:

-to perform a preliminary stress and fatigue analysis of the ANO2 Shutdown Cooling Line in consideration of previously unanalyzed stratified conditions.

Method and Results of Review:

This calculation was verified by the method of Design Review and satisfies, where applicable, the items on Checklist No. 2 of the Quality Assurance Procedures Manual, QAM-101.

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RECORD OF REVISIONS

No.	Date	Pages Involved	Performed by	Approved by
00	8-12-93	- ALL -	P.I. Hammer	[signature]

TABLE OF CONTENTS

1.0 PURPOSE

To perform a preliminary, bounding stress and fatigue analysis of the ANO2 Shutdown Cooling (SDC) line in consideration of previously unanalyzed stratified conditions; these conditions were observed to occur during power changes but are currently not part of the SDC line design basis. This analysis is being done per Reference 1.

2.0 SCOPE

Reference 2 determined moment loadings resulting from a 350°F top-to-bottom differential in the first horizontal section of SDC piping. This analysis will incorporate the results of Reference 2 into the current design basis stress and fatigue analysis for the Class 1 SDC line, 2CCA-25-14"; this analysis will be performed as a bounding analysis of a stress limiting location and will be based on the 1986 ASME Code (Reference 3), to be used for preliminary evaluation.

3.0 SUMMARY OF RESULTS

The stress ranges incorporating the 350°F Thermal Stratification conditions for the limiting location are satisfactory and meet the appropriate allowables of Reference 3. Additionally, the increases in fatigue due to thermally stratified conditions to-date and for the near future are acceptable.

4.0 ANALYSIS

In order to determine bounding stress effects of the stratified conditions on the 14" Class 1 piping, a location that is limiting with respect to stress and fatigue is chosen. Review of References 2 and 4 indicates that the vertical weld at the first elbow downstream of the Shutdown Cooling Outlet Nozzle may be considered as the limiting location, for the following reasons:

Per Reference 2, the highest loadings from the stratified condition were calculated for this location. This determination is made by a review of the moment loadings and ASME Code Equation 10 values of Reference 2 (Calc. Ref./Computer Ref. No. 5; see page 24 of Reference 2); the location is designated as 2A. (Note: the Equation 10 values given in Reference 2 are used for comparison purposes only).

Per Reference 4, this location (designated in this Reference as Data Point 10) has one of the highest usage factors in the portion of the SDC line that directly experiences the stratified conditions (i.e., the first horizontal section of piping downstream of the Shutdown Cooling Outlet Nozzle).

The analysis will determine stress allowables according to Paragraphs NB-3653.1, NB-3653.2, NB-3653.6, and NB-3653.7 of the 1986 ASME Code, as well as estimate increases in the usage factor to-date and for the near future.

4.1 Assumptions

1. The Code of Record for the SDC line is the ASME Boiler and Pressure Vessel Code, 1971 Edition through the Summer 1972 Addenda (per Reference 5). Initial evaluations of the effects of the stratified conditions indicated that usage factor results may be unacceptable if it were calculated in accordance with the Code of Record. The primary reason for this unacceptability is due to the fact that the Code of Record categorizes the ΔT_1 (linear gradient) stress as a Secondary stress. One potential - and significant - effect of this categorization is an increased Primary-plus-Secondary Stress Intensity Range (as calculated in Equation 10) such that a [greater] K_e multiplier would be used in calculating the alternating stress (per Equation 14); a higher alternating stress results in a higher fatigue usage factor. The 1986 ASME Code considers the same ΔT_1 stress as a Peak stress only.

The use of the 1986 Code for this evaluation is justified in that this evaluation is being performed to assess the structural integrity of the SDC line for near-future operations in consideration of the previously unanalyzed stratified conditions. Use of the 1986 Code, in spite of the difference in categorization of the ΔT_1 stress term, still results in conservative values. Additionally, there is precedent in the use of a later Code (and non-Code of Record) for fatigue analysis of thermally stratified lines, as permitted in NRC Bulletin 88-11 (for Pressurizer Surge Line Thermal Stratification; dated December 20, 1988).

2. The radial gradient (through-wall or local) stresses for the stratified conditions are accounted for by incorporating a ratio-ed stress based upon analysis of stratified conditions in a pressurizer surge line. Reference 6 accounted for stratified conditions for a 320°F top-to-bottom ΔT for a 12-inch, Schedule 160 (stainless steel) line, with a local stress value of 15.3 ksi. When multiplied by a ratio of 350/320 (to account for a larger SDC line ΔT), the stress value becomes 16.7 ksi. Though the surge line and SDC line pipe sizes and schedules differ, and though conditions internal to the pipes may differ, it is assumed that the difference in resulting steady state local stresses is minimal such that use of the surge line analysis is acceptable.

   For calculation of the Peak Stress Intensity Ranges (ASME Code Equation 11) in Section 4.2, the local stress value is assumed to be additive, without consideration of the actual algebraic sign. This assumption is conservative since the the resulting Peak Stress Intensity Range is maximized.

3. An S_m value for the elbow material (SA-403, WP-316; see Figure 1) was not directly obtainable from the appropriate table of the 1986 Code (Table I-1.2). Note (4) of this Table specifies that the Sm value for SA-403, WP-316, is to be "the same as those assigned to the material from which the [elbow] is made." Consequently, an S_m value was obtained by first correlating the S_m values used for Data Point 10 in Reference 4 (Page 1128) to a material(s) whose S_m values are given in the Code of Record. (For example, the S_m value used for Load Set Pair 0--1 was 57600 psi/3 = 19.2 ksi (T=400°F). Also, the S_m value used for Load Set Pair 0--15 was 50700 psi/3 = 16.9 ksi (T=611°F).) The Load Set S_m values correspond to a set of high alloy steels given on Page 396 of Table I-1.2 in the Code of Record. A corresponding S_m value for the same material(s) was then

selected from Table I-1.2 of the 1986 Code.

