MASTER

LOFT TECHNICAL REPORT LTR 141-67

RE & C REPORT NUMBER RE-A-77-029

MAY 2, 1978

FLUID LOADS ON LOFT DTT SHROUDS
LOCATED IN REACTOR VESSEL DOWNCOMER
AND DTT THERMAL LOADS DURING NUCLEAR LOCE
G. Kyllingstad

NOTICE

MN ONLY

PORTIONS OF THIS REPORT ARE ILLEGIBLE. It
has been reproduced from the best available
copy to permit the broadest possible avail-
ability.

EG&G Idaho, Inc.

IDAHO NATIONAL ENGINEERING LABORATORY

DEPARTMENT OF ENERGY

IDAHO OPERATIONS OFFICE UNDER CONTRACT EY-76-C-07-1570

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

LOFT TECHNICAL REPORT LTR 141-67
RE&C Report # RE-A-77-029
DATE May 2, 1978 *lh*
WORK REQUEST NO. 54111-405-392

RESEARCH, ENGINEERING AND CONSTRUCTION REPORT ENGINEERING ANALYSIS DIVISION

THERMAL ANALYSIS

FLUID LOADS ON LOFT DTT SHROUDS
LOCATED IN REACTOR VESSEL DOWNCOMER
AND DTT THERMAL LOADS DURING NUCLEAR LOCE

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

G. Kyllingstad

AUTHOR
G. Kyllingstad

CHECKED BY: *W C Kettenacker*
W. C. Kettenacker

APPROVED BY: *N E Pace 7/7/77*
N. E. Pace

~~THIS DOCUMENT CONTAINS UNCLASSIFIED INFORMATION AND IS NOT TO BE RELEASED TO THE PUBLIC WITHOUT~~

EB
DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

IDAHO NATIONAL ENGINEERING LABORATORY
LOFT TECHNICAL REPORT
LOFT PROGRAM

TITLE Fluid Loads on LOFT DTT Shrouds Located in Reactor Vessel		REPORT NO. LTR # 141-67
Downcomer and DTT Thermal Loads During Nuclear LOCE		
AUTHOR G. Kyllingstad <i>G. Kyllingstad</i>	CWA NO. 54111-405-392	
PERFORMING ORGANIZATION Thermal Analysis	DATE May 2, 1978	
LOFT APPROVAL		
<i>[Signature]</i> LEMB Mgr.	<i>[Signature]</i> LPD Mgr.	<i>[Signature]</i> PSE PSB Mgr. LEMB Suprv.
<i>[Signature]</i> RSB Mgr.		<i>[Signature]</i> P&CSB Mgr.

SUMMARY

A thermal analysis was performed on a LOFT DTT for a nuclear LOCE. Thermal gradients through the DTT shroud and turbine body, and temperature differences between body and shroud were calculated. This was done to determine the possible need for additional stress analyses of the DTT shroud to body welds based on thermal loads for a nuclear LOCE.

The DTT geometry analyzed is representative of DTT's specified in drawings 204500 Rev (M) and 207726 Rev (A). DTT's specified in drawing 204645 Rev (L) include a 0.600 inch by 2.25 inch rectangular mounting arm. This arm was not included in the analysis. It is felt, however, that the arm would not have a significant impact on the thermal analysis, and that this study is also valid for these DTT's specified in drawing 204645 Rev (L). Results of the thermal analysis are tabulated below.

DTT Location	Max. Difference Between Shroud and Average Body Temperature (°F)
Intact Loop Cold Leg (PC-1)	220
Intact Loop Hot Leg (PC-2)	132
Steam Generator Outlet (PC-3)	133
Reactor Vessel Upper Plenum	131
Reactor Vessel Downcomer	121
Broken Loop Cold Leg (BL-1)	126
Broken Loop Hot Leg (BL-2)	128

The fluid loads on the DTT's located in the reactor vessel downcomers were also analyzed. Loads were based on velocity and momentum flux data for the nonnuclear LOCE test series L1-1 through L1-4 and are assumed to act on the frontal area of the DTT shroud and screen. Fluid loads for both non-nuclear and nuclear LOCE's should be essentially the same.

Hydraulic loads on the downcomer DTT's are substantially less than those previously calculated in Reference (2). These previous load calculations were based on velocity data from L1-1 and L1-2 data reports released in April and July of 1976 (Reference (8) and (9), respectively) which were in error. Calculations in this report are based on corrected data found in References (4) and (5). Results are tabulated below.

Test	Downcomer	Load (LBf)			
		Steady State		Blowdown	
		Nominal	Worst	Nominal	Worst
L1-1	1	1.2	2.9	1.6	3.7
	2			2.3	5.2
L1-2	1			0.5	0.5
	2			0.5	0.8
L1-3	1			0.7	1.9
	2			0.7	1.9
L1-3A	1			0.7	1.9
	2			0.6	1.8
L1-4	1			11.5	22.
	2	1.2	2.9	4.	8.4

TABLE OF CONTENTS

	<u>Page</u>
SUMMARY	i
1.0 INTRODUCTION	1
2.0 ANALYSIS	1
2.1 Fluid Loads Analysis	1
2.2 Thermal Analysis	2
3.0 RESULTS AND RECOMMENDATIONS	3
4.0 REFERENCES	6
APPENDIX A - COUPLE MOD2 Input and Output	A-i
APPENDIX B - DTT Fluid Load and Average Temperature Calculations . .	B-i
APPENDIX C - R. C. Gottula and R. G. Rahl letter to L. J. Ybarrondo; Gott-4-76, "LOFT Drag Disc Turbine Meter Shroud Welds" (June 9, 1976). K. A. Hedquist letter to R. L. Crumley; KAH- 1-77, "Thermal Analysis of LOFT DTT at Loca- tion PC-1 and BL-1 of L1-1 Test" (March 7, 1977) L2-4 RELAP4 Fluid Temperature Profile Predictions. . . .	C-i

TABLES

I. Measured Maximum Velocities, Momentum Fluxes For Downcomer DTT's From Nonnuclear Tests L1-1, L1-2, L1-3, L1-4 (RELAP4 Prediction) and Estimated Loads Based on Nominal and Expected Max. Drag Coefficients	5
--	---

FIGURES

1. LOFT DTT Body and Shroud Temperature Transient For Nuclear LOCE Calculated from COUPLE MOD2 Computer Run. Fluid Profile Ref. (7). Constant Film Coeffi- cient of 400 Btu/hr-ft ² -°F	7
2. LOFT DTT Body and Shroud Temperature Difference Calculated from COUPLE MOD2 Computer Run	8

3.	LOFT DTT Body and Shroud Temperature Transient In Intact Loop Cold Leg For Nuclear LOCE Calculated By COUPLE MOD2. Fluid Temperature Profile from L2-4 RELAP4 Ref. (11). Constant Film Coefficient of 400 Btu/hr-ft ² -°F.	9
4.	LOFT DTT Body and Shroud Temperature Difference In Intact Loop Cold Leg During Nuclear LOCE.	10
5.	LOFT DTT Body and Shroud Temperature Transient In Intact Loop Hot Leg For Nuclear LOCE. Calculated by COUPLE MOD2. Fluid Temperature Profile from L2-4 RELAP4 Ref.(11). Constant Film Coefficient of 400 Btu/hr-ft ² -°F.	11
6.	LOFT DTT Body and Shroud Temperature Difference In Intact Loop Hot Leg During Nuclear LOCE.	12
7.	LOFT DTT Body and Shroud Temperature Transient In Reactor Vessel Upper Plenum For Nuclear LOCE. Calculated By COUPLE MOD2. Fluid Temperature Profile from L2-4 RELAP4 Ref.(11). Constant Film Coefficient of 400 Btu/hr-ft ² -°F.	13
8.	LOFT DTT Body and Shroud Temperature Difference In Reactor Vessel Upper Plenum During Nuclear LOCE.	14
9.	LOFT DTT Body and Shroud Temperature Transient In Reactor Vessel Lower Downcomer For Nuclear LOCE. Calculated By COUPLE MOD2. Fluid Temperature Profile From L2-4 RELAP4 Ref.(11). Constant Film Coefficient of 400 Btu/hr-ft ² -°F	15
10.	LOFT DTT Body and Shroud Temperature Difference In Reactor Vessel Lower Downcomer During Nuclear LOCE	16
11.	LOFT DTT Body and Shroud Temperature Transient In Broken Loop Cold Leg For Nuclear LOCE. Calculated By COUPLE MOD2. Fluid Temperature Profile from L2-4 REALP4 Ref.(11). Constant Film Coefficient of 400 Btu/hr-ft ² -°F	17
12.	LOFT DTT Body and Shroud Temperature Difference In Broken Loop Cold Leg During Nuclear LOCE	18
13.	LOFT DTT Body and Shroud Temperature Transient In Broken Loop Hot Leg For Nuclear LOCE. Calculated By COUPLE MOD2. Fluid Temperature Profile From L2-4 RELAP4 Ref.(11). Constant Film Coefficient of 400 Btu/hr-ft ² -°F.	19

14. LOFT DTT Body and Shroud Temperature Difference In
Broken Loop Hot Leg During Nuclear LOCE. 20
15. LOFT DTT Body and Shroud Temperature Transient In
Intact Loop Between Steam Generator and Pump For
Nuclear LOCE. Calculated By COUPLE MOD2. Fluid
Temperature Profile from L2-4 RELAP4 Ref.(11).
Constant Film Coefficient of 400 Btu/hr-ft²-°F 21
16. LOFT DTT Body and Shroud Temperature Difference In
Intact Loop Between Steam Generator and Pump During
Nuclear LOCE 22

1.0 INTRODUCTION

In response to recommendations made in Reference (1), a thermal analysis of a LOFT DTT based on an anticipated coolant temperature profile for a nuclear LOCE was performed, and fluid loads experienced by the LOFT DTT's located in the reactor vessel downcomer were estimated.

A previous analysis has been done for other DTT's within the LOFT system in support of weld requirement calculations in attaching the turbine shroud to the DTT body, Reference (2) and (3). These are included in Appendix C for convenience. However, temperature conditions during a nuclear LOCE were not considered, nor was an analysis of the fluid loads on the reactor vessel downcomer DTT's. The current analysis is intended to cover these obvious omissions of the previous analyses.

2.0 ANALYSIS

The analysis for this report consists of two parts:

- (1) Calculation of fluid loads on the reactor vessel downcomer DTT's,
- (2) Calculation of thermal gradients and the temperature difference between LOFT DTT body and turbine shroud during a nuclear LOCE.

2.1 Fluid Loads Analysis

Fluid loads calculations were based on past analysis methods, Reference (2). For blowdown, a maximum fluid density of $60 \text{ lb}_m/\text{ft}^3$ was measured during ECC injection in the cold leg loops for the L1-1 test. This density was used in conjunction with the velocity peaks for all tests, L1-1 through L1-4. The resulting calculated loads are conservative since fluid in the downcomer during these velocity peaks may be a two-phase mixture of steam and water with densities substantially less than the $60 \text{ lb}_m/\text{ft}^3$ used.

At steady state prior to blowdown, high speed pump tests generate higher loads in some cases. The fluid density used to calculate these loads was $47 \text{ lb}_m/\text{ft}^3$ at a flow rate of $3.9 \times 10^6 \text{ lb}_m/\text{hr}$. Steady state loop operating conditions are well defined and allow an accurate assumption of fluid density.

The substantially higher loads calculated in Reference (2) were based on velocity data from L1-1 and L1-2 data reports released in April and July of 1976 (References (8) and (9), respectively). These documents were in error and have been corrected and released in January 1977 (Reference (4) for L1-1 and Reference (5) for L1-2). Fluid velocities in the corrected documents and used in this analysis were substantially less than previously indicated.

Load calculations for the L1-4 test are based on RELAP4 velocity predictions⁽⁶⁾. It should be mentioned that for L1-1 test RELAP4 predictions were in excess of measured velocities by as much as a factor of two. This may also be true for L1-4. Even if RELAP4 predictions for L1-4 are close, resulting loads based on these predictions are still one-half those calculated in Reference (2) for a Type A DTT, used in both the core simulator and the downcomers.

2.2 Thermal Analysis

A thermal analysis similar to the method of Reference (3) was used. The two-dimensional finite element code for plane and axisymmetric geometries, COUPLE MOD2 in lieu of COUPLE II, was used to calculate the transient temperature history of the body and shroud. Initially a fluid temperature profile in accordance with ANC Specification No. MS-201, Rev. 7 for the hot leg nozzle was used. This subjected the DTT to a severe

thermal gradient during ECC injection where the fluid temperature was brought from 615°F to 70°F in 10 seconds. This was judged to be unreasonably severe. Fluid temperature profiles based on RELAP4 predictions of the L2-4 nuclear test is believed to generate the largest temperature gradients. A variable film coefficient as given in Reference (7) was not used. The constant 400 Btu/hr-ft²-°F previously used in Reference (3) was considered the better choice since SEMISCALE data demonstrated considerable uncertainty in heat transfer coefficient.⁽¹⁰⁾ Moreover the heat transfer coefficient in Reference (7) represents specification limits. Using the 400 Btu/hr-ft²-°F subjects the DTT to somewhat higher thermal gradients, and designs to those stresses would then be well within specification. Average temperatures were calculated as they were in Reference (3) with temperatures at interior points being volume weighted.

3.0 RESULTS AND RECOMMENDATIONS

Fluid loads for the various nonnuclear tests (L1-1 through L1-4) are tabulated in Table I. Largest loads are for the L1-4 RELAP4 predictions. Assuming RELAP4 predictions to be close to actual observation, predicted loads are on the order of one-half those calculated in Reference (2) for the Type A DTT analyzed. Although it was located in the core simulator, the same type of DTT is located in the reactor vessel downcomers. Should the shroud to body welds for both Type A DTT's be designed for the loads calculated in Reference (2), no significant design changes based on fluid loads would be anticipated. Should the welds be sized otherwise, a stress analysis may be advisable.

Figures (1) through (16) illustrate the temperature profiles and average body and shroud temperature differences during a nuclear LOCE.

Figures (1) and (2) show the calculated temperature profiles and differences for a DTT body and shroud during a nuclear LOCE in accordance with ANC Specification No. MS-201, Rev. 7.⁽⁷⁾ Although this fluid temperature profile was considered too severe, it is included here for comparison purposes. The remaining figures show the calculated temperature profiles and differences for the various DTT's located throughout the LOFT system during a nuclear LOCE as predicted by RELAP4 for the L2-4 test. The fluid temperature profile for the L2-4 test was used since it was considered the most severe of the L2 test series.

The maximum temperature difference between DTT body and shroud during the L2-4 test is approximately 220°F as illustrated in Figure (4). This is about 20°F less than the calculated maximum difference for the non-nuclear LOCE of Reference (3). This apparent anomaly is a result of the time scale adjustment in Reference (3) to simulate a larger break than actually specified in the L1-1 test, hence a more severe thermal gradient was simulated at the PC-1 location.

TABLE I

Measured Maximum Velocities, Momentum Fluxes For Downcomer DTT's From Nonnuclear Tests L1-1, L1-2, L1-3, L1-4 (RELAP4 Prediction) and Estimated Loads Based on Nominal and Expected Max. Drag Coefficients

Test	Down-comer	Max. Vel. Recorded (ft/sec)	Max. Mom. Flux Recorded (lbm/ft-sec ²)	Load (lb _f)				Remarks
				<u>Steady-State</u>		<u>Blowdown</u>		
				Nominal	Worst	Nominal	Worst	
L1-1	1	15.	7000	1.2	2.9	1.6	3.7	100% Break of Cold Leg, ECC injection in cold leg, Max. density 60 lbm/ft ³
	2	18.2	11000			2.3	5.2	
L1-2	1	Not	4000*			0.5	0.8	100% Break of hot leg, ECC injection in cold leg, Max. density 47 lbm/ft ³ , Max. Mom. Flux used.
	2	Listed	4200*			0.5	0.8	
L1-3	1	10.	4900			0.7	1.9	200% Break of cold leg, No ECC injection, Max. density 47 lbm/ft ³ , but 60 lbm/ft ³ used for Blowdown.
	2	10.	4900			0.7	1.9	
L1-3A	1	10.	4700			0.7	1.9	200% Break of cold leg, ECC injection in RV LWR plenum, Max. density 47 lbm/ft ³ , but 60 lbm/ft ³ used for Blowdown.
	2	9.6	4600			0.6	1.8	
L1-4	1	40.7**	45700**	1.2	2.9	11.5	22.	200% Break of cold leg, ECC injection in cold leg, Max. density 47 lbm/ft ³ , but 60 lbm/ft ³ used for Blowdown.
	2	24. **	32900**			4.	8.4	

* Hot Wall delay data not considered since similar experiments (Hot wall delay) will not be repeated.

** Latest data available based on REALP4 prediction.

4.0 REFERENCES

1. T. L. Kinnaman, Evaluation of Thermal and Hydraulic Loadings on the LOFT DTT's, LOFT Technical Report 141-64 (April 28, 1977).
2. R. C. Gottula and R. G. Rahl Letter to L. J. Ybarrondo; Gott-4-76, "LOFT Drag Disc Turbine Meter Shroud Welds" (June 9, 1976).
3. K. A. Hedquist letter to R. L. Crumley; KAH-1-77, "Thermal Analysis of LOFT DTT at Location PC-1 and BL-1 of L1-1 Test" (March 7, 1977).
4. J. R. Chappell, Experiment Data Report for LOFT Nonnuclear Test L1-1, TREE-NUREG-1025 (January 1977).
5. H. C. Robinson, Experiment Data Report for LOFT Nonnuclear Test L1-2, TREE-NUREG-1026 (January 1977).
6. J. R. White, V. T. Berta, and H. L. O. Holmstrom, Experiment Prediction for LOFT Nonnuclear Experiment L1-4, TREE-NUREG-1086 (April 1977).
7. Reactor Vessel Loss-of-Fluid Test Reactor, ANC Specification No. MS-201, Rev. 7 (June 22, 1972).
8. J. R. Chappell, Experiment Data Report For LOFT Nonnuclear Test L1-1, LOFT Technical Report 20-59 (April 1976).
9. H. C. Robinson, Experiment Data Report For LOFT Nonnuclear Test L1-2, LOFT Technical Report 20-59 (April 1976).
10. R. T. French, An Evaluation of Piping Heat Transfer, Piping Flow Regimes and Steam Generator Heat Transfer for SEMISCALE MOD-1 Isothermal Tests, ANC-1229 (August 1975).
11. J. R. White communication to C. M. Martin, "Expected Thermocouple Response for Nuclear Test" (August 4, 1977).