The temperature at which the S_m value was chosen is 400°F. This temperature is the approximate average temperature for the stratified conditions; it is higher than the average temperature experienced by the line for either of the design basis Load Cases 14 or 17 and, therefore, results in a lower, more conservative S_m value.

4. Load Combination No.1 is used in this calculation to designate the Load Set consisting of Load Case No. 17 - Cooldown with Initiation of Shutdown Cooling (Ref. 4) and the 350°F Thermal Stratification conditions. In order to account for fatigue effects of this Load Combination, it will be assumed that this Load Combination has occurred the same number of times that the plant has had a heatup-cooldown cycle. Review of the information provided in the table in Appendix A entitled "Unit 2 RCS Heatup/Cooldown" indicates that ANO2 has had a heatup/cooldown cycle a total of 68 times, up to and including 2P93-1 (5/1/93).

5. Load Combination No.2 is used in this calculation to designate the Load Set consisting of Load Case No. 14 - S.I. Check Valve Test transient (Ref. 4) and the 350°F Thermal Stratification conditions. In order to account for fatigue effects of this Load Combination, it will be assumed that this Load Combination has occurred the same number of times that the plant has had either a Power Reduction, a Reactor Trip, or Loss of Reactor Coolant Flow.

   Since the number of Power Reductions is available from 2R8 (see the table "ANO2 Power Transient History 2R8 to Present" in Appendix A), the number of Power Reductions prior to 2R8 will be "backfitted" by determining the rate at which Power Reductions have occurred since 2R8 and tripling that rate to estimate how many occurred prior to 2R8 back to Startup (see Section 4.3).

4.2 Details: Stress Considerations

Evaluation of the stresses from the design basis analysis (Ref. 4) indicates that the primary contributors to the fatigue usage factor for the elbow are Load Cases 17 and 14 (Cooldown - with Shutdown Cooling Initiation - and the S.I. Check Valve Test, respectively). Consequently, each of these will be evaluated in a Load Combination with the Thermal Stratification condition.

Load Combination No. 1:

Load Case No. 17 and 350°F Thermal Stratification

[ASME CODE - REF. 3]

4) NB-3653.1 Primary Plus Secondary Stress Intensity Range, S_n:

$$S_n = C_1 \frac{P_o D_o}{2t} + C_2 \frac{D_o}{2I} M_i + C_3 E_{ab} \times |\alpha_a T_a - \alpha_b T_b| \leq 3 S_m$$

[Equation 10]

$C_1 = 1.22$ - Ref. 2 (Computer Run No. 5)

$C_2 = 2.61$ "

$C_3 = 1.00$ "

$P_o = |385 - 2235|$ psi = 1850 psi

385 psi - Ref. 4, p. 22

2235 psi - Ref. 4, p. 21

D_o = 14 in - Figure 1 for "14" SCH 140"
- Ref. 7, for dimensions

t = 1.25 in "

I = 1027 in^4 "

$\alpha_a T_a - \alpha_b T_b = 0$

S_m = 19.3 - Ref. 3, Table I-1.2 (@400°F) (see Assumption 3)

M_i is calculated, as follows:

Load Case No. 17	M_A	M_B	M_C
(Ref. 4, p. 1107 for Location 10)	-9 ft-lb	14207 ft-lb	-27032 ft lb
	= -0.1 in-kips	170 in-kips	-324 in-kips

350°F Thermal Stratification	M_x	M_y	M_z
	82.8 in-kips	-575 in-kips	2675 in-kips
Rotated to Ref. 4 orientation	82.8	575	-2675

RANGES	M_A	M_B	M_C
	82.9	405	2351

$$M_i = \sqrt{M_A^2 + M_B^2 + M_C^2}$$

$$= 2387 \text{ in-kips}$$

$\Longrightarrow S_n = 12.6 + 42.5 + 0 = 55.1 \text{ ksi} \leq 3S_m = 57.9 \text{ ksi}$

3) NB-3653.2 Peak Stress Intensity Range, S_p :

$$S_p = K_1 C_1 \frac{P_o D_o}{2t} + K_2 C_2 \frac{D_o}{2I} M_i + \frac{1}{2(1-\nu)} K_3 E\alpha|\Delta T_1| + K_3 C_3 E_{ab} \times |\alpha_a T_a - \alpha_b T_b|$$

$$+ \frac{1}{1-\nu} E\alpha\, |\Delta T_2|$$ [Equation 11]

$K_1 = K_2 = K_3 = 1.0$ -Ref. 2 (Calc. Ref No 6)

$\nu = 0.3$ -Ref. 4, p. 1105

$E = 28.3 \times 10^6$ psi -Ref. 3

$\alpha = 8.42 \times 10^{-6}$ in/in °F "

ΔT_1 for Load Case No. 17 = 203°F -Ref 4, p 1105

ΔT_2 for Load Case No. 17 = 120°F "

The radial gradient through-wall) stresses for the 350°F Thermal Stratification condition will be accounted for by adding the through-wall stress value of 16.7 ksi (see Assumption 2).

⟹ S_p = 12.6 + 42.5 - 34.6 + 40.8 + 0 + 16.7 = 147.2 ksi

C) NB-3653.6 Simplified Elastic-Plastic Discontinuity Analysis

Since Equation 10 is satisfied for Load Combination No. 1, the alternative analysis allowed under this Analysis section will not be used.