FIGURE 3

LOFT DTT Body and Shroud Temperature Transient at PC-1 Location For Nuclear LOCE Calculated by COUPLE/MOD2. Fluid Temp. Profile From L2-4 RELAP4. Constant Film Coefficient of 400 Btu/hr-ft²-°F.

TEMPERATURE (°F)

500

400

300

200

100

AVERAGE BODY

SHROUD

FLUID

5

10

15

20

25

30

35

40

TIME (SECONDS)

FIGURE 4

LOFT DTT Body and Shroud Temperature Difference at PC-1 Location During Nuclear LOCE From Results Illustrated in Figure 3.

FIGURE 6

LOFT DTT Body and Shroud Temperature Difference at PC-2 Location During Nuclear LOCE From Results Illustrated in Figure 5

FIGURE 8

LOFT DTT Body and Shroud Temperature Difference In Reactor Vessel Upper Plenum During Nuclear LOCE From Results Illustrated in Figure 7.

FIGURE 9

LOFT DTT Body and Shroud Temperature Transient in Reactor Vessel Downcomer For Nuclear LOCE. Calculated by COUPLE/MOD2. Fluid Temp. Profile From L2-4 RELAP4. Constant Film Coefficient of 400 Btu/hr-ft²-°F.

FIGURE 10

LOFT DTT Body and Shroud Temperature
Difference In Reactor Vessel Downcomer
During Nuclear LOCE From Results
Illustrated in Figure 9.

FIGURE 12

LOFT DTT Body and Shroud Temperature
Difference at BL-1 Location During
Nuclear LOCE From Results Illustrated
in Figure 11

FIGURE 14

LOFT DTT Body and Shroud Temperature Difference at BL-2 Location During Nuclear LOCE From Results Illustrated in Figure 13

FIGURE 16

LOFT DTT Body and Shroud Temperature Difference at PC-3 Location During Nuclear LOCE From Results Illustrated in Figure 15.

APPENDIX A

1. Figure A-1 - Schematic of LOFT Drag Disk Turbine Flowmeter (DTT) Body and Shroud
2. Figure A-2 - COUPLE MOD2 Model of Drag Disk Turbine Flowmeter (DTT) Body and Shroud
3. COUPLE MOD2 Input, Node and Element Listing, and Heat Conduction Solution at 0.0, 1.0, and 11.5 Seconds.

Figure A-1 - LOFT Drag Disk Turbine Flowmeter (DTT) Body and Shroud

Figure A-2 - COUPLE MOD2 Model of Drag Disk Turbine Flowmeter (DTT) Body and Shroud

0 1 2 3 4 5 6 7 8
123456789012345678901234567890123456789012345678901234567890

TITLE
LOFT OCT TEMPERATURE RESPONSE FOR NUCLEAR LOCE RUN 05
LOCE - ECC JUN. 16, 1977 COUPLE MOD 2

AUTOMESH
30 16 4 1 0. 0. 0. 0. 1
1 1 0. 0. 1 16 0. .4 1
1 16 .0 .4 8 16 .944 .4
8 16 .944 .4 10 1 1.007 0.00
10 16 1.007 .40 11 13 1.037 .4
11 16 1.037 .4 11 14 1.100 .35
10 14 1.037 .35 11 14 1.1 .35
11 14 1.1 .35 20 16 1.7 .75
11 16 1.037 .4 20 14 1.7 .75
11 14 1.1 .35 30 16 2.45 0.0
30 16 2.45 0.0 30 14 2.4 0.0
9 1 .9755 0.0 9 16 .9755 .4
8 1 .944 0.0 1 1 0.0 0.0
1 1 11 1 16 C.0
1 1 14 16 C.0
1 10 30 14 C.0
2 8 10 14 C.0

MATERIAL
2 1 1.0 316 STAINLESS STEEL 1 2
2.3148E-5 2.3148E-5 573.70E-6
2 1.0 GAP IN WALL 1.0E-7
1.0E-7 1.0E-7 1.0E-7

STEP
0.0 50. 5 1 610. -10 2

FUNCTIONS
5 1 11 2
70. 8.35 THERMAL CONDUCTIVITY OF AUSTENITIC STAINLESS STL BTU/HR, FT, F
200. 8.9 100. 8.4 150. 8.67
450. 10. 300. 9.35 400. 9.9
600. 10.7 500. 10.23 550. 10.45
70. 2 11 2 DENSITY * SPEC HEAT OF AUSTENITIC STAINLESS STL BTU/FT**3, F
200. 55.923 100. 56.157 150. 56.852
450. 57.494 300. 58.442 400. 60.123
600. 61.013 500. 61.464 550. 62.055
600. 62.643 550. 63.355
0.0 610. 1 FLUID TEMPERATURES FAHRENHEIT
1.50 560. 7.0 490.

0 1 2 3 4 5 6 7 8
123456789012345678901234567890123456789012345678901234567890

0 1 2 3 4 5 6 7 8
 123456789012345678901234567890123456789012345678901234567890

TITLE
 LOFT DDT TEMPERATURE RESPONSE FOR NUCLEAR LOCE RUN 05
 LOCE - ECC JUN. 16, 1977 COUPLE MOD 2

AUTOMESH
 30 16 4 1 0. 0. 0. 0. 1
 1 1 0. 0. 1 16 0. .4 1
 1 16 .0 .4 8 16 .944 .4
 8 16 .944 .4 8 1 .944 0.00
 10 16 1.007 .40 10 1 1.007 0.0
 10 16 1.007 .4 11 16 1.037 .4
 11 16 1.037 .4 11 14 1.100 .35
 10 14 1.007 .35 11 14 1.1 .35
 11 14 1.1 .35 11 1 .1 0.0
 11 16 1.037 .4 20 16 1.7 .75 30 16 2.45 0.0
 11 14 1.1 .35 20 14 1.7 .7 30 14 2.4 0.0
 30 16 2.45 0.0 30 14 2.4 0.0
 9 1 .9755 0.0 9 16 .9755 .4
 8 1 .944 0.0 1 1 0.0 0.0

1 1 11 1 14 0.0
 1 1 16 0.0
 1 10 30 14 16 0.0
 2 8 10 14 16 0.0

MATERIAL
 2 1 1.0 316 STAINLESS STEEL
 2.3148E-5 2.3148E-5 578.70E-6 1 1 2
 2 1.0 GAP IN WALL
 1.0E-7 1.0E-7 1.0E-7

STEP
 0.0 50. 5 1 61C. -10 2

FUNCTIONS
 5
 1 11 2 THERMAL CONDUCTIVITY OF AUSTENITIC STAINLESS STL BTU/HR,FT,F
 70. 8.35 100. 8.4 150. 8.67
 200. 8.9 300. 9.35 400. 9.8
 450. 10. 500. 10.23 550. 10.45
 600. 10.7 650. 10.9
 2 11 2 DENSITY * SPEC HEAT OF AUSTENITIC STAINLESS STL BTU/FT**3,F
 70. 55.928 100. 56.187 150. 56.852
 200. 57.494 300. 58.842 400. 60.123
 450. 61.013 500. 61.664 550. 62.033
 600. 62.693 650. 63.335
 3 4 1 FLUID TEMPERATURES FAHRENHEIT
 0.0 510. 1.50 560. 7.0 490.

0 1 2 3 4 5 6 7 8
 123456789012345678901234567890123456789012345678901234567890

A-3

LINK 41 06

0 1 2 3 4 5 6 7 8
1234567890123456789012345678901234567890123456789012345678901234567890

10. 4 3 70. 1
0.0 5 400. 1
0.0 8 1.0 1
9.75 0.25 6.0 1.0 7.0 0.25
20. 1.0 50.0 0.5 19.5 0.5

CONVECTSETS

175	1	1	16	1.9290E-6	4	1.0	3
1	15	8	16	1.9290E-6	4	1.0	3
8	14	8	15	1.9290E-6	4	1.0	3
8	14	10	14	1.9290E-6	4	1.0	3
10	14	10	16	1.9290E-6	4	1.0	3
10	16	30	16	1.9290E-6	4	1.0	3
11	1	11	14	1.9290E-6	4	1.0	3
11	14	30	14	1.9290E-6	4	1.0	3

PLOTS

4 0

COUPLE

END OF DATA

0 1 2 3 4 5 6 7 8
1234567890123456789012345678901234567890123456789012345678901234567890

A-4

LRI 41 62

COUPLE MOD 2 (MAY-23,77) UPDATE 1 (MAY-23,77) ECL
 LOFT DDT TEMPERATURE RESPONSE FOR NUCLEAR LOCE RUN 05
 LOCE - ECC JUN. 16, 1977 COUPLE MOD 2

MESH OUTPUT DATA

NODE DATA

NODE NUMBERS, I-J, R-Z COORDINATE INFORMATION

I	J	NODE	R	Z	I	J	NODE	R	Z	I	J	NODE	R	Z
1	1	1	0.	0.	2	1	2	1.349E-01	0.	3	1	3	2.697E-01	0.
4	1	4	4.046E-01	0.	5	1	5	5.394E-01	0.	6	1	6	6.743E-01	0.
7	1	7	8.091E-01	0.	8	1	8	9.440E-01	0.	9	1	9	9.755E-01	0.
10	1	10	1.007E+00	0.	11	1	11	1.100E+00	0.					
1	2	1	0.	2.667E-02	12	2	12	1.349E-01	2.667E-02	3	2	14	2.697E-01	2.667E-02
4	2	4	4.046E-01	2.667E-02	5	2	13	5.394E-01	2.667E-02	6	2	17	6.743E-01	2.667E-02
7	2	7	8.091E-01	2.667E-02	8	2	16	9.440E-01	2.667E-02	9	2	20	9.755E-01	2.667E-02
10	2	10	1.007E+00	2.667E-02	11	2	19	1.100E+00	2.667E-02					
1	3	1	0.	5.333E-02	12	3	22	1.349E-01	5.333E-02	3	3	25	2.697E-01	5.333E-02
4	3	4	4.046E-01	5.333E-02	5	3	24	5.394E-01	5.333E-02	6	3	28	6.743E-01	5.333E-02
7	3	7	8.091E-01	5.333E-02	8	3	27	9.440E-01	5.333E-02	9	3	31	9.755E-01	5.333E-02
10	3	10	1.007E+00	5.333E-02	11	3	30	1.100E+00	5.333E-02					
1	4	1	0.	8.000E-02	12	4	33	1.349E-01	8.000E-02	3	4	36	2.697E-01	8.000E-02
4	4	4	4.046E-01	8.000E-02	5	4	35	5.394E-01	8.000E-02	6	4	39	6.743E-01	8.000E-02
7	4	7	8.091E-01	8.000E-02	8	4	38	9.440E-01	8.000E-02	9	4	42	9.755E-01	8.000E-02
10	4	10	1.007E+00	8.000E-02	11	4	41	1.100E+00	8.000E-02					
1	5	1	0.	1.067E-01	12	5	44	1.349E-01	1.067E-01	3	5	47	2.697E-01	1.067E-01
4	5	4	4.046E-01	1.067E-01	5	5	46	5.394E-01	1.067E-01	6	5	50	6.743E-01	1.067E-01
7	5	7	8.091E-01	1.067E-01	8	5	49	9.440E-01	1.067E-01	9	5	53	9.755E-01	1.067E-01
10	5	10	1.007E+00	1.067E-01	11	5	52	1.100E+00	1.067E-01					
1	6	1	0.	1.333E-01	12	6	55	1.349E-01	1.077E-01	3	6	58	2.697E-01	1.333E-01
4	6	4	4.046E-01	1.333E-01	5	6	57	5.394E-01	1.333E-01	6	6	61	6.743E-01	1.333E-01
7	6	7	8.091E-01	1.333E-01	8	6	60	9.440E-01	1.333E-01	9	6	64	9.755E-01	1.333E-01
10	6	10	1.007E+00	1.333E-01	11	6	63	1.100E+00	1.333E-01					
1	7	1	0.	1.600E-01	12	7	66	1.349E-01	1.600E-01	3	7	69	2.697E-01	1.600E-01
4	7	4	4.046E-01	1.600E-01	5	7	68	5.394E-01	1.600E-01	6	7	72	6.743E-01	1.600E-01
7	7	7	8.091E-01	1.600E-01	8	7	71	9.440E-01	1.600E-01	9	7	75	9.755E-01	1.600E-01
10	7	10	1.007E+00	1.600E-01	11	7	74	1.100E+00	1.600E-01					
1	8	1	0.	1.867E-01	12	8	77	1.349E-01	1.615E-01	3	8	80	2.697E-01	1.867E-01
4	8	4	4.046E-01	1.867E-01	5	8	79	5.394E-01	1.867E-01	6	8	83	6.743E-01	1.867E-01
7	8	7	8.091E-01	1.867E-01	8	8	82	9.440E-01	1.867E-01	9	8	86	9.755E-01	1.867E-01
10	8	10	1.007E+00	1.867E-01	11	8	85	1.100E+00	1.867E-01					
1	9	1	0.	2.133E-01	12	9	88	1.349E-01	2.133E-01	3	9	91	2.697E-01	2.133E-01
4	9	4	4.046E-01	2.133E-01	5	9	90	5.394E-01	2.133E-01	6	9	94	6.743E-01	2.133E-01
7	9	7	8.091E-01	2.133E-01	8	9	93	9.440E-01	2.133E-01	9	9	97	9.755E-01	2.133E-01
10	9	10	1.007E+00	2.133E-01	11	9	96	1.100E+00	2.133E-01					
1	10	1	0.	2.400E-01	12	10	99	1.349E-01	2.400E-01	3	10	102	2.697E-01	2.400E-01
4	10	4	4.046E-01	2.400E-01	5	10	101	5.394E-01	2.400E-01	6	10	105	6.743E-01	2.400E-01
7	10	7	8.091E-01	2.400E-01	8	10	104	9.440E-01	2.400E-01	9	10	108	9.755E-01	2.400E-01
10	10	10	1.007E+00	2.400E-01	11	10	107	1.100E+00	2.400E-01					
1	11	1	0.	2.667E-01	12	11	110	1.349E-01	2.423E-01	3	11	113	2.697E-01	2.667E-01
4	11	4	4.046E-01	2.667E-01	5	11	112	5.394E-01	2.667E-01	6	11	116	6.743E-01	2.667E-01
7	11	7	8.091E-01	2.667E-01	8	11	115	9.440E-01	2.667E-01	9	11	119	9.755E-01	2.667E-01
							118	1.100E+00	2.667E-01					

I	J	NODE	R	Z
10	11	120	1.0C7E+00	2.667E-01
1	12	122	0.	2.933E-01
4	12	125	4.046E-01	2.933E-01
7	12	129	8.091E-01	2.933E-01
10	12	131	1.007E+00	2.933E-01
1	13	133	0.	3.200E-01
4	13	136	4.046E-01	3.200E-01
7	13	139	8.091E-01	3.200E-01
10	13	142	1.007E+00	3.200E-01
1	14	144	0.	3.467E-01
4	14	147	4.046E-01	3.467E-01
7	14	150	8.091E-01	3.467E-01
10	14	153	1.007E+00	3.500E-01
13	14	156	1.217E+00	5.017E-01
16	14	159	1.459E+00	6.556E-01
19	14	162	1.743E+00	6.989E-01
22	14	165	2.019E+00	6.244E-01
25	14	168	2.243E+00	4.447E-01
28	14	171	2.375E+00	1.902E-01
1	15	174	0.	3.733E-01
4	15	177	4.046E-01	3.733E-01
7	15	180	8.091E-01	3.733E-01
10	15	183	1.007E+00	3.733E-01
13	15	186	1.198E+00	5.240E-01
16	15	189	1.450E+00	6.763E-01
19	15	192	1.741E+00	7.168E-01
22	15	195	2.024E+00	6.385E-01
25	15	198	2.253E+00	4.544E-01
28	15	201	2.390E+00	1.945E-01
1	16	204	0.	4.000E-01
4	16	207	4.046E-01	4.000E-01
7	16	210	8.091E-01	4.000E-01
10	16	213	1.007E+00	4.000E-01
13	16	216	1.171E+00	5.556E-01
16	16	219	1.435E+00	7.097E-01
19	16	222	1.739E+00	7.480E-01
22	16	225	2.034E+00	6.646E-01
25	16	228	2.273E+00	4.726E-01
28	16	231	2.418E+00	2.025E-01

B L A N K C A R D

I	J	NODE	R	Z
11	11	121	1.100E+00	2.692E-01
2	12	123	1.349E-01	2.933E-01
5	12	126	5.394E-01	2.933E-01
8	12	129	9.440E-01	2.933E-01
11	12	132	1.100E+00	2.962E-01
2	13	134	1.349E-01	3.200E-01
5	13	137	5.394E-01	3.200E-01
8	13	140	9.440E-01	3.200E-01
11	13	143	1.100E+00	3.231E-01
2	14	145	1.349E-01	3.467E-01
5	14	148	5.394E-01	3.467E-01
8	14	151	9.440E-01	3.467E-01
11	14	154	1.100E+00	3.500E-01
14	14	157	1.291E+00	5.640E-01
17	14	160	1.551E+00	6.831E-01
20	14	163	1.838E+00	6.870E-01
23	14	166	2.102E+00	5.750E-01
26	14	169	2.398E+00	3.662E-01
29	14	172	2.394E+00	9.597E-02
2	15	175	1.349E-01	3.733E-01
5	15	178	5.394E-01	3.733E-01
8	15	181	9.440E-01	3.733E-01
11	15	184	1.069E+00	3.750E-01
14	15	187	1.275E+00	5.859E-01
17	15	190	1.544E+00	7.030E-01
20	15	193	1.838E+00	7.037E-01
23	15	196	2.108E+00	5.877E-01
26	15	199	2.310E+00	3.742E-01
29	15	202	2.412E+00	9.820E-02
2	16	205	1.349E-01	4.000E-01
5	16	208	5.394E-01	4.000E-01
8	16	211	9.440E-01	4.000E-01
11	16	214	1.037E+00	4.000E-01
14	16	217	1.252E+00	6.186E-01
17	16	220	1.535E+00	7.360E-01
20	16	223	1.841E+00	7.335E-01
23	16	226	2.122E+00	6.115E-01
26	16	229	2.333E+00	3.893E-01
29	16	232	2.441E+00	1.023E-01

I	J	NODE	R	Z
3	12	124	2.697E-01	2.933E-01
6	12	127	6.743E-01	2.933E-01
9	12	130	9.755E-01	2.933E-01
3	13	135	2.697E-01	3.200E-01
6	13	138	6.743E-01	3.200E-01
9	13	141	9.755E-01	3.200E-01
3	14	146	2.697E-01	3.467E-01
6	14	149	6.743E-01	3.467E-01
9	14	152	9.755E-01	3.467E-01
12	14	155	1.153E+00	4.299E-01
15	14	158	1.372E+00	6.157E-01
18	14	161	1.646E+00	6.976E-01
21	14	164	1.931E+00	6.620E-01
24	14	167	2.177E+00	5.147E-01
27	14	170	2.343E+00	2.808E-01
30	14	173	2.400E+00	0.
3	15	176	2.697E-01	3.733E-01
6	15	179	6.743E-01	3.733E-01
9	15	182	9.755E-01	3.733E-01
12	15	185	1.130E+00	4.528E-01
15	15	188	1.359E+00	6.371E-01
18	15	191	1.642E+00	7.166E-01
21	15	194	1.933E+00	6.774E-01
24	15	197	2.185E+00	5.260E-01
27	15	200	2.356E+00	2.871E-01
30	15	203	2.425E+00	0.
3	16	206	2.697E-01	4.000E-01
6	16	209	6.743E-01	4.000E-01
9	16	212	9.755E-01	4.000E-01
12	16	215	1.099E+00	4.823E-01
15	16	218	1.340E+00	6.703E-01
18	16	221	1.637E+00	7.489E-01
21	16	224	1.940E+00	7.055E-01
24	16	227	2.202E+00	5.471E-01
27	16	230	2.382E+00	2.987E-01
30	16	233	2.450E+00	0.

COUPLE MOD 2 (MAY-23,77) UPDATE 1 (MAY-23,77) ECL
 LOFT DOT TEMPERATURE RESPONSE FOR NUCLEAR LUCE RUN 05
 LOCE - ECC JUN. 16, 1977 COUPLE MOD 2
 HEAT CONDUCTION SOLUTION

TIME = 0.00000

DT = 0.00000

STEP = 1

PASS = 1

NODE	TEMPERATURE	NODE	TEMPERATURE	NODE	TEMPERATURE	NODE	TEMPERATURE	NODE	TEMPERATURE
1	6.10000E+02	2	6.10000E+02	3	6.10000E+02	4	6.10000E+02	5	6.10000E+02
6	6.10000E+02	7	6.10000E+02	8	6.10000E+02	9	6.10000E+02	10	6.10000E+02
11	6.10000E+02	12	6.10000E+02	13	6.10000E+02	14	6.10000E+02	15	6.10000E+02
16	6.10000E+02	17	6.10000E+02	18	6.10000E+02	19	6.10000E+02	20	6.10000E+02
21	6.10000E+02	22	6.10000E+02	23	6.10000E+02	24	6.10000E+02	25	6.10000E+02
26	6.10000E+02	27	6.10000E+02	28	6.10000E+02	29	6.10000E+02	30	6.10000E+02
31	6.10000E+02	32	6.10000E+02	33	6.10000E+02	34	6.10000E+02	35	6.10000E+02
36	6.10000E+02	37	6.10000E+02	38	6.10000E+02	39	6.10000E+02	40	6.10000E+02
41	6.10000E+02	42	6.10000E+02	43	6.10000E+02	44	6.10000E+02	45	6.10000E+02
46	6.10000E+02	47	6.10000E+02	48	6.10000E+02	49	6.10000E+02	50	6.10000E+02
51	6.10000E+02	52	6.10000E+02	53	6.10000E+02	54	6.10000E+02	55	6.10000E+02
56	6.10000E+02	57	6.10000E+02	58	6.10000E+02	59	6.10000E+02	60	6.10000E+02
61	6.10000E+02	62	6.10000E+02	63	6.10000E+02	64	6.10000E+02	65	6.10000E+02
66	6.10000E+02	67	6.10000E+02	68	6.10000E+02	69	6.10000E+02	70	6.10000E+02
71	6.10000E+02	72	6.10000E+02	73	6.10000E+02	74	6.10000E+02	75	6.10000E+02
76	6.10000E+02	77	6.10000E+02	78	6.10000E+02	79	6.10000E+02	80	6.10000E+02
81	6.10000E+02	82	6.10000E+02	83	6.10000E+02	84	6.10000E+02	85	6.10000E+02
86	6.10000E+02	87	6.10000E+02	88	6.10000E+02	89	6.10000E+02	90	6.10000E+02
91	6.10000E+02	92	6.10000E+02	93	6.10000E+02	94	6.10000E+02	95	6.10000E+02
96	6.10000E+02	97	6.10000E+02	98	6.10000E+02	99	6.10000E+02	100	6.10000E+02
101	6.10000E+02	102	6.10000E+02	103	6.10000E+02	104	6.10000E+02	105	6.10000E+02
106	6.10000E+02	107	6.10000E+02	108	6.10000E+02	109	6.10000E+02	110	6.10000E+02
111	6.10000E+02	112	6.10000E+02	113	6.10000E+02	114	6.10000E+02	115	6.10000E+02
116	6.10000E+02	117	6.10000E+02	118	6.10000E+02	119	6.10000E+02	120	6.10000E+02
121	6.10000E+02	122	6.10000E+02	123	6.10000E+02	124	6.10000E+02	125	6.10000E+02
126	6.10000E+02	127	6.10000E+02	128	6.10000E+02	129	6.10000E+02	130	6.10000E+02
131	6.10000E+02	132	6.10000E+02	133	6.10000E+02	134	6.10000E+02	135	6.10000E+02
136	6.10000E+02	137	6.10000E+02	138	6.10000E+02	139	6.10000E+02	140	6.10000E+02
141	6.10000E+02	142	6.10000E+02	143	6.10000E+02	144	6.10000E+02	145	6.10000E+02
146	6.10000E+02	147	6.10000E+02	148	6.10000E+02	149	6.10000E+02	150	6.10000E+02
151	6.10000E+02	152	6.10000E+02	153	6.10000E+02	154	6.10000E+02	155	6.10000E+02
156	6.10000E+02	157	6.10000E+02	158	6.10000E+02	159	6.10000E+02	160	6.10000E+02
161	6.10000E+02	162	6.10000E+02	163	6.10000E+02	164	6.10000E+02	165	6.10000E+02
166	6.10000E+02	167	6.10000E+02	168	6.10000E+02	169	6.10000E+02	170	6.10000E+02
171	6.10000E+02	172	6.10000E+02	173	6.10000E+02	174	6.10000E+02	175	6.10000E+02
176	6.10000E+02	177	6.10000E+02	178	6.10000E+02	179	6.10000E+02	180	6.10000E+02
181	6.10000E+02	182	6.10000E+02	183	6.10000E+02	184	6.10000E+02	185	6.10000E+02
186	6.10000E+02	187	6.10000E+02	188	6.10000E+02	189	6.10000E+02	190	6.10000E+02
191	6.10000E+02	192	6.10000E+02	193	6.10000E+02	194	6.10000E+02	195	6.10000E+02
196	6.10000E+02	197	6.10000E+02	198	6.10000E+02	199	6.10000E+02	200	6.10000E+02
201	6.10000E+02	202	6.10000E+02	203	6.10000E+02	204	6.10000E+02	205	6.10000E+02
206	6.10000E+02	207	6.10000E+02	208	6.10000E+02	209	6.10000E+02	210	6.10000E+02
211	6.10000E+02	212	6.10000E+02	213	6.10000E+02	214	6.10000E+02	215	6.10000E+02
216	6.10000E+02	217	6.10000E+02	218	6.10000E+02	219	6.10000E+02	220	6.10000E+02
221	6.10000E+02	222	6.10000E+02	223	6.10000E+02	224	6.10000E+02	225	6.10000E+02
226	6.10000E+02	227	6.10000E+02	228	6.10000E+02	229	6.10000E+02	230	6.10000E+02
231	6.10000E+02	232	6.10000E+02	233	6.10000E+02				

SSSSS

LTR141 62

A-7

COUPLE MOD 2 (MAY-23,77) UPDATE 1 (MAY-23,77) ECL
DOT TEMPERATURE RESPONSE FOR NUCLEAR LOCE RUN 05
- ECC JUN. 16, 1977 COUPLE MOD 2

AT CONDUCTION SOLUTION

TIME = 1.00000

DT = 1.00000

STEP = 2

PASS = 2

NODE	TEMPERATURE	NODE	TEMPERATURE	NODE	TEMPERATURE	NODE	TEMPERATURE	NODE	TEMPERATURE
1	6.0439E+02	2	6.0866E+02	3	6.0462E+02	4	6.0983E+02	5	6.0986E+02
6	6.0983E+02	7	6.0967E+02	8	6.0896E+02	9	6.0844E+02	10	6.0772E+02
11	6.0375E+02	12	6.0439E+02	13	6.0866E+02	14	6.0961E+02	15	6.0986E+02
16	6.0985E+02	17	6.0983E+02	18	6.0966E+02	19	6.0895E+02	20	6.0844E+02
21	6.0771E+02	22	6.0375E+02	23	6.0439E+02	24	6.0866E+02	25	6.0985E+02
26	6.0980E+02	27	6.0984E+02	28	6.0981E+02	29	6.0964E+02	30	6.0893E+02
31	6.0841E+02	32	6.0769E+02	33	6.0373E+02	34	6.0435E+02	35	6.0861E+02
36	6.0956E+02	37	6.0977E+02	38	6.0981E+02	39	6.0973E+02	40	6.0981E+02
41	6.0889E+02	42	6.0837E+02	43	6.0765E+02	44	6.0370E+02	45	6.0433E+02
46	6.0857E+02	47	6.0952E+02	48	6.0972E+02	49	6.0976E+02	50	6.0973E+02
51	6.0955E+02	52	6.0883E+02	53	6.0831E+02	54	6.0759E+02	55	6.0364E+02
56	6.0427E+02	57	6.0851E+02	58	6.0945E+02	59	6.0966E+02	60	6.0969E+02
61	6.0965E+02	62	6.0947E+02	63	6.0874E+02	64	6.0822E+02	65	6.0751E+02
66	6.0357E+02	67	6.0420E+02	68	6.0842E+02	69	6.0935E+02	70	6.0955E+02
71	6.0952E+02	72	6.0955E+02	73	6.0935E+02	74	6.0861E+02	75	6.0809E+02
76	6.0738E+02	77	6.0346E+02	78	6.0410E+02	79	6.0829E+02	80	6.0922E+02
81	6.0942E+02	82	5.0945E+02	83	6.0941E+02	84	6.0949E+02	85	6.0842E+02
86	6.0791E+02	87	6.0720E+02	88	6.0332E+02	89	6.0395E+02	90	6.0812E+02
91	6.0903E+02	92	6.0922E+02	93	6.0926E+02	94	6.0921E+02	95	6.0897E+02
96	6.0815E+02	97	6.0764E+02	98	6.0695E+02	99	6.0311E+02	100	6.0375E+02
101	6.0787E+02	102	6.0877E+02	103	6.0896E+02	104	6.0899E+02	105	6.0894E+02
106	6.0867E+02	107	6.0778E+02	108	6.0727E+02	109	6.0659E+02	110	6.0282E+02
111	6.0348E+02	112	6.0753E+02	113	6.0840E+02	114	6.0859E+02	115	6.0862E+02
116	6.0856E+02	117	6.0827E+02	118	6.0724E+02	119	6.0672E+02	120	6.0607E+02
121	6.0244E+02	122	6.0309E+02	123	6.0705E+02	124	6.0790E+02	125	6.0808E+02
126	6.0910E+02	127	6.0805E+02	128	6.0772E+02	129	6.0647E+02	130	6.0594E+02
131	6.0532E+02	132	6.0194E+02	133	6.0254E+02	134	6.0639E+02	135	6.0720E+02
136	6.0737E+02	137	6.0740E+02	138	6.0735E+02	139	6.0649E+02	140	6.0537E+02
141	6.0479E+02	142	6.0422E+02	143	6.0133E+02	144	6.0179E+02	145	6.0545E+02
146	6.0623E+02	147	6.0640E+02	148	6.0643E+02	149	6.0637E+02	150	6.0603E+02
151	6.0338E+02	152	6.0301E+02	153	6.0236E+02	154	6.0066E+02	155	5.9813E+02
156	5.9737E+02	157	5.9681E+02	158	5.9631E+02	159	5.9581E+02	160	5.9530E+02
161	5.9480E+02	162	5.9433E+02	163	5.9390E+02	164	5.9353E+02	165	5.9324E+02
166	5.9305E+02	167	5.9296E+02	168	5.9299E+02	169	5.9312E+02	170	5.9335E+02
171	5.9366E+02	172	5.9400E+02	173	5.9408E+02	174	6.00073E+02	175	6.0415E+02
176	6.0490E+02	177	6.0506E+02	178	6.0508E+02	179	6.0503E+02	180	6.0470E+02
181	6.0214E+02	182	6.0159E+02	183	6.0028E+02	184	6.0105E+02	185	5.9930E+02
186	5.9840E+02	187	5.9777E+02	188	5.9719E+02	189	5.9662E+02	190	5.9604E+02
191	5.9548E+02	192	5.9495E+02	193	5.9447E+02	194	5.9405E+02	195	5.9373E+02
196	5.9351E+02	197	5.9342E+02	198	5.9344E+02	199	5.9359E+02	200	5.9385E+02
201	5.9420E+02	202	5.9458E+02	203	5.9477E+02	204	5.9925E+02	205	6.0234E+02
206	6.0305E+02	207	5.0321E+02	208	6.0323E+02	209	6.0318E+02	210	6.0285E+02
211	6.0041E+02	212	6.0098E+02	213	5.9839E+02	214	5.9947E+02	215	5.9802E+02
216	5.9729E+02	217	5.9677E+02	218	5.9628E+02	219	5.9579E+02	220	5.9529E+02
221	5.9480E+02	222	5.9433E+02	223	5.9390E+02	224	5.9352E+02	225	5.9323E+02
226	5.9303E+02	227	5.9294E+02	228	5.9296E+02	229	5.9309E+02	230	5.9333E+02
231	5.9364E+02	232	5.9394E+02	233	5.9413E+02				

COUPLE MOD 2 (MAY-23,77) UPDATE 1 (MAY-23,77) ECL
 FT DOT TEMPERATURE RESPONSE FOR NUCLEAR LOCE RUN 05
 CE - ECC JUN. 16, 1977 COUPLE MOD 2
 EAT CONDUCTION SOLUTION