D) NB-3653.7 Thermal Stress Ratchet

Since Equation 10 is satisfied for Load Combination No. 1, consideration of the ΔT_1 range is not required.

Consequently, per NB-3653.3, the Alternating Stress Intensity for Load Combination No. 1 is calculated as follows:

$$S_{alt} = \frac{S_p}{2}$$

$$= \frac{147.2}{2}$$

$$= 73.6 \text{ ksi}$$

Load Combination No. 2:

Load Case No. 14 and 350°F Thermal Stratification

A) NB-3653.1

All terms are the same as for Load Combination No. 1 except

$P_o = |2235 - 1635| = 600$ psi

2235 psi - Ref 4, p. 21

1635 psi - " - conservatively assumed low for Reactor Trip

Load Case No. 14	M_A	M_B	M_C
(Ref. 4, p 1086)	22741 ft-lb	-13427 ft-lb	10694 ft-lb
	= 273 in-kips	-161 in-kips	128 in-kips
RANGES	190.2	736	-2803

M_i = 2904 in-kips

$\Longrightarrow S_n = 4.1 + 51.7 + 0 = 55.8 \text{ ksi} \leq 57.9 \text{ ksi}$

B) NB-3653.2

For Load Case 14: $\Delta T_1 = -128°F$ - Ref. 4, p. 1084

$\Delta T_2 = -32°F$ "

$\Longrightarrow S_p = 4.1 + 51.7 + 21.8 + 0 + 10.9 + 16.7 = 105.2$ ksi

$\Longrightarrow S_{alt} = \frac{S_p}{2} = 52.6$ ksi

4.3 Details: Fatigue Considerations

Consideration of fatigue effects is accomplished by the evaluation of cumulative fatigue at the same weld which was evaluated for stresses (in the previous section). Emphasis for the fatigue effects will be upon determining the increase in the fatigue usage factor to-date and for the near future. It is noted that the limiting location does not have the highest usage factor for the entire line. However, the increase in the fatigue usage factor for this location for consideration of thermally stratified conditions effectively bounds all locations in the line.

A) DETERMINATION OF TRANSIENT OCCURRENCES for LOAD COMBINATION NO. 2

Power Reductions:

Number of Power Reductions in the two (2) years since 2RB: 16

Estimated number of Power Reductions in the thirteen (13) years prior to 2RB: 312

$$\text{Number} = \frac{16}{2} \times 3 \times 13 =$$

- $\frac{16}{2}$ → Rate per year since 2RB
- 3 → Rate prior to 2RB tripled that since 2RB
- 13 → Number of years prior to 2RB

Reactor Trips and Loss of Reactor Coolant Flows:

$$\text{Number} = (103 + 1) + 4 = 108$$

- 1 → Turbine Trip with Delayed Reactor Trip

TOTAL NUMBER OF TRANSIENTS TO-DATE 436

3) To-date Fatigue Usage Factor Calculation:

	Salt	Nall	N	U	
Load Comb. No. 1	73.6 ksi	5690	68	.012	0.029
Load Comb. No. 2	52.6 ksi	26,200	436	.017	
Design Basis Usage Factor (Ref. 4, p. 112B)				.044	
		Total U		0.073	

c) Near Future Fatigue Usage Factor Calculation.

The Near Future Fatigue Usage Factor will be calculated on the assumption that there will be ten (10) additional Heatup/Cooldown cycles and 1000 (one thousand) additional Power Reductions (including Trips, etc.)

	Salt	Nall	N	U	
Load Comb. No 1	73.6 ksi	5690	78	.014	0.069
Load Comb. No. 2	52.6 ksi	26,200	1436	.055	
Design Basis Usage Factor				.044	
		Total U		0.113	

$\Delta = 0.113 - 0.073 = 0.040$

According to the 1986 ASME Code, then, the increase in the fatigue usage factor for the elbow is 0.029 to-date and 0.069 for the near future (10 additional Heatup-Cooldown cycles and 1000 additional Power Reductions, including Trips, etc.). For the location on the line with the highest usage factor - 0.398 at Data Point 63 (per the Code of Record and Reference 4) - the overall usage factor for the near future becomes 0.398 + 0.069 = 0.467. It is noted that this value is based upon the occurrence of all design basis transients as well as the additional Load Combinations.