TIME = 11.50000 DT = .50000 STEP = 23 PASS = 2

NODE	TEMPERATURE	NODE	TEMPERATURE	NODE	TEMPERATURE	NODE	TEMPERATURE	NODE	TEMPERATURE
1	3.65222E+02	2	4.92633E+02	3	5.41322E+02	4	5.60033E+02	5	5.65133E+02
6	5.60244E+02	7	5.42233E+02	8	4.98144E+02	9	4.40033E+02	10	4.59711E+02
11	3.77499E+02	12	3.84699E+02	13	4.92199E+02	14	4.70033E+02	15	5.39866E+02
16	5.64622E+02	17	5.59733E+02	18	5.41566E+02	19	4.47033E+02	20	4.79933E+02
21	4.59166E+02	22	3.77033E+02	23	3.83888E+02	24	5.60033E+02	25	5.39866E+02
26	5.58299E+02	27	5.63033E+02	28	5.50033E+02	29	5.60033E+02	30	4.95833E+02
31	4.78233E+02	32	5.37499E+02	33	5.60033E+02	34	5.60033E+02	35	4.95833E+02
36	5.36822E+02	37	5.55622E+02	38	5.60033E+02	39	5.60033E+02	40	5.37066E+02
41	4.92833E+02	42	4.75303E+02	43	4.54499E+02	44	5.60033E+02	45	5.37066E+02
46	4.85433E+02	47	4.33199E+02	48	4.71033E+02	49	5.60033E+02	50	5.37066E+02
51	3.32903E+02	52	4.88566E+02	53	5.28333E+02	54	5.60033E+02	55	3.69622E+02
56	5.32903E+02	57	4.81133E+02	58	5.28333E+02	59	4.40033E+02	60	5.51144E+02
61	5.45999E+02	62	3.72144E+02	63	4.62799E+02	64	5.60033E+02	65	4.44944E+02
66	3.64855E+02	67	3.92444E+02	68	4.75666E+02	69	5.60033E+02	70	5.40033E+02
71	5.44499E+02	72	3.92444E+02	73	5.20333E+02	74	4.75666E+02	75	4.57799E+02
76	5.37744E+02	77	3.58666E+02	78	3.66666E+02	79	5.60033E+02	80	5.14377E+02
81	3.32011E+02	82	3.62799E+02	83	3.30900E+02	84	5.60033E+02	85	4.66666E+02
86	4.48755E+02	87	5.28666E+02	88	3.50877E+02	89	5.60033E+02	90	4.60033E+02
91	3.04922E+02	92	5.28666E+02	93	5.26200E+02	94	5.60033E+02	95	5.01200E+02
96	5.54699E+02	97	4.37333E+02	98	5.17444E+02	99	5.60033E+02	100	5.01200E+02
101	4.50018E+02	102	4.93333E+02	103	5.10244E+02	104	5.60033E+02	105	5.01200E+02
106	4.88755E+02	107	4.40033E+02	108	4.23333E+02	109	4.99033E+02	110	3.29933E+02
111	3.43666E+02	112	3.38111E+02	113	4.30066E+02	114	4.99033E+02	115	4.99033E+02
116	5.94511E+02	117	4.74999E+02	118	4.24499E+02	119	4.06666E+02	120	4.99033E+02
121	3.14999E+02	122	3.33333E+02	123	4.24499E+02	124	4.06666E+02	125	4.99033E+02
126	3.83333E+02	127	4.77499E+02	128	4.57477E+02	129	4.06666E+02	130	4.99033E+02
131	3.66666E+02	132	2.97833E+02	133	3.20033E+02	134	4.06666E+02	135	4.99033E+02
136	4.60777E+02	137	4.64111E+02	138	4.58766E+02	139	4.06666E+02	140	4.99033E+02
141	3.63266E+02	142	3.41222E+02	143	2.77711E+02	144	4.06666E+02	145	4.99033E+02
146	4.24722E+02	147	3.38999E+02	148	4.42133E+02	149	4.06666E+02	150	4.99033E+02
151	3.58444E+02	152	3.37633E+02	153	3.04222E+02	154	4.06666E+02	155	4.99033E+02
156	1.62111E+02	157	1.48099E+02	158	1.38877E+02	159	4.06666E+02	160	4.99033E+02
161	1.19222E+02	162	1.14233E+02	163	1.10022E+02	164	4.06666E+02	165	4.99033E+02
166	1.02333E+02	167	1.01888E+02	168	1.02077E+02	169	4.06666E+02	170	4.99033E+02
171	1.07500E+02	172	1.10066E+02	173	1.10977E+02	174	4.06666E+02	175	4.99033E+02
176	4.00088E+02	177	4.14299E+02	178	4.17255E+02	179	4.06666E+02	180	4.99033E+02
181	3.34133E+02	182	3.04433E+02	183	2.85255E+02	184	4.06666E+02	185	4.99033E+02
186	1.67559E+02	187	1.52833E+02	188	1.42900E+02	189	4.06666E+02	190	4.99033E+02
191	1.21711E+02	192	1.16322E+02	193	1.11799E+02	194	4.06666E+02	195	4.99033E+02
196	1.03379E+02	197	1.03022E+02	198	1.03211E+02	199	4.06666E+02	200	4.99033E+02
201	1.09002E+02	202	1.11803E+02	203	1.13133E+02	204	4.06666E+02	205	4.99033E+02
206	3.74099E+02	207	3.85655E+02	208	3.80466E+02	209	4.06666E+02	210	4.99033E+02
211	3.12339E+02	212	2.93499E+02	213	2.37400E+02	214	4.06666E+02	215	4.99033E+02
216	1.50877E+02	217	1.47599E+02	218	1.38655E+02	219	4.06666E+02	220	4.99033E+02
221	1.19333E+02	222	1.14333E+02	223	1.10099E+02	224	4.06666E+02	225	4.99033E+02
226	1.02551E+02	227	1.01777E+02	228	1.01944E+02	229	4.06666E+02	230	4.99033E+02
231	1.07336E+02	232	1.09822E+02	233	1.11122E+02				

APPENDIX B

DTT FLUID LOAD AND AVERAGE TEMPERATURE CALCULATIONS

L1-1 Testsee J.R. Chappell, Experiment Data Report for LOFT Nonnuclear Test L1-1, TREE-NUREG-1025 (Jan. 1977)Downcomer #1 (FE-1ST-1)BlowdownNominal case $C_D = 1.5$ velocity $V = 15 \text{ ft/sec}$ TREE-NUREG-1025, FIG. 9.1density $\rho = 60 \text{ lb}_m/\text{ft}^3$ FIG. 18frontal area $A = .7174 \text{ in}^2$ GOTT-4-76 (JUNE 9, 1976)

$$\text{Load} = F = \frac{C_D \rho V^2 A}{2 g_c} \quad \text{GOTT-4-76}$$

$$F_{\text{nom}} = \frac{(1.5)(60 \text{ lb}_m/\text{ft}^3)(15 \text{ ft/sec})^2(.7174 \text{ in}^2)}{(144 \frac{\text{in}^2}{\text{ft}^2})(2)(32.2 \text{ lb}_m \text{ ft}/\text{lb}_f \text{ sec}^2)} = \underline{\underline{1.57 \text{ lb}_f}}$$

Worst Case $C_D = 2.5$ $V = 15 + 2.85 = 17.85 \text{ ft/sec}$ DTT, TYPE Aaccuracy $\pm 10\%$ of range, range: 1.5 to 30 ft/sec
or $\pm 2.85 \text{ ft/sec}$, Reactor Vessel Loss-of-Fluid
Test Reactor, AEC Spec. No. MS-201, Rev. 7 (June 22, 1972)

$$F_{\text{worst}} = \frac{(2.5)(60)(17.85)^2(.7174)}{(144)(64.4)} = \underline{\underline{3.7 \text{ lb}_f}}$$

Steady state

For high speed pump tests the flow rate is $3.9 \times 10^6 \text{ lb}_m/\text{hr}$
and the density $\rho = 47 \text{ lb}_m/\text{ft}^3$. Knowing the cross-sectional
area of the downcomers the velocity can be calculated.

U-1 cont'd

steady state cont'd

$$A = \frac{\pi}{4} (37^2 - 33^2) / 144 = 1.527 \text{ ft}^2 \quad \text{dimensions are from:}$$

H.C. Robinson, LOFT SYSTEMS and Test Description
(Loss-of-Coolant Experiments Using A Core Simulator),
 TREE-NUREG-1019 (NOV. 1976).

$$\therefore N = \frac{(3.9 \times 10^6 \text{ lb}_m/\text{hr})(1 \text{ hr}/3600 \text{ sec})}{(47 \text{ lb}_m/\text{ft}^3)(1.527 \text{ ft}^2)} = 15 \text{ ft/sec}$$

Nominal case

$$F_{\text{nom}} = \frac{(1.5)(47 \frac{\text{lb}_m}{\text{ft}^3})(15 \frac{\text{ft}}{\text{sec}})^2 (.7174 \text{ in}^2)}{(144 \frac{\text{in}^2}{\text{ft}^2})(64.4 \frac{\text{lb}_m \text{ ft}}{\text{lb}_f \text{ sec}^2})} = \underline{\underline{1.23 \text{ lb}_f}}$$

Worst case

Assume velocity uncertainty same as DTT measurement

$$\therefore N_{\text{worst}} = 15 + 2.85 = 17.85 \text{ ft/sec}$$

and a density variation of $\pm .6 \text{ lb}_m/\text{ft}^3$ ref: GOTT-4-76

$$F_{\text{worst}} = \frac{(2.5)(47.6)(17.85)^2 (.7174)}{(144)(64.4)} = \underline{\underline{2.9 \text{ lb}_f}}$$

Downcomer #2 (FE-2ST-1)BlowdownNominal case $c_D = 1.5$

velocity $U = 18.2 \text{ ft/sec}$ TREE-NUREG-1025, FIG. 92

$$F_{\text{nom}} = \frac{(1.5)(60)(18.2)^2 (.7174)}{(144)(64.4)} = \underline{\underline{2.3 \text{ lb}_f}}$$

L1-1 cont'd

Blowdown cont'dWorst case $C_D = 2.5$

$$V = 18.3 + 2.85 = 21.15 \text{ ft/sec}$$

$$F_{\text{Worst}} = \frac{(2.5)(60)(21.15)^2(.7174)}{(144)(64.4)} = \underline{\underline{5.2 \text{ lbf}}}$$

Steady State

$$F_{\text{nom}} = 1.23 \text{ lbf}$$

$$F_{\text{Worst}} = 2.9 \text{ lbf}$$

L1-2 Test see H.C. Robinson, Experiment Data Report for LOFT Nonnuclear Test
L1-2, TREE-NUREG-1026 (JAN. 1977).

Downcomer #1 (FE-1ST-1)

note: no velocities recorded, ECC injection after hot wall delay
momentum flux low; 4000 lb_m/ft²-sec² after HWD
7000 lb_m/ft²-sec². see fig. 105 and fig 276 of ref.

Blowdown

$$\text{MAX. MOM. FLUX} = 4000 \text{ lb}_m/\text{ft}^2\text{-sec}^2$$

" after HWD = 7000

$$\text{nominal } C_D = 1.5$$

$$F_{\text{nom}} = \frac{(1.5)(4000 \frac{\text{lb}_m}{\text{ft}^2\text{sec}^2})(.7174 \text{ in}^2)}{(144 \frac{\text{in}^2}{\text{ft}^2})(64.4 \frac{\text{lb}_m \text{ ft}}{\text{lb}_f \text{ sec}^2})} = \underline{\underline{0.5 \text{ lbf}}}$$

after HWD

$$F_{\text{nom}} = \frac{(1.5)(7000)(.7174)}{(144)(64.4)} = \underline{\underline{0.8 \text{ lbf}}}$$

LFC cont'd

Blowdown cont'dWorst case $C_D = 2.5$

$$F_{\text{Worst}} = \frac{(2.5)(4000)(.7174)}{(144)(64.4)} = \underline{0.77} \text{ lbf}$$

after HWD

$$F_{\text{Worst}} = \frac{(2.5)(7000)(.7174)}{(144)(64.4)} = \underline{1.4} \text{ lbf}$$

Steady state

$$\underline{F_{\text{nom}} = 1.23 \text{ lbf}}$$

$$\underline{F_{\text{Worst}} = 2.9 \text{ lbf}}$$

Downcomer #2 (FE-2ST-1)Blowdown

$$\text{MAX. MOM. FLUX} = 4200 \text{ lb}_m / \text{ft}^2 \text{ sec}^2$$

$$\text{HWD} = 7500$$

fig. 106 of ref.
fig. 277Nominal case $C_D = 1.5$

$$F_{\text{nom}} \approx \underline{0.5 \text{ lbf}} = \underline{0.5 \text{ lbf}}$$

after HWD

$$F_{\text{nom}} = \frac{(1.5)(7500)(.7174)}{(144)(64.4)} = \underline{0.9 \text{ lbf}}$$

Worst case $C_D = 2.5$

$$F_{\text{Worst}} = \frac{(2.5)(4200)(.7174)}{(144)(64.4)} = \underline{0.8 \text{ lbf}}$$

after HWD

$$F_{\text{Worst}} = \frac{(2.5)(7500)(.7174)}{(144)(64.4)} = \underline{1.45 \text{ lbf}}$$

Steady state

$$\underline{F_{\text{nom}} = 1.23 \text{ lbf}} \quad \underline{F_{\text{Worst}} = 2.7 \text{ lbf}}$$

L1-3 Test see G.M. Millar, Experiment Data Report for LOFT Nonnuclear Test L1-3, TREE-NUREG-1065 (April 1977)

note: No ECC injection due to procedural error

Downcomers #1 & 2

Blowdown

velocity $V = 10 \frac{\text{ft}}{\text{sec}}$ fig. 58 & 59 of above ref.

density; assume $\rho = 60 \text{ lb}_m/\text{ft}^3$

nominal case $C_D = 1.5$

$$F_{\text{nom}} = \frac{(1.5)(60)(10)^2(.7174)}{(144)(64.4)} = \underline{\underline{0.7 \text{ lbf}}}$$

Worst case $C_D = 2.5$

$$V = 10 + 2.85 = 12.85 \frac{\text{ft}}{\text{sec}}$$

$$F_{\text{worst}} = \frac{(2.5)(60)(12.85)^2(.7174)}{(144)(64.4)} = \underline{\underline{1.9 \text{ lbf}}}$$

Steady state

$$F_{\text{nom}} = \underline{\underline{1.23 \text{ lbf}}} \quad F_{\text{worst}} = \underline{\underline{2.9 \text{ lbf}}}$$

L1-3A Test see G.M. Millar, Experiment Data Report for LOFT Nonnuclear Test L1-3A, TREE-NUREG-1027 (Dec. 1976)

note: ECC injection into lower RV plenum

Downcomer #1 (FE-1ST-1)

Blowdown

nominal case $C_D = 1.5$

velocity $v = 10 \frac{\text{ft}}{\text{sec}}$ fig. 69

$$F_{\text{nom}} = \frac{(1.5)(60)(10)^2(0.7174)}{(144)(64.4)} = \underline{\underline{0.7 \text{ lbf}}}$$

Worst case $C_D = 2.5$

$v = 12.85 \frac{\text{ft}}{\text{sec}}$ (same as L1-3)

$$F_{\text{Worst}} = \underline{\underline{1.9 \text{ lbf}}}$$

Steady state

$$F_{\text{nom}} = \underline{\underline{1.23 \text{ lbf}}}, F_{\text{Worst}} = \underline{\underline{2.9 \text{ lbf}}}$$

Downcomer #2 (FE-2ST-1)

Blowdown

nominal case $C_D = 1.5$

$v = 9.6 \frac{\text{ft}}{\text{sec}}$ fig. 70

$$F_{\text{nom}} = \frac{(1.5)(60)(9.6)^2(0.7174)}{(144)(64.4)} = \underline{\underline{0.6 \text{ lbf}}}$$

Worst case $C_D = 2.5$

$v = 9.6 + 2.85 = 12.45 \frac{\text{ft}}{\text{sec}}$

$$F_{\text{Worst}} = \frac{(2.5)(60)(12.45)^2(0.7174)}{(144)(64.4)} = \underline{\underline{1.8 \text{ lbf}}}$$

L1-3A cont'd

Downcomer #2 cont'd

Steady State

$$F_{nom} = \underline{1.23} \text{ lbf} \quad F_{worst} = \underline{2.9} \text{ lbf}$$

L1-4 Test see J.R. White, et al., Experiment Prediction For LOFT Nonnuclear Experiment L1-4, TREE-NUREG-1086 (April 1977)

note: Test represented a 200% break in cold leg loop. ECC injection at intact cold leg loop as in L1-1. Max density $\rho = 47 \text{ lbm/ft}^3$ predicted but used $\rho = 60 \text{ lbm/ft}^3$ recorded for L1-1.

Downcomer #1 (FE-1ST-1)Blowdownnominal case $C_D = 1.5$

$$\text{velocity } v = 40.7 \text{ ft/sec} \quad \text{Fig. 31}$$

$$F_{nom} = \frac{(1.5)(60)(40.7)^2(0.7174)}{(144)(64.4)} = \underline{11.5} \text{ lbf}$$

worst case $C_D = 2.5$

$$\text{velocity } v = 40.7 + 2.85 = 43.55 \text{ ft/sec}$$

$$F_{worst} = \frac{(2.5)(60)(43.55)^2(0.7174)}{(144)(64.4)} = \underline{22.0} \text{ lbf}$$

steady state

$$F_{nom} = \underline{1.23} \text{ lbf} \quad F_{worst} = \underline{2.9} \text{ lbf}$$

Downcomer #2 (FE-2ST-1)Blowdownnominal case $C_D = 1.5$

$$\text{velocity } v = 24 \text{ ft/sec} \quad \text{Fig 32}$$

LI-4 cont'd

nominal case cont'd

$$F_{nom} = \frac{(1.5)(60)(24)^2(1.7174)}{(144)(64.4)} = \underline{\underline{4.0}} \text{ lb}_f$$

Worst case $C_0 = 2.5$

$$N = 24 + 2.85 = 26.85 \text{ ft/sec}$$

$$F_{worst} = \frac{(2.5)(60)(26.85)^2(1.7174)}{(144)(64.4)} = \underline{\underline{8.4}} \text{ lb}_f$$

Steady State

$$F_{nom} = \underline{\underline{1.23}} \text{ lb}_f \quad F_{worst} = \underline{\underline{2.9}} \text{ lb}_f$$

6/16/72

Average Body Temp.

ANC Spec.