ABB
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5.0 REFERENCES

1. Arkansas Nuclear One Contract Order No. 103, under Contract No. A-1007.

2. ABB CE Calculation No. MISC-ME-C-164, Rev. 01, July 1993.

3. The ASME Boiler and Pressure Vessel Code, Section III, 1986 Edition, no Addenda.

4. ANO2 Report No. 85-E-0055-21, Rev 00 (including Class 1 Stress Analysis of the Shutdown Cooling Line).

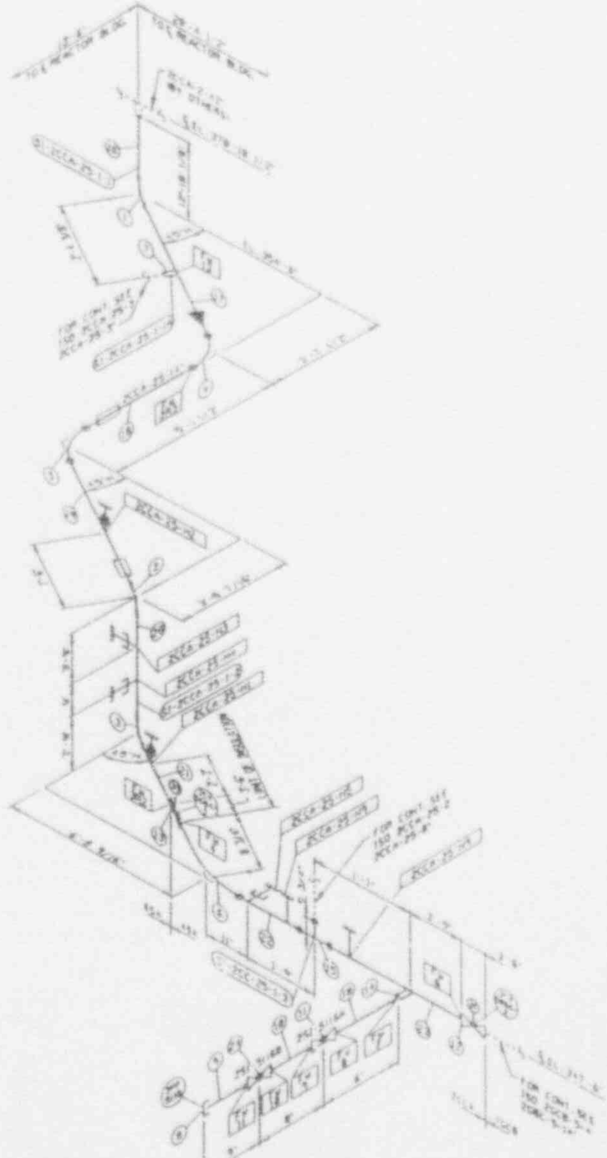
5. Specification No. 6600-M-2200, Rev. 09, "Design Specification for ASME Section III Nuclear Piping for Arkansas Nuclear One - Unit 2."

6. ABB CE Calculation No. MISC-ME-C-057, Rev 02, May 1991.

7. Crane Co. Publication No. VC-1900A, "Engineering Data Catalog," 1976.

BILL OF MATERIAL

ITEM	QTY.	DESCRIPTION	HEAT NO.	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



NOTE:
1.) PIPING INSULATED AS SHOWN.

REFERENCE	
P & ID NO. M-2232, M-2238 PIPING DWG: M-2056, M-2057 AREA NO. 25 ELEV: 336'-6" BLDG: REACTOR BLDG. SYSTEM: SAFETY INJECTION SYSTEM	9 — UPDATE PER W.P. [illegible] NO. DATE REVISION SCALE: [illegible] DESIGN: [illegible] DRAWN: [illegible]
HANGER TYPE: CRITICAL SEISMIC CL. I DWG. NO.	ARKANSAS POWER AND LIGHT COMPANY ARKANSAS NUCLEAR ONE UNIT 2
SYSTEM CLEANING REQMT.	
SERVICE CONDITIONS: NORMAL 2250 PSIG 300 °F MAXIMUM 2350 PSIG 650 °F	LARGE PIPE ISOMETRIC SAFETY INJECTION SYSTEM
STARTUP NO. 65A & 47A INSULATION CLASS: C THICKNESS: 3 1/2" FILENAME: [illegible]	DRAWING NO. 2CCA-25-1 REV. 9

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FIGURE 1: Shutdown Cooling Line Isometric

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A-MECH-CALC-023 | 00
Calculation Number | Rev.

APPENDIX A

Transient Histories - ANO-2

"ME153E.XLS

ANO-2 Power Transient History 2R8 to Present

Date	Transient	Initial Power	Final Power	Cooldown?	Rx Trip > 20%?
4/13/91	Cooldown from Hot Stby	0	0	YES	NO
4/25/91	Power Reduction	100	0	NO	NO
6/8/91	Power Reduction	100	76	NO	NO
6/21/91	Power Reduction	100	60	NO	NO
6/28/91	Power Reduction	100	63	NO	NO
9/27/91	Power Reduction	100	72	NO	NO
10/9/91	Shutdown	100	0	NO	NO
10/23/91	Shutdown	100	0	YES	NO
11/1/91	Power Reduction	100	80	NO	NO
11/28/91	Power Reduction	100	77	NO	NO
3/9/92	Shutdown	100	0	YES	NO
5/17/92	Power Reduction	100	73	NO	NO
5/22/92	Power Reduction	100	73	NO	NO
6/6/92	Power Reduction	100	30	NO	NO
8/4/92	Shutdown	100	0	YES	NO
11/19/92	Power Reduction	100	80	NO	NO
11/21/92	Power Reduction	100	30	NO	NO
2/21/93	Power Reduction	100	80	NO	NO
3/18/93	Power Reduction	100	80	NO	NO
3/31/93	Power Reduction	100	75	NO	NO
5/1/93	Shutdown	100	0	YES	NO

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UNIT 2 RCS HEATUP/COOLDOWN

[TRANSENT.XLW]ATRANS.XLS

DATE	CYCLE	DESCRIPTION OF TRANSIENT
2-15-78	1	Precore Hot Functional Testing
8-16-78	2	Post Core Hot Functional Testing
10-22-78	3	Secondary Relief Valve Repair
11-8-78	4	Wiped Bearing in 2DG2 (Diesel was inoperable)
12-2-78	5	Replace "B" Excore Detector
12-20-78	6	High Clorides in S/G Drain & Refill of S/G
2-23-78	7	Condenser Tube Leak in North Water Box
2-?-78	8	2E8A/B Condenser Modification
4-6-78	9	Steam Relief Testing
4-22-78	10	Steam Relief Valve Testing
5-15-79	11	Steam Relief Valve Testing
5-28-79	12	Steam Relief Valve Testing
6-13-78	13	Lost power to 2HI&2, 2AI&2 due to water in switchgear.
9-9-78	14	2T40A/B dumps to condenser caused by multiple tube failures
10-4-79	15	Th Anomaly Reactor internals inspection. Diesel replacement (2DG2)
1-30-80	16	TMI - Lessons Learned Modifications
4-9-80	17	Lost 500 KVA Transmission Lines due to weather con [illegible] ons
4-13-80	18	Replace CEDM Coil Stack
8-5-80	19	Repair Main Steam Vent Line Break
6-25-80	20	RCP Seal replacement following partial loss of offsite power (ground fault on 500KV line)
9-4-80	21	Cooldown to clean S.W. System. Asian clam problem.
12-5-80	22	Cooldown to fix 2P36 suction piping (non-isolatable weld failure)
3-28-81	23	Cooldown for Refueling Operations
9-27-81	24	Cooldown for "A" RCP seal replacement and 2E4A feedwater extraction line repair.
1-7-82	25	Cooldown to mode 5 because RCS RTD's did not pass response time testing.
4-16-82	26	Cooldown to mode 5 because of a steam leak inside containment on the "B" S/G blowdown line.
5-22-82	27	Cooldown to repair weld leak on 2P32A middle seal sensing line.
6-4-82	28	Cooldown to replace 2P32C seal.
7-28-82	29	Cooldown to repair 2FW-5A and replace coil stack on CEA-28.
8-20-82	30	Cooldown to Mode 5 because of an unidentified RCS leak inside containment > 1 gpm. Beginning of 2R2.
11-18-82	31	Cooldown for incore repair.
12-11-82	32	Cooldown to Mode 5 forreplacement of failed upper gripper coil on CEA-26.
1-7-83	33	Cooldown to Mode 5 due toa leak on "A" SDC Heat Exchanger.
6-28-83	34	Cooldown to Mode 5 for repair to 2P32A seal pressure sensing line.
9-26-83	35	Cooldown to Mode 5 for repair/replacement of battery bank.
1-10-84	36	Cooldown to replace reactor head o-ring gasket seals.
7-20-84	37	Cooldown to Mode 5 for Startup Channel replacement.
8-29-84	38	Cooldown to Mode 5 for RCP seal replacement.
10-26-84	39	Cooldown to replace coil stack on CEA-7.

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UNIT 2 RCS HEATUP/COOLDOWN

[TRANSENT.XLW]ATRANS.XLS

3-16-85	40	Cooldown for refueling outage 2R4.
5-17-85	41	Cooldown to repair seal leak on 2P32B.
9-13-85	42	Cooldown to Mode 5 for "A" and "C" RCP seal replacement.
9-28-85	43	Cooldown to Mode for repair to 2P32C seal pressure sensing line.
10-3-85	44	Cooldown to replace 2TE-4711-4
12/7/85	45	Cooldown to Mode 5 for repairs to extraction line expansion joints.
12/11/85	46	Cooldown to Mode 5 for repair to a CEDM coil.
8/14/86	47	Cooldown for refueling outage 2R5.
11/4/86	48	Cooldown for repair of 2PW-5B.
4/24/87	49	Cooldown for repair of pressurizer heater sleeve.
7/8/87	50	Cooldown for repair of failed welds on pressurizer heater wells.
2/12/88	51	Cooldown for refueling outage 2R6.
5/8/88	52	Cooldown for CEA-8 coupling.
7/24/88	53	Cooldown to repair leak on 2PSV-4633, PZR code safety valve.
8/1/88	54	Cooldown to perform RCP seal pressure sensing line MODS after leak on "A" RCP.
1/7/89	55	Cooldown to Mode 5 to repair 2P32C upper seal pinhole leak.
4/19/89	56	Cooldown to Mode 5 to repair HP Extraction line to 2E1A.
6/23/89	57	Cooldown to Mode 5 to repair 2RC-1001 due to high RCS leakage.
6/27/89	58	Cooldown to Mode 5 to again repair 2RC-1001.
9/26/89	59	Cooldown for refueling outage 2R7.
1/1/90	60	Cooldown to Mode 5 to troubleshoot CEDMCS and FWCS.
7/13/90	61	Cooldown to Mode 5 to facilitate repairs to pressurizer code safeties.
7/20/90	62	Cooldown to Mode 5 (from RCS temperature 545 F) when the wrong nozzle was discovered to be installed in one of the code safeties.
2/23/91	63	Cooldown for refueling outage 2R8
4/13/91	64	Cooldown to Mode 5 for repair of 2SI-14D
10/23/91	65	Cooldown for pressurizer code safety valve replacement.
03/09/92	66	Cooldown for Steam Generator Tube Leak
09/05/92	67	Cooldown for refueling outage 2R9
5/1/93	68	Cooldown for 2P93-1 S/G Inspection Outage