Film coef. = $400 \text{ Btu/hr ft}^2 \text{ } ^\circ\text{F}$ time
(sec) T_{node} (area)

	$T_5 (.03103)$	$T_{48} (.10352)$	$T_{102} (.13112)$	$T_{134} (.17434)$	T_{ave}
0	610.00	610.00	610.00	610.00	610.00
1	609.86	609.72	608.77	606.39	608.14
2	609.38	608.90	606.12	600.45	604.77
3	608.40	607.43	602.52	593.88	600.68
4	606.83	605.31	598.24	586.97	596.06
5	604.66	602.56	593.10	579.76	590.96
6	601.89	599.22	588.09	572.24	585.41
7	598.56	595.34	582.33	564.44	579.46
8	594.83	590.93	574.33	547.79	569.18
9	589.99	584.62	569.37	535.47	550.09
10	582.92	574.86	566.36	470.54	522.63
11	571.99	560.36	507.87	426.19	492.39
12	557.50	542.54	479.61	392.33	464.54
13	540.20	522.69	453.09	361.09	439.17
14	521.01	501.79	428.55	336.67	415.91
15	500.75	480.53	405.90	315.79	394.45
16	480.02	459.37	384.95	297.57	374.55
17	459.26	438.61	365.49	281.39	355.99
18	438.77	418.47	347.37	266.86	338.65
19	418.80	399.07	330.46	253.66	322.41
20	399.51	380.49	314.63	241.59	307.18
21	381.23	363.00	300.02	230.67	293.09
22	363.78	346.37	286.30	220.54	279.85
23	347.18	330.58	273.41	211.13	267.39
24	331.40	315.62	261.30	202.37	255.68
25	316.43	301.46	249.90	194.18	244.65

6/17/77

ANC Spec.

Average Shroud Temp

Time (sec)	T ₁₉₃	T ₂₀₀	T ₂₂₅	T ₂₃₀	T _{ave}
0	610.00	610.00	610.00	610.00	610.00
1	594.47	593.85	593.90	593.33	593.89
2	575.28	574.22	574.57	573.57	574.41
3	559.07	557.90	558.46	557.35	558.20
4	544.50	543.33	543.96	542.84	543.66
5	530.80	529.66	530.29	529.20	529.99
6	517.55	516.45	517.06	516.00	516.77
7	504.54	503.46	504.05	503.03	503.77
8	443.37	439.82	440.15	436.88	440.06
9	336.38	329.93	331.79	325.76	330.97
10	208.70	200.23	203.35	195.39	201.92
11	132.39	125.69	129.86	123.45	127.85
12	98.00	93.708	96.866	92.739	95.33
13	82.605	80.094	82.106	79.681	81.12
14	75.709	74.304	75.488	74.127	74.91
15	72.605	71.838	72.508	71.762	72.18
16	71.201	70.786	71.157	70.753	70.97
17	70.560	70.336	70.541	70.323	70.44
18					
19					
20					
21					
22					
23					
24					
25	70.006	70.000	70.006	70.000	70.003
7.25	495.76	494.30	494.46	493.11	494.41
7.50	482.09	480.04	480.03	478.15	480.08
7.75	464.38	461.62	461.69	459.15	461.71

6/17/17

Average Body & Shroud Temperature Diff.

ANC Spec.

Time (sec)	Body	Shroud	Temp. Diff.
0	610.00	610.00	0.0
1	608.14	593.89	14.25
2	604.77	574.41	30.36
3	600.68	558.20	42.48
4	596.06	543.66	52.40
5	590.96	529.99	60.97
6	585.41	516.77	68.64
7	579.46	503.77	75.69
8	569.18	440.06	129.12
9	550.09	330.97	219.12
10	522.63	201.92	320.71
11	492.39	127.85	364.54
12	464.54	95.33	369.21
13	439.17	81.12	358.05
14	415.91	74.91	341.00
15	394.45	72.18	322.27
16	374.55	70.97	303.58
17	355.99	70.44	285.55
18	338.65		~ 268.65
19	322.41		~ 252.41
20	307.18		~ 237.18
21	293.09		~ 223.09
22	279.85		~ 209.85
23	267.39		~ 197.39
24	255.68		~ 185.68
25	244.65	70.00	174.65

8/10/77

Average Body Temp.Intact loop
COLD LEG T_{node} (area)

Time (sec)	T_5 (.03103)	T_{48} (.10352)	T_{102} (.13112)	T_{134} (.17939)	T_{ave}
0	550.	550.	550.	550.	550.
1	550.	550.	550.	550.	550.
2	550.	550.	550.	550.	550.
3	550.01	550.02	550.09	550.27	550.14
4	550.05	550.09	550.32	550.81	550.42
5	550.14	550.23	550.72	551.62	551.01
6	550.27	550.41	551.00	551.84	551.14
7	550.42	550.55	551.03	551.46	551.04
8	550.51	550.61	550.78	550.58	550.64
9	550.52	550.53	550.25	549.31	549.96
10	550.40	550.27	549.41	547.60	548.96
11	550.11	549.81	548.27	545.51	547.67
12	549.62	549.13	546.84	543.11	546.10
13	548.91	548.21	545.10	540.31	544.20
14	547.96	547.02	543.00	537.03	541.93
15	546.74	545.55	540.55	533.34	539.31
16	545.23	543.75	537.65	528.99	536.19
17	543.40	541.60	534.29	524.06	532.60
17.2	543.02	541.16	533.60	523.05	531.86
17.4	542.63	540.70	532.89	522.02	531.11
17.6	542.22	540.23	532.16	520.97	530.33
17.8	541.80	539.74	531.42	519.89	529.54
18.0	541.36	539.23	530.63	518.61	528.65
18.2	540.91	538.71	529.78	517.01	527.61
18.4	540.45	538.17	528.82	515.05	526.38
18.6	539.97	537.59	527.74	512.73	524.97
18.8	539.46	536.99	526.51	510.06	523.37
19	538.94	536.34	525.12	507.05	521.57
20	535.20	531.50	514.86	487.94	504.54
21	530.01	524.88	502.20	467.08	495.58
22	523.24	516.55	487.98	445.90	480.52
23	514.92	506.71	472.86	425.29	464.94
24	505.21	495.61	457.23	405.35	449.09
25	494.29	483.47	441.26	385.97	433.02
25.5	488.55	477.17	433.26	376.62	425.05
26.0	482.56	470.67	425.31	367.65	417.17
26.5	476.35	464.02	417.48	359.31	409.53
27	469.95	457.26	409.87	351.63	402.18
28	456.74	443.60	395.62	338.38	388.54
29	443.36	430.06	382.36	326.78	375.86
30	430.04	416.81	369.99	316.47	364.03
35	368.89	351.74	319.27	277.45	315.26
40	320.43	311.88	282.42	250.91	279.55

8/10/77

Average Shroud Temp.Intact loop
COLD LEG

Time (Sec)	T ₁₉₃	T ₂₀₀	T ₂₂₅	T ₂₃₀	T _{ave}
0	550.	550.	550.	550.	550.
1	550.	550.	550.	550.	550.
2	550.	550.	550.	550.	550.
3	551.17	551.22	551.21	551.26	551.22
4	552.97	553.07	553.04	553.13	553.05
5	555.42	555.57	555.51	555.65	555.54
6	554.60	554.64	554.57	554.61	554.56
7	552.01	551.93	551.92	551.85	551.93
8	548.50	548.32	548.37	548.20	548.35
9	544.49	544.25	544.34	544.11	544.30
10	539.68	539.37	539.50	539.21	539.44
11	534.44	534.08	534.25	533.90	534.17
12	528.98	528.58	528.77	528.40	528.68
13	522.86	522.41	522.63	522.21	522.53
14	515.85	515.35	515.59	515.11	515.48
15	508.37	507.82	508.09	507.56	507.96
16	499.36	498.73	499.02	498.42	498.88
17	489.53	488.82	489.16	488.49	489.00
17.2	487.54	486.81	487.16	486.47	487.00
17.4	485.52	484.78	485.14	484.44	484.97
17.6	483.48	482.73	483.10	482.39	482.93
17.8	481.43	480.67	481.04	480.32	480.87
18.0	477.52	476.62	476.80	475.95	476.72
18.2	471.90	470.77	470.85	469.80	470.83
18.4	464.82	463.40	463.47	462.17	463.47
18.6	456.49	454.76	454.90	453.31	454.87
18.8	447.11	445.05	445.31	443.41	445.22
19	436.82	434.44	434.85	432.64	434.69
20	385.57	382.40	383.59	380.61	383.04
21	339.48	336.13	337.69	334.52	336.96
22	300.52	297.35	298.99	295.98	298.21
23	268.69	265.89	267.43	264.76	266.69
24	241.57	239.14	240.50	238.18	239.85
25.0	217.38	215.24	216.42	214.38	215.86
25.5	207.21	205.27	206.40	204.55	205.86
26.0	198.40	196.66	197.69	196.03	197.20
26.5	192.39	190.93	191.91	190.51	191.44
27	188.36	187.18	188.03	186.90	187.62
28	184.26	183.51	184.10	183.38	183.81
29	182.18	181.72	182.10	181.65	181.91
30	181.12	180.84	181.08	180.81	180.96
35	180.03	180.01	180.03	180.01	180.02
40	180.01	180.00	180.01	180.00	180.00

Average Body & Shroud Temp Difference

Intact Imp
COLD LEG

	T Body	T Shroud	Δ T
0	550.	550.	0.0
2	550.	550.	0.0
4	550.42	553.05	2.63
6	551.14	554.56	3.42
8	550.64	548.35	2.29
10	548.96	539.44	9.52
12	546.10	528.68	17.42
14	541.93	515.48	26.45
15	539.31	507.96	31.35
16	536.19	498.88	37.31
11	532.60	489.00	43.60
17.2	531.86	487.00	44.86
17.4	531.11	484.97	46.14
17.6	530.33	482.93	47.40
17.8	529.54	480.87	48.67
18	528.65	476.72	51.93
18.2	527.61	470.83	56.78
18.4	526.38	463.47	62.91
18.6	524.97	454.87	70.10
18.8	523.37	445.22	78.15
19	521.57	434.69	86.88
20	509.54	383.04	126.50
22	480.52	298.21	182.31
24	449.09	239.85	209.24
25	433.02	215.86	217.16
26	417.17	197.20	219.97
26.5	409.53	191.44	218.09
27	402.18	187.02	214.56
28	388.54	183.81	204.73
29	375.86	181.91	193.95
30	364.03	180.96	183.07
35	315.26	180.02	135.24
40	279.55	180.00	99.55

8/11/77

Average Body TemperatureIntact loop
HOT LEG T_{body} (arcmin)

Time (sec)	T_5 (.03103)	T_{48} (.10352)	T_{102} (.13112)	T_{134} (.17434)	T_{ave}
0	615.	615.	615.	615.	615.
1	614.94	614.88	614.47	613.45	614.20
2	614.72	614.49	613.17	610.43	612.50
3	614.21	613.71	611.07	606.21	609.99
3.5	614.09	613.53	610.61	605.32	609.45
3.9	613.97	613.34	610.13	604.38	608.88
3.6	613.82	613.13	609.61	603.42	608.28
3.8	613.67	612.90	609.07	602.45	607.67
4.0	613.49	612.65	608.50	601.50	607.05
4.2	613.30	612.38	607.92	600.56	606.43
4.4	613.10	612.09	607.33	599.63	605.81
4.6	612.87	611.79	606.72	598.72	605.18
4.8	612.63	611.46	606.11	597.83	604.55
5.0	612.37	611.12	605.49	596.95	603.92
6	610.70	609.08	602.32	592.77	600.72
8	606.42	604.24	595.78	584.77	594.16
10	601.22	598.65	588.99	576.93	587.35
12	595.35	592.48	581.87	568.84	580.15
14	588.87	585.72	574.01	559.56	572.09
16	581.70	578.20	565.13	548.89	562.94
18	573.50	569.45	553.99	534.16	551.15
20	563.90	559.14	541.00	517.92	537.74
22	552.81	547.54	526.64	500.65	523.06
24	540.32	534.17	511.12	482.51	507.27
26	523.59	527.13	502.97	473.14	498.99
25.5	530.14	523.53	498.83	468.40	494.79
26.0	526.62	519.86	494.64	463.62	490.54
26.5	523.03	516.12	490.42	458.99	486.31
27.0	519.37	512.33	486.23	454.53	482.15
27.5	515.66	508.50	482.08	450.25	478.05
28.0	511.89	504.64	477.98	446.11	474.02
28.5	508.09	500.75	473.86	441.71	469.86
29.0	504.24	496.83	469.62	436.95	465.52
29.5	500.36	492.85	465.24	431.84	460.98
30.0	496.42	488.80	460.72	426.58	456.32
30.5	492.42	484.69	456.08	421.23	451.57
31.0	488.36	480.50	451.40	416.02	446.83
33	471.47	463.27	433.21	397.47	428.82
35	454.35	446.02	415.86	380.65	411.72
37	437.38	429.14	399.56	365.56	395.71
41	405.54	398.06	371.70	342.48	368.71
45	378.21	371.92	349.95	326.16	347.69

8/11/77

Average Shroud Temperature

Intact Imp
HOT LEG

Time (Sec)	T ₁₉₃	T ₂₂₀	T ₂₂₃	T ₂₃₀	T _{Ave}
0	615.	615.	615.	615.	615.
1	608.35	608.09	608.11	607.86	608.10
2	598.09	597.55	597.71	597.21	597.64
3	585.91	585.16	585.46	584.75	585.32
3.2	583.41	582.62	582.95	582.20	582.80
3.4	580.85	580.03	580.38	579.60	580.22
3.6	578.39	577.54	577.93	577.13	577.75
3.8	576.14	575.29	575.73	574.91	575.52
4.0	574.10	573.25	573.72	572.91	573.50
4.2	572.23	571.39	571.88	571.08	571.65
4.4	570.50	569.69	570.18	569.40	569.94
4.6	568.89	568.10	568.59	567.84	568.36
4.8	567.38	566.63	567.11	566.38	566.88
5.0	565.96	565.24	565.71	565.01	565.48
6	560.02	559.41	559.80	559.22	559.61
8	549.65	549.18	549.47	549.02	549.33
10	540.03	539.61	539.85	539.45	539.74
12	529.67	529.24	529.46	529.05	529.36
14	518.04	515.52	515.78	515.38	515.66
16	499.75	499.12	499.42	498.82	499.28
18	472.36	471.39	471.85	470.94	471.64
20	447.01	446.02	446.64	445.59	446.29
22	422.30	421.32	421.83	420.89	421.59
24	397.76	396.78	397.29	396.36	397.05
26	385.51	384.54	385.04	384.12	384.80
26.5	379.39	378.43	378.92	378.00	378.69
26.0	373.27	372.31	372.80	371.89	372.57
26.5	368.27	367.37	367.89	367.02	367.64
27.0	364.07	363.25	363.74	362.96	363.51
27.5	360.41	359.66	360.12	359.41	359.90
28.0	357.11	356.45	356.86	356.22	356.66
28.5	351.75	351.01	351.33	350.64	351.18
29.0	344.89	344.04	344.35	343.56	344.21
29.5	337.01	336.04	336.40	335.48	336.23
30.0	329.37	328.33	328.78	327.80	328.57
30.5	321.94	320.86	321.35	320.34	321.12
31.0	315.87	314.85	315.39	314.42	315.13
33	299.59	298.83	299.27	298.54	299.06
35	286.81	286.22	286.56	286.00	286.40
37	277.14	276.69	276.95	276.52	276.83
41	270.86	270.72	270.83	270.69	270.78
45	270.11	270.08	270.10	270.08	270.09

Average Body & Shroud Temp DifferenceIntact lwp
HOT LEGTime
(sec) ΔT

0	0.0
2	14.86
4	33.55
6	41.11
8	44.83
10	47.61
12	50.79
14	56.43
16	63.66
18	79.51
20	91.45
22	101.47
24	110.22
25	114.19
25.5	116.10
26	117.97
26.5	118.67
27	118.64
27.5	118.15
28	117.36
28.5	118.68
29	121.31
29.5	124.75
30	127.75
30.5	130.45
31	131.70
33	129.76
35	125.32
37	118.88
41	97.93
45	77.60

Time (sec)	Average Body Temp.				Reactor Vessel/ Upper Plenum	T _{ave}
	T ₅ (.03103)	T ₄₈ (.10352)	T ₁₀₂ (.13112)	T ₁₃₄ (.17434)		
0	615.0					615.0
3.5	613.98	613.33	610.00	604.04		608.70
5	612.38	611.14	605.58	597.12		604.02
10	601.32	598.74	589.06	576.99		590.10
15	585.35	581.98	569.41	553.82		567.31
20	564.25	559.73	542.66	521.22		539.70
25	535.40	529.18	505.71	476.37		501.70
27.0	521.52	514.59	488.69	456.88		484.49
29.5	502.59	495.09	467.49	434.21		463.27
30.0	498.66	491.05	463.04	429.15		458.71
30.5	494.67	486.95	458.48	423.92		454.04
31.0	490.62	482.79	453.86	418.78		449.36
31.5	486.52	478.57	449.23	413.79		444.72
32.0	482.37	474.31	444.62	408.96		440.14
32.5	478.16	470.01	440.04	404.26		435.60
33.0	473.92	466.68	435.50	399.67		431.11
33.5	469.64	461.33	431.00	395.18		426.67
34.0	465.34	456.98	426.54	390.78		422.27
34.5	461.02	452.62	422.13	386.45		417.91
35.0	456.68	448.26	417.75	382.18		413.58
35.5	452.35	443.91	413.44	378.10		409.35
38.0	430.84	422.59	393.31	360.27		389.75
40.0	414.34	406.51	378.92	348.20		375.74