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UNIT 2 REACTOR TRIPS

[TRANSENT.XLW]FTRANS.XLS

DATE	DESCRIPTION	CYCLE	FRACTION
1-28-80	Scheduled Trip per TP 2.800.01, Appendix BB. (See transient Report #2-80-04)	1	1.00
3-28-80	Loss of Level indication on Condenser Hotwell Initiated MFWP Trip. Rx tripped on high pzr pressure. (See Transient Report #2-80-10)	1	1.00
4-2-80	Loss of MFWP caused high pzr. pressure Rx trip. (See Transient Report #2-80-12)	1	1.00
4-7-80	Loss of offsite power due to weather conditions. Rx tripped on Loss of Power to CEDMS. (See Transient Report #2-80-13.) Cycle reset to zero since it is addressed by loss of coolant flow transient. (Ref: CE Spec 00000-PE-140 Fig 4).	0	0.00
4-24-80	Reactor tripped due to problems with the CEAC rod position indication on CEA 67. (80% FP, See Transient Report #2-80-15)	1	0.80
4-25-80	Reactor tripped due to problems with the CEAC rod position indication on CEA 67. (80% FP, See Transient Report #2-80-16).	1	0.80
6-11-80	Two simultaneous spurious DNBR/LPD trips. (See Transient Report #2-80-18.)	1	1.00
6-24-80	Partial Loss of offsite power due to ground fault on 500 KV transmission line. (91% FP, See Transient Report #2-80-20). Cycle reset to zero since it is addressed by loss of coolant flow transient. (Ref: CE Spec 00000-PE-140 Fig 4).	0	0.00
7-7-80	Unit tripped due to human error when CEAC #1 was placed in the test mode with CEAC #2 in the inop mode. (93% FP, See Transient Report #2-80-21).	1	0.93
7-24-80	CEA #48 dropped into the Core. (See Transient Report #2-80-22.)	1	1.00
8-15-80	Stator cooling water problem. (See Transient Report #2-80-23.)	1	1.00
8-16-80	"A" MFWP reg. valve failed. (See Transient Report #2-80-25.)	1	1.00
8-21-80	Unit tripped due to human error when inverter power was transferred from battery to primary AC source. (94% FP, See Transient Report #2-80-26)	1	0.94
10-1-80	Unit tripped from 27%FP due to losing "B" RCP Rx was manually tripped. (27% FP, See Transient Report #2-80-28)	1	0.27
10-14-80	Unit tripped on high S/G level caused by overfeeding. (See Transient Report #2-80-29).	1	1.00
12-5-80	S/G Level trip. (30% FP, See Transient Report #2-80-31).	1	0.30
12-20-80	Manual Rx trip. (35% FP, See Transient Report #2-80-32).	1	0.35
1-15-81	Dropped CEA02 (See Transient Report #2-81-01).	1	1.00
2-18-81	RSPT Failure (See Transient Report #2-81-02).	1	1.00
3-10-81	Trip due to low Generator Voltage (See Transient Report#2-81-03).	1	1.00
3-16-81	Trip due to F.W. Control System Problems (See Transient Report #2-81-04).	1	1.00
3-18-81	CPC Channels I and 2 DNBR Trip. (91% FP, See Transient Report #2-81-05)	1	0.91
7-7-81	Reactor trip on steam generator level high. (< 15% FP, See Transient Report #2-81-06)	1	0.15
7-13-81	Manual trip when main feedwater flow reduced to a circuit board failure in the "A" MFW Pump speed sensing circuit. (50% FP, See Transient Report #2-81-08)	1	0.50
7-18-81	The reactor tripped on high LPD and low DNBR due to combined penalty factors when PLCEA No. 22 dropped. (50% FP, See Transient Report No. 2-81-09)	1	0.50
8-8-81	During a turbine overspeed trip test the turbine tripped on a false overspeed signal. (96% FP, See Transient Report #2-81-10)	1	0.96
8-8-81	PLCEA No. 22 dropped. (20% FP See Transient Report #2-81-11)	1	0.20

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UNIT 2 REACTOR TRIPS

[TRANSENT.XLW]FTRANS.XLS

8-11-81	Inadvertent loss of main feedwater on lube oil. The reactor was tripped manually. (98% FP, See Transient Report #2-81-12)	1	0.98
8-14-81	Inadvertent MSIV's closure. (98% FP, See Transient Report #2-81-13)	1	0.98
8-15-81	Loss of condenser vacuum due to "B" circulating water pump discharge valve trip. (67% FP, See Transient Report #2-81-04)	1	0.67
8-20-81	MSIV closure on loss of valve operator air supply. (See Transient Report #2-81-15)	1	1.00
10-12-81	The turbine tripped on MSR high level trip and the reactor tripped on low DNBR/high LPD. (See Transient Report #2-81-17).	1	1.00
10-25-81	The reactor tripped on low DNBR and high LPD when "D RCP tripped for no apparent cause. (See Transient Report #2-81-19).	1	1.00
11-04-81	The reactor tripped on low DNBR due to anomolous Th input to the CPCs. (See Transient Report #2-81-21.)	1	1.00
11-23-81	The unit tripped on low "A" steam generator level due to an inadvertent power supply trip for the level instrumentation by a technician. (See Transient Report #2-81-23.)	1	1.00
11-27-81	The unit tripped due to a feedwater flow upset, cause undetermined. (See Transient Report #2-81-24).	1	1.00
11-27-81	Manual reactor tripped after both main feedwater pumps tripped. Cause unknown. (66% FP, See Transient Report #2-81-25).	1	0.66
12-10-81	The unit tripped on low level in "A" steam generator due to loss of both MFW pump. (See Transient Report #2-81-26).	1	1.00
12-14-81	The unit tripped on low DNBR during CEAC #2 monthly test. Cause unknown. (See Transient Report #2-81-27.)	1	1.00
12-21-81	The unit tripped on low DNBR. A turbine generator runback on high stator cooling temperature was caused due to isolation of ACW to both heating exchangers. Human error.(81% FP, See Transient Report #2-81-28.)	1	0.81
1-24-82	Manual Rx trip after both MFW pumps tripped on high discharge pressure. (83% FP, See Transient Report #2-82-1).	1	0.83
1-26-82	Manual Rx trip after both MFW pumps tripped on high discharge pressure. (90% FP, See Transient Report #2-82-2).	1	0.90
3-7-82	Turbine runback to 20 mwe initiated by stator cooling pressure/temp/flow limits. Rx tripped on high S/L level. SIAS was initiated on low RCS pressure. (71%FP, See Transient Report #2-82-03)	1	0.71
4-29-82	Automatic Reactor Trip on DNBR/LPD generated by penalty factor from 2CEA's being mismatched. (.05% FP, See Transient Report#2-82-4)	1	0.00
5-4-82	The unit tripped on low S/G level due to both Main Feedwater Pumps tripping on high discharge pressure. (84% FP, See Transient Report #2-82-5).	1	0.84
5-21-82	The reactor tripped due to a low S/G level initiated by the loss of the "B" Heater Drain Pump on Low Heater Drain Tank level. (See Transient Report #2-82-6)	1	1.00
6-11-82	The reactor tripped on high S/G level due to level control instabilities at low power levels. (9%FP, See Transient Report #2-82-7)	1	0.09
6-16-82	The reactor tripped on low DNBR due to a penalty factor generated from CEAC-1. All subgroup 20 rods appeared low. Exact cause unknown. (See Transient Report #2-82-8)	1	1.00
7-27-82	The reactor tripped on low DNBR due to a penalty factor generated from PLCEA-28. The rod dropped due to a failure of the CEDM upper gripper coils. (88% FP, See Transient Report #2-82-9).	1	0.88