Time (sec.)	Average Shroud Temp.					ΔT
	T_{193}	T_{200}	T_{223}	T_{230}	Reactor Vessel Upper Plenum T_{ave}	
0	615.				615.	0.
3.5	579.65	578.79	579.17	578.36	578.99	29.71
5	566.35	565.61	566.07	565.87	565.85	38.17
10	540.03	539.61	539.85	539.45	539.74	50.36
15	506.67	506.08	506.38	505.82	506.24	61.07
20	456.10	455.22	455.65	454.82	455.45	84.25
25.	388.87	387.80	388.34	387.33	388.08	113.62
27.0	364.88	363.97	364.53	363.66	364.26	120.23
29.5	340.19	339.31	339.67	338.84	339.50	123.77
30.0	333.15	332.20	332.60	331.71	332.42	126.29
30.5	325.80	324.79	325.23	324.27	325.02	129.02
31.0	319.69	318.70	319.21	318.27	318.97	130.39
31.5	314.47	313.54	314.06	313.18	313.81	130.91
32.0	309.85	309.00	309.49	308.68	309.26	130.88
32.5	305.65	304.86	305.32	304.57	305.10	130.50
33.0	301.73	301.00	301.42	300.72	301.22	129.89
33.5	297.99	297.31	297.70	297.05	297.51	129.16
34.0	294.38	293.74	294.10	293.48	293.93	128.34
34.5	290.86	290.24	290.58	290.00	290.42	127.49
35.0	287.39	286.80	287.12	286.56	286.97	126.61
35.5	284.70	284.17	284.49	283.98	284.34	125.01
38.0	276.65	276.38	276.55	276.29	276.47	113.28
40.0	272.24	272.05	272.16	271.98	272.11	103.63

Time (sec)	Average Shroud Temp. (°F)				Reactor Vessel Lower Downcomer	
	T ₁₉₃	T ₂₀₀	T ₂₂₃	T ₂₃₀	T _{ave}	ΔT
0	550.00	550.00	550.00	550.00	550.00	0.0
7.0	550.00	550.00	550.00	550.00	550.00	0.0
9.0	544.34	544.14	544.19	544.01	544.17	5.1
11.0	535.28	534.96	535.11	534.80	535.04	12.22
15.0	507.54	506.96	507.24	506.68	507.10	31.77
20.0	456.41	455.52	455.96	455.11	455.75	63.07
23.0	416.47	415.43	415.95	414.96	415.70	84.95
25.0	388.89	387.81	388.36	387.34	388.10	98.15
25.5						
26.0	375.03	373.96	374.50	373.48	374.24	104.30
26.5						
27.0	364.88	363.97	364.53	363.66	364.26	106.57
27.5						
28.0	360.96	360.15	360.66	359.88	360.41	106.64
28.5						
29.0	348.98	348.27	348.63	347.96	348.46	107.03
29.5						
30.0	339.26	338.52	338.88	338.18	338.71	109.4
32.0	318.47	317.68	318.06	317.31	317.88	114.23
34.0	297.14	296.33	296.72	295.95	296.54	118.88
34.5	291.79	290.97	291.37	290.59	291.18	119.97
35.0	286.43	285.60	286.00	285.22	285.81	121.03
36.0	280.09	279.43	279.84	279.21	279.64	118.98
40.0	269.06	268.84	268.98	268.78	268.92	101.01

Time (sec)	Average Body Temp.				Reactor Vessel Lower Downcomer
	T_{node} (area)				
	T_E (.03103)	T_{48} (.10352)	T_{102} (.13112)	T_{134} (.17434)	T_{ave}
0	550.	550.	550.	550.	550.
7.0	550.	550.	550.	550.	550.
9.0	549.95	549.90	549.51	548.60	549.27
11.0	549.54	549.25	547.80	545.27	547.26
15.0	546.28	545.11	540.14	532.89	538.87
20.0	535.37	532.51	521.20	505.96	518.82
21.0					
22.0					
23.0	524.00	519.85	503.79	482.72	500.65
24.0					
25.0	514.15	509.11	489.83	465.01	486.25
25.5					
26.0	508.66	503.18	482.32	455.71	478.54
26.5					
27.0	502.74	496.85	474.63	446.83	470.83
27.5					
28.0	499.63	493.56	470.81	442.67	467.05
28.5					
29.0	489.87	483.38	459.49	430.61	455.49
29.5					
30.0	483.08	476.38	451.84	422.29	448.11
32.0	468.92	461.85	436.00	404.97	432.11
34.0	454.04	446.61	419.46	386.98	415.42
34.5	450.21	442.69	415.23	382.40	411.15
35.0	446.33	438.73	410.96	377.78	406.84
36.0	438.44	430.71	402.62	369.46	398.62
40.0	407.05	399.56	373.08	343.35	369.93

Time (sec)	Average Shroud Temp.				Broken Loop Cold leg	ΔT
	T_{193}	T_{200}	T_{223}	T_{230}	T_{ave}	
0	550.00					
3.0						
5.0	554.32	554.46	554.42	554.55	554.44	- 3.8
10.0	539.83	539.53	539.66	539.38	539.60	9.21
15.0	506.66	506.08	506.37	505.81	506.23	32.64
20.0	453.47	452.55	453.01	452.14	452.79	65.34
25.0	385.20	384.12	384.66	383.63	384.40	100.48
27.5	358.03	357.21	357.74	356.95	357.48	108.05
29.0	341.79	340.81	340.97	340.06	340.91	113.05
29.5	329.87	328.60	328.94	327.75	328.79	120.51
30.0	321.21	319.93	320.53	319.32	320.25	124.25
30.5	314.91	313.75	314.42	313.31	314.10	125.86
31.0	310.22	309.21	309.86	308.88	309.54	125.92
31.5	306.62	305.75	306.34	305.51	306.06	125.03
35.0	276.27	275.57	276.02	275.35	275.80	125.05
40.0	266.18	266.05	266.14	266.01	266.10	98.75
33.0	299.35	298.83	299.19	298.70	299.02	119.65
33.5	290.42	289.60	289.73	288.96	289.68	124.50
34.0	283.98	283.11	283.46	282.64	283.30	126.33
34.5	279.46	278.66	279.10	278.34	278.89	126.29

Average Body Temp. Broken Loop Cold Leg

 T_{hole} (area)

Time (sec)	T_5 (.03103)	T_{48} (.10352)	T_{p2} (.13112)	T_{134} (.17434)	T_{ave}
0	550.00	550.00	550.00	550.00	550.00
3.0	550.00	550.00	550.00	550.00	550.00
5.0	550.07	550.13	550.47	551.17	550.64
10.0	550.23	550.10	549.24	547.48	548.81
15.0	546.55	545.33	540.17	532.68	538.87
20.0	535.28	532.32	520.60	504.80	518.13
24.5					
25.0	513.52	508.34	488.54	463.10	484.88
27.5	498.68	492.48	469.34	440.77	465.53
29.0	488.76	482.16	457.85	428.09	453.96
29.5	485.31	478.57	453.54	422.31	449.30
30.0	481.79	474.87	449.03	416.64	444.50
30.5	478.17	471.06	444.46	411.32	439.96
31.0	474.45	467.16	439.92	406.35	435.46
31.5	470.64	463.18	435.46	401.70	431.09
35.0	442.58	434.49	405.07	370.28	400.85
40.0	402.02	394.44	367.86	338.39	364.85
33.0	458.85	451.05	422.67	389.28	418.67
33.5	454.84	446.97	418.35	384.39	414.18
34.0	450.79	442.85	413.91	379.37	409.63

Average Shroud Temp. Broken Loop Hot Leg

Time (sec)	T_{193}	T_{200}	T_{223}	T_{230}	T_{ave}	ΔT
0	615				615.0	0
2	598.35	597.82	597.98	597.48	597.91	14.51
4	574.90	574.08	574.48	573.70	574.29	32.60
5	567.86	567.17	567.61	566.94	567.40	36.58
6	561.81	561.21	561.59	561.02	561.41	39.35
10	540.71	540.28	540.52	540.11	540.41	47.23
15	507.57	506.98	507.27	506.70	507.13	60.60
20	455.72	454.79	455.24	454.35	455.02	85.35
25	387.81	386.73	387.28	386.25	387.02	115.22
30.0	334.31	333.41	333.80	332.94	333.62	125.65
31.0	323.53	322.66	323.11	322.29	322.90	127.35
32.0	314.10	313.30	313.73	312.97	313.52	127.78
33.0	305.35	304.61	305.01	304.31	304.82	127.61
34.0	296.96	296.27	296.63	295.97	296.46	127.17
35.0	288.75	288.09	288.43	287.80	288.27	126.61
36.0	283.43	282.89	283.22	282.71	283.06	123.44
40.0	271.58	271.34	271.48	271.26	271.42	105.39

Average Body Temp Broken Loop/Hot Leg

Time (Sec)	T_5 (.03103)	T_{48} (.10352)	T_{102} (.13112)	T_{134} (.17439)	T_{ave}
0	615.0				615.0
2	614.72	614.50	613.20	610.50	612.42
4	613.35	612.50	608.41	601.58	606.89
5	612.09	610.87	605.47	597.32	603.98
6	610.47	608.91	602.41	593.25	600.76
10	601.28	598.76	589.28	577.38	587.64
15	585.55	582.23	569.82	554.38	567.73
20	564.95	560.46	543.39	521.80	540.37
25	536.38	530.08	506.31	476.57	502.24
30.0	499.28	491.63	463.55	429.71	459.27
31.0	491.19	483.36	454.59	420.04	450.25
32.0	482.93	474.94	445.63	410.67	441.30
33.0	474.55	466.42	436.72	401.53	432.43
34.0	466.08	457.85	427.87	392.56	423.63
35.0	457.53	449.23	419.08	383.73	414.88
36.0	448.96	440.63	410.55	375.64	406.50
40.0	415.63	407.80	380.08	349.04	376.81

Average Shroud Temp. Intact Loop Between Steam
Generator and Pump.

Time (sec)	T_{193}	T_{200}	T_{223}	T_{230}	T_{ave}	ΔT
0	550.				550.	0.
4	560.09	560.27	560.16	560.34	560.22	- 8.1
5	559.45	559.52	559.43	559.50	559.48	- 6.9
10	540.04	539.70	539.87	539.55	539.79	10.33
15	506.67	506.08	506.37	505.82	506.24	33.56
20	453.47	452.55	453.01	452.14	452.79	66.03
26.0	436.19	436.04	436.15	436.01	436.10	56.87
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
27.0	394.91	393.02	393.75	391.98	393.42	92.05
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
28.0	393.78	393.16	394.35	393.69	393.75	84.91
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
29.0	409.46	409.82	409.80	410.13	409.80	65.16
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
30.0	403.54	403.31	403.16	402.96	403.24	67.58
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
31.0	409.28	409.54	409.79	410.02	409.66	57.28
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
32.0	373.53	372.10	372.89	371.53	372.51	87.55
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
33.0	395.50	396.05	396.67	397.13	396.34	59.61

Average shroud temp. Intact loop Between
Steam Generator & Pump

Time (sec)	T_{193}	T_{200}	T_{223}	T_{230}	T_{ave}	ΔT
33.2	401.59	402.43	402.78	403.52	402.58	53.08
34.0	360.61	358.79	358.35	356.72	358.62	91.67
34.2	350.37	348.23	348.35	346.38	348.33	99.96
34.4	341.12	338.77	339.29	337.11	339.07	107.15
34.6	332.71	330.22	331.04	328.72	330.67	113.41
34.8	324.99	322.44	323.47	321.07	322.99	118.92
35.0	317.86	315.29	316.46	314.03	315.91	123.80
36.0	298.46	296.45	297.70	295.78	297.10	132.12
37.0	287.54	286.12	287.12	285.75	286.63	132.81
38.0	280.98	280.01	280.72	279.79	280.38	129.92
39.0	276.63	275.97	276.46	275.82	276.22	125.51
40.0	273.43	272.96	273.30	272.85	273.14	120.52

Intact Loop Between Steam Generator & Pump (continued)

Average Body Temp

Time (sec)	T_5 (.03103)	T_{48} (.10352)	T_{102} (.13112)	T_{139} (.17434)	T_{ave}
33.2	478.89	474.12	457.14	439.44	465.66
34.0	474.97	470.29	453.41	431.68	450.29
34.2	474.00	469.31	451.92	428.51	448.29
34.4	473.02	468.29	450.27	425.29	446.22
34.6	472.04	467.23	448.49	422.05	444.08
34.8	471.03	466.13	446.61	418.82	441.91
35.0	470.00	464.97	444.64	415.61	439.71
36.0	464.02	458.15	434.42	401.93	429.22
37.0	457.26	450.63	424.48	390.39	419.44
38.0	449.90	442.68	415.04	380.46	410.30
39.0	442.14	434.54	406.13	371.75	401.73
40.0	434.17	426.36	397.73	363.96	393.66

APPENDIX C

PREVIOUS ANALYSES

- (1) R. C. Gottula and R. G. Rahl letter to L. J. Ybarrondo; Gott-4-76 "LOFT Drag Disc Turbine Meter Shroud Welds" (June 9, 1976).
- (2) K. H. Hedquist letter to R. L. Crumley; KAH-1-77, "Thermal Analysis of LOFT DTT at Location PC-1 and BL-1 of L1-1 Test" (March 7, 1977).
- (3) L2-4 RELAP4 Fluid Temperature Profile Predictions

Aerojet Nuclear Company

Interoffice Correspondence

June 9, 1976

L. J. Ybarrondo
CSC-TSB

LOFT DRAG DISC TURBINE METER SHROUD WELDS - Gott-4-76

As a result of the failure of the LOFT PC-3 drag disc turbine (DDT) flow-meter shroud, calculations have been made to determine the weld area required on the shrouds of the other DDT flowmeters to prevent another similar occurrence. The maximum fluid forces on the flowmeters in the blowdown pipe, operating loop, and core simulator locations have been estimated, at their respective locations, for both best estimate (nominal) and worst case conditions during steady state, blowdown, or ECC injection conditions. The stresses in the shroud welds have been calculated on each flowmeter for the following conditions: 1) present condition taking credit only for the estimated good weld area, 2) best fix assuming all good edge remaining on the flowmeter body can be welded, and 3) proposed new weld design. The following table summarizes the safety factors for each flowmeter and each condition.

It can be seen that the PC-2 flowmeter is the only one with adequate welds and can be reinstalled into the loop with no rework. Also, PC-1 and BL-2 cannot be repaired without removing the shroud and rewelding. Flowmeter BL-1 can be fixed by additional welding (.035 inch throat thickness new weld, total length 1.73 inch outboard side and 1.46 inch inboard side) without removing the shroud.

The proposed new weld design ~~should be satisfactory~~ for the core simulator and BL-2 flowmeters. The safety factors listed for the PC-1 flowmeter are based on loads estimated at the PC-3 location. However, the loads on the PC-1 flowmeter should be between those estimated at the PC-3 and PC-2 locations. Therefore, the proposed new weld design should be satisfactory for the PC-1 flowmeter, particularly in view of the fact that the proposed weld design provides more weld area than presently exists on the PC-1 shroud, and that the PC-1 flowmeter has remained intact during the L1-1 and L1-2 blowdowns.

For the DDT flowmeter at location PC-3, the highest forces on the shroud should occur during normal operation at the highest pump speed. The flow at PC-3 will be highly turbulent and swirling effects caused by the 90° bend at the steam generator outlet will probably not be damped out at the PC-3 location. The actual flow pattern at the PC-3 location is unknown. Also, vibration forces caused by turbulence cannot be defined.

Before the failure of the PC-3 meter, two meters had been installed in the PC-3 location. During steady state operation, both of these meters measured a velocity about half that measured at PC-1 and PC-2. This indicates that a large amount of crossflow was occurring at the PC-3 meter preventing a good velocity measurement by this instrument. Also, crossflow on the PC-3 shroud will result in a much higher fluid force than flow parallel to the shroud would give. Due to the uncertainty in determining the maximum fluid and vibration forces on the PC-3 flowmeter, there is still a significant risk that the PC-3 flowmeter may not stay intact for extended operation. Also, since there are good indications that the PC-3 flowmeter is in a poor location to obtain a good flow measurement, it is strongly recommended that the PC-3 flowmeter not be installed in the LOFT primary coolant system for either steady state or blowdown operation.

Recommendations

- CS: Attach shroud with new procedure calling for 3.5 inch weld of .035 inch minimum thickness.
- PC-1: Attach shroud with new procedure or install PC-3 instrument here with added weld (minimum 1.29 inch outboard and 1.46 inch inboard).
- PC-2: OK as is.
- PC-3: Omit instrument at this location or use full length welds on shroud.
- BL-1: Add weld to present shroud (minimum length of new weld 1.73 inch outboard and 1.46 inch inboard).
- BL-2: Attach shroud with new procedure calling for 3.5 inch weld of .035 inch minimum thickness.

The assumptions and calculations for this analysis are shown in the attachment. Best estimate and worst case values used for various factors in the analysis are given in the attachment.

R. C. Gottula

R. C. Gottula
Thermal Analysis Branch

R. G. Rahl

R. G. Rahl
Applied Mechanics Branch

jh

cc: LFBurdge
HMBurton
RLGump

RCGuenzler
DWHood
JRKarvinen

JLLiebenthal
CAMoore
MLStanley

RPWadkins
RCGottula
RGRahl
LPLeach

SUMMARY OF SAFETY FACTORS FOR SHROUD WELDS

LOCATION	LOADS (lbs)		AREA REQ'D		PRESENT		BEST FIX**		NEW DESIGN	
	Nominal	Worst	Nominal	Worst	S.F.N	S.F.W	S.F.N (L _{NW})*	S.F.W (L _{NW})*	S.F.N	S.F.W
CS-1	21.1	41.6	.0070	.0221	-	-	-	-	17.5	4.7
PC-1***	152.8	254.7	.0508	.1355	0	0	.6(⁰ / _{.23})	.2(⁰ / _{.23})	2.4	.8
PC-2	12.8	25.0	.0043	.0133	10.1	3.4	-	-	28.5	7.9
PC-3	152.8	254.7	.0508	.1355	.14	.05	2.2(^{1.31} / _{1.46})	.7(^{1.29} / _{1.46})	2.4	.8
BL-1	69.8	137.4	.0232	.0731	.4	.1	5.4(^{1.69} / _{1.46})	1.5(^{1.73} / _{1.46})	5.3	1.4
BL-2	69.8	137.4	.0232	.0731	1.6	.04	1.7(^{.5} / ₀)	.5(^{.5} / ₀)	5.3	1.4
Consider PC-3 Instr in PC-2 Location	12.8	25.0	.0043	.0133	1.6	0.5	24.9(^{1.31} / _{1.46})	7.2(^{1.29} / _{1.46})	-	-

***These loads are thought to be between PC-2 and PC-3 load values.

**Best Fix assumes good edges welded as indicated by L_{NW}

*Length of additional new weld (outboard add. weld / inboard add. weld) (inches)

CALCULATIONS FOR LOFT DRAG DISC
TURBINE METER SHROUD WELDS

CONTENTS

- I. Summary Table of Safety Factors
- II. Basic Assumptions and Definitions Used in This Analysis
- III. Fluid Loads on DDT Shroud
- IV. Parallel Flow Frontal Area Calculations
- V. "New Design" (3.5 inch total weld length x .035 inch thickness)
Evaluation
- VI. Present Acceptability Evaluation
- VII. Shaft Cover and Front Cover Piece Welds

CHKD. BY ----- DATE

.....