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UNIT 2 REACTOR TRIPS

[TRANSENT.XLW]FTRANS.XLS

11-15-82	The reactor tripped due to a failure of the number 12 DC power supply for the reactor protective system CD trip matrix while the number 4 and 8 trip breakers were open(.78% FP, See Transient Report #2-82-10).	1	0.01
11-16-82	The reactor tripped on high S/G level due to level control instabilities at low power levels. (16% FP,See Transient Report #2-82-11).	1	0.16
11-18-82	The unit tripped on low DNBR while performing a controlled shutdown. (.008% FP,See Transient Report #2-82-12.)	1	0.00
11-27-82	The unit tripped on a CPC generated low DNBR/high LPD trip on all four RPS channels following a spurious trip of the "B" RCP breaker. (48% FP,See Transient Report #2-82-13).	1	0.48
12-11-82	The reactor tripped on low DNBR caused from CPC generated penalty factors. Initial cause was a dropped rod as a result of a failed upper gripper coil. (91.5% FP, See Transient Report#2-82-14).	1	0.92
12-22-82	The unit tripped on low DNBR from penalty factors generated in CEAC-1 due to a spurious subgroup rod position deviation.(See Transient Report #2-82-15).	1	1.00
2-14-83	The unit tripped when a spurious target rod position indication in the CEACs generated a packed penalty factor which resulted in a CPC calculated DNBR of less than 1.24. (See Transient Report #28302.)	1	1.00
2/16/83	The reactor was manually tripped when an electrical fault developed on S/U transformer #3 and the 22KV windings of the auto transformer. (6% FP, see Transient Report #2- 83-03)	1	0.06
5/27/83	The reactor tripped from 100% on low DNBR, channels A and B. The DNBR signal was produced as a result of a perceived delta Tc condition.(See Transient Report #2-83-04)	1	1.00
6/24/83	The reactor tripped from 100% FP on low DNBR following a turbine trip. (See Transient Report #2-83-05)	1	1.00
6/27/83	The reactor tripped from 100% FP on low steam generator level following the loss of both main feedwater pumps. (See Transient Report #2-83-06)	1	1.00
6/24/83	The reactor tripped from 88% on low steam generator level following the loss of both main feedwater pumps. (See Transient Report 2- 83-07)	1	0.88
9/1/83	The reactor tripped from 6% on low steam generator level during the transition from EFW to MFW. (See Transient Report 2-83-08)	1	0.06
1/30/84	The reactor tripped from 4% on low "A" steam generator pressure. (See Transient Report 2-84-02.)	1	0.04
1/31/84	The reactor tripped from 10% FP on low level in "B" steam generator after the transition from EFW to MFW. (See Transient Report 2-84- 03.)	1	0.10
3/12/84	The reactor tripped from 4% FP because of low level in "A" steam generator. (See Transient Report 2-84-05.)	1	0.04
05/07/84	The reactor tripped on high level in "B" steam generator during a power increase. (67% FP, See Transient Report 28406.)	1	0.67
08/17/84	The reactor tripped from 100% on low DNBR caused from CPC generated penalty factors due to CEA #1 dropping. (See Transient Report 28407.)	1	1.00
08/18/84	The reactor tripped on high level in "A" steam generator. (10% FP, See Transient Report 28408.)	1	0.10
07/20/84	The reactor was manually tripped following an inadvertent switching of vital power inverter 2Y11 to an alternate source. (See Transient Report 28409.)	1	1.00
07/26/84	The reactor tripped during heatup on high SG level. (0% FP See Transient Report 28410.)	1	0.00

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[TRANSENT.XLW]FTRANS.XLS

07/28/84	The reactor tripped on high level in "B" steam generator due to manual feedwater control error. (See Transient Report 28411.)	1		0.88
08/28/84	The reactor tripped on low DNBR due to CEA #4 dropping. (See Transient Report 28412.)	1		1.00
10/26/84	The reactor tripped from 100% FP on low DNBR when CEA #7 dropped. (See Transient Report 28413)	1		1.00
10/31/84	The unit tripped on a CPC auxiliary trip due to out of tolerance ASI. (7% FP, See Transient Report 28414)	1		0.07
11/03/84	The unit tripped from 90% FP on low steam generator level due to partial closure of stop valves during stroke testing. (See Transient Report 28415)	1		0.90
02/04/85	The unit tripped from 100% FP on high RCS pressure following a turbine trip. The turbine trip was due to the loss of a generator field excitation breaker.	1		1.00
02/06/85	The unit tripped from 7% FP on low DNBR (auxiliary ASI trip) during startup.	1		0.07
07/18/85	The reactor tripped from 100% FP on low DNBR during PPS matrix testing due to a loss of power to the CEAs. (See Transient Report 2-85-03)	1		1.00
07/30/85	The reactor tripped from 100% FP on low DNBR. During testing of "D" CPC, a CEA position deviation signal was generated by CEAC-2, generating high penalty factors. (See Transient Report 2-85-04)	1		1.00
08/05/85	The reactor tripped from 100% FP on low DNBR due to CEAC penalty factors generated following a lightning strike in the switchyard. (See Transient Report 2-85-05)	1		1.00
08/13/85	The reactor tripped from 100% FP on high pressurizer pressure when a steam generator blowdown pump catastrophically failed causing a loss of condenser vacuum. (See Transient Report 2-85-06)	1		1.00
08/16/85	The reactor tripped from 96% FP on low DNBR following a CEAC #2 card failure. (See Transient Report 2-85-07)	1		0.96
10/08/85	The reactor tripped from 100% FP on high level in "A" steam generator when "B" MFW pump regulating valve closed.	1		1.00
10/19/85	The reactor tripped from 100% FP following loss of condenser vacuum when the circulating pump 2P-3B discharge valve did not close when securing the pump.	1		1.00
02/11/86	The reactor tripped from 100% FP on low DNBR following the inadvertent closure of an MSIV. The closure was apparently caused by a failure of a motor driven relay.	1		1.00
04/21/86	The reactor tripped from 100% FP due to the apparent loss of "D" RCP. The cause was a faulty light bulb in the pump handswitch indication. (See Transient Report 2-86-02)	1		1.00
04/26/86	The reactor tripped from 100% FP on loss of "D" RCP due to a failed starting surge capacitor. (See Transient Report 28603)	1		1.00
06/13/86	The reactor tripped from 12% FP due to QASI during the power reduction to begin refueling outage 2R5. (See Transient Report 28604)	1		0.12
09/24/86	The reactor tripped from 100% FP due to high level in the "A" MSR. (See Transient Report 28605)	1		1.00
08/09/87	The reactor tripped from 100% FP due to open in the 'B' phase of 2X-11 (See Transient Report 2-87-01).	1		1.00
11/14/87	The reactor tripped from 100% FP due to high PZR pressure following turbine trip on high bearing vibration. (See Transient Report 2-87-2). After going critical at 2055, the unit tripped again due to CPC trip.	1		1.00

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UNIT 2 REACTOR TRIPS

[TRANSENT.XLW]FTRANS.XLS

8/1/88	The reactor was manually tripped from 100% FP due to a seal sensing line failure on "A" RCP (see Transient Report 2-88-01).	1	1.00
12/1/88	The reactor tripped from 100% FP due to an inadvertant SIAS (see Transient Report 2-88-02).	1	1.00
4/18/89	The reactor tripped from 100% FP due to a turbine trip caused by an extraction steam line rupture.	1	1.00
12/31/88	The reactor tripped from 100% FP due to high S/G level caused by a FWCS malfunction. (See UTR 2-89-02).	1	1.00
06/26/90	The reactor tripped from 30% FP on Low DNBR caused by CEA 29 RSPT input to CEAC 1 failure. (See UTR-2-90-01).	1	0.30
3/4/90	(Out of sequence) The reactor was manually tripped from 20% FP during power reduction to repair surge capacitors on "D" RCP.	1	0.20
8/21/90	Reactor tripped from 100% FP on low DNBR/high LPD after MSIV closed at power due to failed solenoid.	1	1.00
2/1/91	Reactor tripped from 88% FP due to loss of "B" RCP.	1	0.88
2/22/91	Planned reactor trip from 20% power to begin 2R8	1	0.20
10/9/91	Planned reactor trip from 20% power for excore replacement	1	0.20
10/23/91	Planned reactor trip from 20% power for replacement of pressurizer code safety valves	1	0.20
03/09/92	Planned reactor trip from 20% full power due to a leak in the "A" Steam Generator	1	0.20
09/05/92	Planned reactor trip from 20% power to begin 2R9	1	0.20
5/1/93	Planned reactor trip from 20% power to begin 2P93-1 S/G Inspection Outage	1	0.20
TOTALS		103	73.32

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UNIT 2 TURBINE TRIP WITH DELAYED REACTOR TRIP

[TRANSIENT.XLW]GTRANS.XLS

DATE	CYCLE	DESCRIPTION
9/28/90	1	Turbine trip on low condenser vacuum at 82% FP followed by a manual reactor trip.

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PERMANENT.XLW]HTRANS.XLS

UNIT 2 LOSS OF REACTOR COOLANT FLOW @100%

DATE	CYCLE	DESCRIPTION
12-30-79	0.80	80% FP loss of flow test per T.P. 2.800.01 Appendix AA.
3-22-80	0.20	20% FP station blackout. Test per T.P. 2.800.01 Appendix BB.
4-7-80	1.00	Loss of offsite power. Lost three 500 KVA transmission lines and one 161 KVA line.
6-24-80	0.91	Partial loss of offsite power (ground fault on KV line). 91% full power.
10-1-80	0.00	Partial loss of RCS Flow. "B" RCP tripped. Power was 27%. Cycle reset to zero since "B" RCP was the only pump that tripped. The cycle is defined as simultaneous loss of all RCPs. Log item maintained for info only.
TOTALS	2.91	

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