JOB NO.

LR141-67

Length of Additional New Weld (outboard add. weld)
(inboard " ") (in.)

I BASIC ASSUMPTIONS AND DEFINITIONS USED IN THIS INVESTIGATION

SAFETY FACTOR (SF): Defined in this case as
allowable stress/calculated stress

ALLOWABLE STRESS: AISC allowable shear stress of $0.4 F_y$ used where F_y = mat'l yield stress (30155) at $550^\circ F = 18,800 \text{ psi}$
 $\therefore$ allowable stress = $.4(18800) = 7520 \text{ psi}$

NOMINAL CASE: Nominal values are used for parameters listed below

WORST CASE: Conservative error limits are added to nominal values

Parameter	Nominal	Worst
Drag Coefficient (C_d)	1.5	2.5
New Weld fillet Thickness	.035	.030
Old Weld fillet Thickness	.020	.020
Stress Concentration Factor	2.5	4.0
Water Density	measured value	$+0.6 \text{ }^\circ F/\rho$
Flow rate	measured values	$+8 \%$

NEW DESIGN: Calls for 3.5" total weld length

EXISTENT WELDS: Evaluation based on measured weld lengths, excluding "burnouts" and "starts" and assuming each side must take $\frac{1}{2}$ total

III. PROBLEM: DETERMINE THE MAXIMUM FLUID FORCE ON EACH FLOW METER SHROUD TO PREDICT THE REQUIRED WELD AREA.

I. CORE SIMULATOR

STEADY STATE VELOCITIES ARE HIGHER THAN THOSE DURING BLOWDOWN.

MAX. VEL PRIOR TO LI-1 = 34 FT/SEC AT A LOOP FLOW RATE OF 2.13×10^6 LB/HR.

∴ FOR PUMPS OPERATING AT HIGH SPEED WITH LOOP FLOW = 3.9×10^6 LB/HR:

$$\text{MAX. VEL.} = \frac{3.9}{2.13} (34) = 62.25 \text{ FT/SEC}$$

$$\rho = 47 \text{ LBM/FT}^3$$

$$(PV^2)_{\text{MAX}} = (47)(62.25)^2 = 182,128 \text{ LBM/FT}^2\text{-SEC}^2$$

ASSUME FLOW PARALLEL TO SHROUD:

$$\begin{aligned} \text{NOMINAL } C_D &= 1.5 \\ \text{WORST CASE } C_D &= 2.5 \end{aligned}$$

$$\begin{aligned} \text{SHROUD FRONTAL AREA} &= .7174 \text{ IN}^2 \\ &(\text{SEE P. 11}) \end{aligned}$$

$$F_{\text{NOM.}} = \frac{C_D PV^2 A}{2gc} = \frac{(1.5)(47)(62.25)^2 (.7174)}{(144)(64.4)} = \underline{\underline{21.13 \text{ LBF}}}$$

ASSUME 8% ERROR ON VEL. MEASUREMENT AND .6 LB/FT³ ON DENSITY:

$$F_{\text{WORST CASE}} = \frac{(2.5)(47.6)(67.23)^2 (.7174)}{(144)(64.4)} = \underline{\underline{41.61 \text{ LBF}}}$$

2. BLOWDOWN PIPE (BL-1 AND BL-2)

HIGHEST PV^2 IS DURING BLOWDOWN.

MEASURED SPIKE FOR BL-2 COLD LEG = 162,000 LBM/FT-SEC^2
WITH DRAG DISC.

DENSITOMETER + TURBINE MEASUREMENTS GIVE:

$$PV^2 = (47)(80)^2 = 300,800 \text{ LBM/FT-SEC}^2$$

ASSUME 8% MEASUREMENT ERROR ON VEL.
AND .6 LB/FT^3 ON DENSITY;

$$(PV^2)_{\text{WORST CASE}} = (47.6)(86.4)^2 = 355,332 \text{ LBM/FT-SEC}^2$$

ASSUME FLOW PARALLEL TO SHROUD.

NOMINAL $C_D = 1.5$

WORST CASE $C_D = 2.5$

SHROUD FRONTAL AREA = .7174 IN^2

$$F_{\text{NOM.}} = \frac{(1.5)(47)(80)^2(.7174)}{(144)(64.4)} = 34.9 \text{ LBF}$$

WITH DYNAMIC LOAD FACTOR = 2, $F_{\text{NOM.}} = 69.81 \text{ LBF}$

$$F_{\text{WORST CASE}} = \frac{(2.5)(47.6)(86.4)^2(.7174)}{(144)(64.4)} = 68.72 \text{ LBF}$$

WITH DYNAMIC LOAD FACTOR = 2, $F_{\text{WORST CASE}} = 137.4 \text{ LBF}$

3. OPERATING LOOP

- (a) DURING LI-1 ECC INJECTION, VELOCITY SPIKES OF 115 FT/SEC WERE SEEN WITH $\rho = .71 \text{ LBM/FT}^3$.

$$\Rightarrow \rho V^2 = (.71)(115)^2 = 9390 \text{ LBM/FT-SEC}^2$$

THIS IS A VERY LOW MOMENTUM FLUX.

THE HIGHEST MOM. FLUX OCCURS DURING HIGH SPEED PUMP TESTS.

- (b) THE HIGHEST FORCES ON PC-1, PC-2, AND PC-3 FLOW METERS OCCUR DURING STEADY STATE OPERATION. THE HIGHEST VELOCITY MEASURED DURING HIGH SPEED PUMP TESTS WAS 48.5 FT/SEC AT PC-1. ASSUMING AN 8% ERROR, THE MAXIMUM CENTERLINE VELOCITY THAT CAN OCCUR IN THE PRIMARY PIPE IS 52.4 FT/SEC.

TO DETERMINE THE FLUID FORCE ON THE SHROUD, THE DIRECTION OF FLUID FLOW ON THE SHROUD MUST BE KNOWN. THE FLOW AT PC-3 WILL BE HIGHLY TURBULENT AND SWIRLING EFFECTS CAUSED BY THE 90° BEND AT THE STEAM GENERATOR OUTLET WILL PROBABLY NOT BE DAMPED OUT AT THE PC-3 LOCATION. THE ACTUAL FLOW PATTERN AT THE PC-3 LOCATION IS UNKNOWN. ALSO, VIBRATION FORCES CAUSED BY TURBULENCE CANNOT BE DEFINED.

BEFORE THE FAILURE OF THE PC-3 METER, TWO METERS HAD BEEN INSTALLED IN THE PC-3 LOCATION. DURING STEADY STATE OPERATION, BOTH OF THESE METERS MEASURED A VELOCITY ABOUT HALF THAT MEASURED AT PC-1 AND PC-2. THIS INDICATES THAT A LARGE AMOUNT OF CROSSFLOW WAS OCCURRING AT THE PC-3 METER PREVENTING A GOOD VELOCITY MEASUREMENT BY THIS INSTRUMENT. ALSO, CROSSFLOW ON THE PC-3 SHROUD WILL RESULT IN A MUCH HIGHER FLUID FORCE THAN FLOW PARALLEL TO THE SHROUD WOULD GIVE. SINCE VIBRATION FORCES, INCLUDING THOSE CAUSED BY THE PRIMARY PUMPS CANNOT BE DEFINED, THE FLUID FORCE ON THE PC-3 SHROUD WILL BE CALCULATED ASSUMING 100% CROSSFLOW AT 52.4 FT/SEC.

FLOWMETER

LTR141 67

ASSUME: NOMINAL $C_D = 1.5$, WORST CASE $C_D = 2.5$
CROSS FLOW FRONTAL AREA = $(1.5)(4.88) = 7.32 \text{ IN}^2$

$$F_{\text{NOMINAL}} = \frac{(1.5)(47)(48.5)^2(7.32)}{(144)(64.4)} = 152.8 \text{ LBF}$$

$$F_{\text{WORST CASE}} = \frac{(2.5)(47)(52.4)^2(7.32)}{(144)(64.4)} = 254.7 \text{ LBF}$$

THIS FORCE SHOULD BE USED TO DETERMINE THE REQUIRED WELD AREA ON THE SHOULDERS FOR THE FLOW METERS AT THE PC-3 LOCATION.

DUE TO THE UNCERTAINTY IN DETERMINING THE MAXIMUM FLUID AND VIBRATION FORCES ON THE PC-3 FLOW METER, THERE IS STILL A SIGNIFICANT RISK THAT THE PC-3 FLOW METER MAY NOT STAY INTACT FOR EXTENDED OPERATION. ALSO, SINCE THERE ARE GOOD INDICATIONS THAT THE PC-3 FLOW METER IS IN A POOR LOCATION TO OBTAIN A GOOD FLOW MEASUREMENT, IT IS STRONGLY RECOMMENDED THAT THE PC-3

FLOW METER NOT BE INSTALLED IN THE LOFT PRIMARY COOLANT SYSTEM FOR EITHER STEADY STATE OR BLOWDOWN OPERATION.

THE MAXIMUM FORCE ON PC-1 SHOULD BE ASSUMED TO BE THE SAME AS THAT ON PC-3 SINCE PC-1 IS JUST DOWNSTREAM OF A 45° PIPE BEND WHERE A HIGH DEGREE OF TURBULENCE IS PROBABLE. HOWEVER, THE MAXIMUM FORCE ON THE PC-1 SHOULD BE MOST LIKELY LESS THAN THAT ON PC-3, BUT HIGHER THAN THAT ON PC-2.

THE MAXIMUM FORCE ON THE PC-2 SHROUD
CAN BE CALCULATED ASSUMING THE FLOW IS
PARALLEL TO THE SHROUD.

ASSUME NOMINAL $C_D = 1.5$
WORST CASE $C_D = 2.5$

$$F_{\text{NOMINAL}} = \frac{(1.5)(47)(48.5)^2(.7174)}{(144)(64.4)} = 12.8 \text{ LBF}$$

$$F_{\text{WORST CASE}} = \frac{(2.5)(47)(52.4)^2(.7174)}{(144)(64.4)} = \underline{\underline{25 \text{ LBF}}}$$

FRONTAL AREA CALCULATIONS

IV.

①

$$\alpha_1 = \cos^{-1} \frac{.626}{.7} = 26.583^\circ = .464 \text{ rad}$$

$$\alpha_3 = \cos^{-1} \frac{.154}{.7} = .7564$$

$$\alpha_2 = .2620 \text{ rad}$$

$$A_1 = \frac{.7^2}{2} (2(.464) - \sin(2(.464))) = .031 \text{ in}^2$$

$$A_3 = \frac{.7^2}{2} (2(.756) - \sin(2(.756))) = .014 \text{ in}^2$$

$$A_2 = \frac{1}{2} (.1316)(.1270) + \frac{.7^2}{2} (2(.262) - \sin(2(.262))) = .014 \text{ in}^2$$

$$A_4 = \frac{\pi}{4} (1.5^2 - 1.4^2) = .2278$$

$$A_5 = (.215 - .009)(.009) = .0019 \text{ in}^2$$

Frontal Area $A_F = 2A_1 + 4A_2 + 2A_3 + 52A_5 + A_4$

$$= 2(.031) + 4(.014) + 2(.014) + 52(.0019) + .2278$$

$$A_F = .062 + .056 + .028 + .099 + .2278 = .4726 \text{ in}^2$$

$$\begin{array}{r} .2448 \\ .019 \\ \hline .2738 \end{array}$$

$$\text{Avg Area} = 52(.5) .0019 =$$

(3718 ps)

Exit Area $A_X = A_F - A_4 = .4726 - .2278 = .2448 \text{ in}^2$

Total Shroud Flow Exposed Area

$$\begin{aligned} &= A_X + A_i = .7174 \text{ in}^2 \\ &= .00498 \text{ ft}^2 \end{aligned}$$

CALCULATION WORK SHEET

SUBJECT LOFT pV^2 Meter Shrouds PAGE 12 OF PAGES
 PREPARED BY R G Pahl DATE 6-8-'76
 CHECKED WORK REQUEST

V. $A_{req'd}$ is based on the following

$$A_{req'd} = \frac{(SCF) \times F}{7520}$$

where SCF = stress concentration Factor

F = Load (lbs)

7520 = Allowable Shear Stress (psi)

$$\text{Nominal Safety Factor, } S.F._n = \frac{.035 \times 3.5}{A_{req'd}}$$

where $.035 \times 3.5$ = nominal area available

$$\text{"Worst" Safety Factor, } S.F._w = \frac{.03 \times 3.5}{A_{req'd}}$$

where $.03 \times 3.5$ = estimated "worst" area available

CALCULATION WORK SHEET

SUBJECT LOFT PV² ShroudsPAGE 13 OF PAGESDATE 6-4-76PREPARED BY R G RahlCHECKED WORK REQUEST VI. Present Acceptability Evaluation

CS : Shroud not installed
Will be done by new procedure

PC-1 : Good weld outboard = 1.10" -
Edge remaining = 0"

Good weld inboard = 0.3" may be no
Edge remaining = .23" good due to roll lap

Assumptions: 1) Each side must be able
to carry $\frac{1}{2}$ of total load.

2) Nominal stress concentration factor = 2.5

3) Worst stress concentration factor = 4.0

4) Allowable shear stress = $0.4 \sigma_y = 7520 \text{ psi}$

5) Present throat minimum = .020" (nom)

Req'd Length of Good Weld Each Side

$$L_{\text{req'd}} = \frac{F K}{2 F_v (.02)}$$

where F = force on weld

K = stress conc. factor

$F_v = .4 \sigma_y = 7520 \text{ psi}$

.02" = present throat min

2 = division for only one side

CALCULATION WORK SHEET

SUBJECT LOFT PV^2 ShroudsPAGE 14 OF PAGESDATE 6-4-76PREPARED BY R G Pahl CHECKED WORK REQUEST

PC-1 : (Cont)

F_n = nominal load
= 152.8

F_w = worst load
= 254.7

nominal

worst

$$L_{req'd} = \frac{152.8(2.5)}{(2)7520(.02)} = 1.27"$$

$$= \frac{254.7(4.0)}{(2)7520(.02)} = 3.39"$$

Note that the above lengths correspond to safety factor of 1.0 and that this corresponds to allowable stress, not to failure stress or yield stress. Allowable shear stress is $\sim 2/3$ of yield stress in shear.

Test Fix on PC-1 w/o shroud removal would result in .53" of weld on one side.

Unacceptable

PC-1 Shroud must be removed and reworked.

Present

$$SF_n = 0$$

$$SF_w = 0$$

2/32 x .23 new
5.36 lb Log Fix

$$SF_n = \frac{.53}{1.27} = .4$$

$$SF_w = \frac{.53}{3.39} = .16$$

2/32 x .23 new
5.36 lb Fix
.030 t worst

$$SF_n = \frac{.70}{1.27} = .6$$

$$SF_w = \frac{.65}{3.39} = .19$$

CALCULATION WORK SHEET

SUBJECT LOFT PV² Shrouds PAGE 15 OF PAGES
 PREPARED BY R G Rahl DATE 6-4-76
 CHECKED WORK REQUEST

PC-2:

$$F_n = 12.8$$

$$F_w = 25.0$$

$$\text{nom. } L_{\text{req'd}} = \frac{12.8 (2.5)}{2 (7520) .02} = .11"$$

$$\text{worst } L_{\text{req'd}} = \frac{25}{12.8} \left(\frac{4}{2.5} \right) (.1064) = .33"$$

PC-2 1.54" Good Weld Outboard Side
 1.63" " " Inboard "

$$\text{Nominal } S.F. = \frac{1.11}{.11} = 10.1$$

$$\text{Worst } S.F. = \frac{1.11}{.33} = 3.4$$

Sufficient weld length

CALCULATION WORK SHEET

SUBJECT LOFT PV² shroudsPAGE 16 OF PAGESDATE 6-4-76PREPARED BY R G RahlCHECKED WORK REQUEST PC-3: loads same as PC-1∴ Nom $L_{req'd} = 1.27"$ Worst $L_{req'd} = 3.39"$ Outboard: Good Weld .44
Good Edge 1.42"

Present:

$$SF_n = \frac{.18}{1.27} = .14$$

$$SF_w = \frac{.18}{3.39} = .05$$

Inboard: Good Weld .18
Good Edge 1.46

Present Weld Insufficient

If good edge welded with .02t $L_{Total} = 1.64"$

$$Nom, SF_n = \frac{1.64}{1.27} = 1.3$$

$$Worst SF_w = \frac{1.64}{3.39} = .5$$

If good edge welded w/.035t (nom) .030t worst

$$equiv. L_{Total} = .18 + \frac{.035}{.02} 1.46 = 2.74"$$

$$or .18 + (.03/.02) 1.46 = 2.37"$$

$$Nom SF_n = \frac{2.74}{1.27} = 2.2$$

$$Worst SF_w = \frac{2.37}{3.39} = .7$$

$$2.74 - .44 = 2.30 \quad \text{Equiv. .02t L} \quad 2.37 - .44 = 1.93$$

$$\frac{.02}{.03}(1.93) = 1.29$$

$$\frac{.02}{.035}(2.3) = 1.31$$

CALCULATION WORK SHEET

SUBJECT LOFT PV² Shrouds PAGE 17 OF PAGES
 PREPARED BY R G Pahl CHECKED DATE 6-4-76
 WORK REQUEST

BL-1:

$$F_n = 69.8$$

$$F_w = 137.4$$

nom. $L_{req'd} = \frac{69.8 (2.5)}{2 (7520) .02} = .58"$

worst $L_{req'd} = \frac{137.4 (4.0)}{2 (7520) .02} = 1.83"$

Outboard: .2 Good Weld includes
 1.8 Good Edge .30 in. (1.1)

Present: $S.F._n = .4$ $S.F._w = .1$

w/.02 x 1.8 additional weld

$$S.F._n = \frac{2.0}{.58} = 3.5$$

$$S.F._w = \frac{2.0}{1.83} = 1.1$$

w/.035 x 1.8 additional weld (not worst)

$1.8 + .125 = 1.925$
 $S.F._n = \frac{3.35}{.58} = 5.8$

$$S.F._w = \frac{2.9}{1.83} = 1.6$$

Can probably be fixed by adding weld.

CALCULATION WORK SHEET

SUBJECT LOFT p12 Shrouds PAGE 18 OF PAGES
 PREPARED BY R G Pahl DATE 6-4-76
 CHECKED WORK REQUEST

BL-1: (cont)

inboard : .60 Good Weld
 1.43 Good Edge

Present: $S.F._n = 1.0$ $S.F._w = .3$

w/.02 x 1.46 additional weld

$$S.F._n = \frac{2.06}{.58} = 3.6$$

$$S.F._w = \frac{2.06}{1.83} = 1.1$$

w/.035 x 1.46
 added weld

$$S.F._n = \frac{3.16}{.58} = 5.4$$

(lost worst)

$$S.F._w = \frac{2.79}{1.83} = 1.5$$

BL-2: Forces & Leaps same as BL-1

Outboard: Good Weld: .08"
 Good Edge: .50"

Inboard: Good Weld: .62
 Good Edge: .95

Present: $S.F._n = \frac{.08}{.58} = .1$ $S.F._w = \frac{.08}{1.83} = .04$

w/.02 x .5 added weld

$$S.F._n = \frac{.58}{.58} = 1.0$$

$$S.F._w = \frac{.58}{1.83} = .3$$

w/.035 x .5 added weld (lost worst)

$$S.F._n = \frac{.96}{.58} = 1.7$$

$$S.F._w = \frac{.83}{1.83} = .5$$

CALCULATION WORK SHEET

PAGE 19 OF PAGES
 SUBJECT 10FT PV² Meter Shrouds DATE 6-8-76
 PREPARED BY R G Rahl CHECKED WORK REQUEST

Consider PC-3 instrument in PC-2 location. This is done to facilitate judging the advisability of putting PC-3 with added weld in PC-1 location. PC-1 loads are judged to be somewhere between PC-2 loads and PC-3 loads.

nom. $L_{Req'd} = .11$

worst $L_{Req'd} = .33$

Present $S.F._n = \frac{.18}{.11} = 1.6$

$S.F._w = \frac{.18}{.33} = .5$

Added Weld $S.F._n = \frac{2.74}{.11} = 24.9$

$S.F._w = \frac{2.37}{.33} = 7.2$

CALCULATION WORK SHEET

PAGE 20 OF PAGESSUBJECT LOFT 2V² MeterDATE 6-8-76PREPARED BY R G' RahlCHECKED WORK REQUEST VII Shaft Cover Welds:

$$\text{Sideflow Area} = .332 \times 2.464 - 9\left(\frac{\pi}{4}\right).125^2 = .708 \text{ in}^2$$

Ratio Areas of shaft cover and
shroud to obtain loads

$$A_{\text{shroud}} = 7.29 \text{ in}^2$$

$$\text{Max nominal load} = \frac{.708}{7.29} 152.8 = 14.8 \#$$

$$\text{Max "worst" load} = \frac{.708}{7.29} 254.7 = 24.7 \#$$

Based on worst

$$A_{\text{req'd}} = \frac{4(24.7)}{7520} = .0131 \text{ in}^2 \quad \text{For S.F.} = 1.0$$

$$\times 2 = \underline{\underline{.0263 \text{ in}^2}} \quad \text{For S.F.} = 2.0$$

Presently called for 6 - .03 x .25 fillets

$$A_{\text{weld}} = 6(.25)[.707(.03)] = .0318 \text{ in}^2$$

$$> .0263 \text{ in}^2 \quad \text{OK}$$

Front Cover Piece:

$$\text{Sideflow } A = 1.25(.4) = .5 \text{ in}^2$$

$$\text{Max "worst" load} = \frac{.5}{7.29} 254.7 = 17.5 \#$$

$$A_{\text{req'd}} = \frac{4(17.5)}{7520} = .0093 \text{ in}^2$$

For S.F. = 1.0

$$\times 2 = .0186 \text{ in}^2$$

For S.F. = 2.0

$$A_{\text{weld}} = 6(.12).03 = .0216 \text{ in}^2$$

$$> .0186$$

OK

Idaho

 INTEROFFICE CORRESPONDENCE

date March 7, 1977
 to R. L. Crumley
 from K. A. Hedquist *K. A. Hedquist*
 subject THERMAL ANALYSIS OF LOFT DTT AT LOCATION PC-1 and BL-1
 OF L1-1 TEST KAH-1-77

References:

- a) "LOFT Piping Drag-Disk, Turbine Flow Meter Assembly",
ANC Drawing 204645, Rev. L, May 22, 1972.
- b) Personal Communication, J. S. Martinell to K. A. Hedquist
February 9, 1977.
- c) J. S. Martinell letter to R. L. Crumley; JSM-2-77, "Evaluation
of LOFT Piping Type DTT Shroud and Cover Welds", February 10, 1977.
- d) R. L. Moore, COUPLE II - A Two Dimensional or Axisymmetric
Finite Element Steady-State and Transient Heat Conduction
Code With Inverse Capabilities and Dynamic Dimensioning for
Use on an IBM 360/75 Computer, (To be published).
- e) S. A. Naff, Quick Look Report, LOFT Loss of Coolant
Experiment L1-1, March 11, 1976.
- f) Personal Communication, J. K. Jacoby to N. E. Pace,
February 2, 1977.
- g) R. T. French, An Evaluation of Piping Heat Transfer,
Piping Flow Regimes and Steam Generator Heat Transfer for
the Semiscale Mod-1 Isothermal Tests, ANCR-1229, August 1975.

This letter is to document the thermal transient analyses of the LOFT piping type DTT's as defined in References (a) and (b) which were done in support of the stress analysis as reported in Reference (c).

A horizontal cut through the DTT body and shroud was taken and a two dimensional symmetric finite element model was made (see Fig. 1 and 2). The small covers and extensions that protrude from the main body of the DTT were neglected in the computer model. They were taken into account by assuming the DTT body solid whereas it actually has small voids within. The model was used in the COUPLE II Code (Reference (d)) to obtain transient temperature histories throughout the body and shroud. Several computer runs were made using the fluid temperature histories at the PC-1 and BL-1 location from the LOFT L1-1 test (Reference (e)). The PC-1 location is the intact loop.

Page 2
R. L. Crumley
March 7, 1977
KAH-1-77

cold leg vessel inlet and BL-1 is the broken loop cold leg vessel exit. The time scale of these temperature histories was modified by a factor of .73 to represent a larger break area (Reference (f)).

Since the heat transfer coefficients are difficult to obtain for the varied locations and surfaces of the DTT turbine meter, a lower limit of 400 Btu/hr ft² °F was used as a constant value during the LOCE transient for both locations (PC-1 and BL-1). Figure 3, taken from Reference (g), shows the measured piping heat transfer coefficient at the intact loop cold leg vessel inlet from the Semiscale test that corresponds to the LOFT L1-1 test. By using this lower limit, a slightly conservative estimate of the temperatures within the DTT body will result.

The stress analysis calculations required the difference between the shroud and the average body temperature. Temperatures at interior points within the DTT body and shroud were volume weighted to obtain an average temperature. Figures 4 and 6a show the fluid, average shroud, and average body temperatures for locations PC-1 and BL-1, respectively. The maximum difference between the average body and shroud temperature was 240°F for location PC-1 and 75°F for location BC-1. Figures 5 and 6b show the average body and shroud temperature difference throughout the transient. Lower temperature differences may be obtained by using higher film coefficients at times during the transient, but because of the uncertainty of calculating these coefficients, the conservative lower limit as shown in Figure 3 will result in a maximum bound for the shroud and body temperature difference.

KAH-prk

cc: R. D. Wesley* R. C. Guenzler*
K. B. Wilson* G. B. Shull*
N. E. Pace* H. A. Rau*
W. C. Kettenacker* L. P. Leach*
J. S. Martinell J. R. Karvinen*
J. K. Jacoby* T. L. Kinnaman
S. A. Naff
K. A. Hedquist (2)
J. L. Liebenthal*

(* without attachment)

Page 3
R. L. Crumley
March 7, 1977
KAH-1-77

FIGURE 1 - LOFT DRAG DISK TURBINE FLOWMETER (DTT) BODY AND SHROUD

FIGURE 2 - COUPLE II MODEL OF DRAG DISK TURBINE FLOWMETER (DTT) BODY AND SHROUD

Page 5
 R. L. Crumley
 March 7, 1977
 KAH-1-77

FIGURE 3 - FILM COEFFICIENTS AT INTACT LOOP COLD LEG VESSEL INLET
 FROM SEMISCALE TESTS (Reference (g) Figure 7)

TEMPERATURE (°F)

FIGURE 4 LOFT DTF BODY & SHROUD TEMPERATURES
(CALCULATED FROM COMPLEX II COMPUTER RUN)

CONSTANT FILM COEFF. of 400 BTU/HR FT² °F

FLUID DATA FROM PC-1 TEST L-1 TIME
MULTIPLIED BY .75 TO SIMULATE LARGER
EFFECT AREA

KITH 5 FEB 77

FIGURE 5 LOFT DTT BODY AND SKIN TEMPERATURE DIFFERENCE
LOCATION: PL-1
(CALCULATED FROM COUPLE II COMPUTER RUN)

KAH 6 DEC 77

FIGURE 6a LOFT DTT AVERAGE BODY SHROUD AND FLUID TEMPERATURE
LOCATION BL-4 OF TEST L1-1 ($h=400 \text{ BTU/FT}^2\text{F}$)
(FROM COUPLE II COMPUTER RUN)

FIGURE 6b LOFT DTT TEMPERATURE DIFFERENCE BETWEEN
BODY AND SHROUD (LOCATION BL-4) (KAH JEC 3.77)

Attachment
March 7, 1977
KAH-1-77
Page 1 of 10

THIS ATTACHMENT CONTAINS:

1. Method of Calculating the Average Body Temperature for the LOFT DTT
2. Input Echos of Data Used for Runs* 04 and 05, Locations PC-1 and BL-1
3. Listing of Model Nodes and Elements

* Note Runs 01 thru 03 used higher film coefficients that were not included as part of the report.

METHOD OF CALCULATING THE AVERAGE BODY TEMPERATURE OF LOFT DTT

AREA WEIGHTED TEMPERATURE AVERAGE

NODE LOCATIONS (INCHES)

	R	Z
5	.5394	0.0
48	.4046	.1067
102	.2697	.2400
134	.1349	.3200

AREA CALCULATIONS

$$\textcircled{A} \quad 1.1 \times (.4 - .32) + 2 \times (.32 \times .1349) = .17434$$

$$\textcircled{B} \quad (1.1 - .1349 \times 2) \times (.32 - .24) + 2 \times .24 \times (.2697 - .1349) = .13112$$

$$\textcircled{C} \quad (1.1 - 2 \times .2697) \times (.24 - .1067) + 2 \times .1067 \times (.4046 - .2697) = .10352$$

$$\textcircled{D} \quad (1.1 - 2 \times .4046) \times .1067 = .03103$$

$$\text{TOTAL} \quad .4400 \text{ in}^2$$

$$1.1 \times .4 = .44 \text{ in}^2 \quad \text{CHECK.}$$

AVERAGE BODY TEMPERATURE

$$T_{AVE} = \frac{(A) * T_{134} + (B) T_{102} + (C) T_{48} + (D) T_5}{(A+B+C)+D}$$

T_{NODE} WAS THE NODE TEMPERATURE DURING THE TRANSIENT

AVERAGE SHROUD TEMPERATURE WAS FOUND BY AVERAGING THE TEMPERATURES OF NODE 193, 200, 223 and 230

$$T_{SHROUD} = (T_{193} + T_{200} + T_{223} + T_{230}) / 4$$

THE FOLLOWING 7 PAGES CONTAIN ECHOS OF THE COUPLE II INPUT DATA FOR RUNS 04 and 05 WHICH CORRESPOND TO LOCATIONS PC-1 and BL-1 OF THE LOFT 'LI-1 TEST. THE FLUID TEMPERATURES AT THESE LOCATIONS WERE USED. ALSO A LISTING OF THE NODE AND ELEMENT INFORMATION IS GIVEN.

* INPUT ECHO RUN 04 ** COUPLE II CODE **

TITLE
LEFT DRAG DISK THREE DOT WAKE ASSEMBLY RUN 04
LOCE - FCU FEB. 3-1977 COUPLE II

AUTOMESH

30	16	4	1	0.	0.	0.	0.	1
1	1	0.	0.	1	16	0.	.4	1
1	16	.0	.4	8	16	.944	.4	1
8	16	.944	.4	8	1	.944	0.00	1
10	16	1.007	.40	10	1	1.007	0.0	1
10	14	.944	.35	10	14	1.007	.35	1
10	16	1.007	.4	11	16	1.037	.4	1
11	16	1.037	.4	11	14	1.100	.35	1
10	14	1.007	.35	11	14	1.1	.35	1
11	14	1.1	.35	11	1	1.1	0.0	1
11	16	1.037	.4	20	16	1.7	.75	3
11	14	1.1	.35	20	14	1.7	.7	3
30	16	2.45	0.0	20	14	2.4	0.0	1
9	1	.9755	0.0	9	16	.9755	.4	1
8	1	.944	0.0	1	1	0.0	0.0	1

1	1	11	1	14	0.0
1	1	1	14	16	0.0
1	10	30	14	16	0.0
2	8	10	14	16	0.0

MATERIAL

2	1		
1	1.0	316 STAINLESS STEEL	
2.3148E-5	2.2148E-5	578.70E-6	1 1 2
2	1.0	GAP IN WALL	
1.0E-7	1.0E-7	1.0E-7	

STEP

0.0	50.	1.0	1 540.	-10	2
-----	-----	-----	--------	-----	---

FUNCTIONS

4					
1	8	2			
200.	8.9	300.	9.35	400.	9.8
450.	10.	500.	10.23	550.	10.45
600.	10.7	650.	10.9		
2	8	2			
200.	57.494	300.	58.242	400.	60.123
450.	61.013	500.	61.654	550.	62.055
600.	62.683	650.	63.335		
3	2	1			
0.	540.	7.3	530.	14.6	520.
21.9	480.	25.55	400.	29.2	300.
32.85	200.	36.5	100.	37.96	70.
4	3	1			
0.0	400.	25.	400.	50.	400.

CONVECTSETS

4 of 10

0000000011111111122222222233333333334444444445555555556666666667777777778
 1234567890123456789012345678901234567890123456789012345678901234567890

175						
1	1	1	16	1.5290E-6	4	1.0
1	16	8	16	1.5290E-6	4	1.0
8	14	8	16	1.5290E-6	4	1.0
8	14	10	16	1.5290E-6	4	1.0
10	14	10	16	1.5290E-6	4	1.0
10	16	30	16	1.5290E-6	4	1.0
11	1	11	14	1.5290E-6	4	1.0
11	14	30	14	1.5290E-6	4	1.0

PLOTS

4		1		3		600.		500.		450.		400.		350.		300.		250.		200.	
150.	1	6	11	16	21	26	31	41													

COUPLE

END OF DATA

0000000011111111122222222233333333334444444445555555556666666667777777778
 1234567890123456789012345678901234567890123456789012345678901234567890

C-G-U-P-L-E II

LOFT DRAG DISK THREE DDT RAKE ASSEMBLY RUN 04
 ECC - ECC FFB. 3-1977 COUPLE II

BLANK CARD

57 of 10.0

000000001111111111112222222222333333333344444444445555555555666666666677777777778
1 78901234567890123456789012345678901234567890123456789012345678901234567890

INPUT ECHO RUN OS ** COUPLE II CODE **

TITLE
LOFT DRAG DISK THREE CTT PAKE ASSEMBLY RUN 05
LOCE - ECC FEB. 7 1977 COUPLE II

AUTOMESH

30	16	4	1	0.	0.	0.	0.	1
1	1	0.	0.	1	16	0.	.4	1
1	16	.0	.4	8	16	.944	.4	1
8	16	.944	.4	8	1	.944	0.00	1
10	16	1.007	.40	10	1	1.007	0.0	1
10	16	1.007	.4	11	16	1.037	.4	1
11	16	1.037	.4	11	14	1.100	.35	1
10	14	1.007	.35	11	14	1.1	.35	1
11	14	1.1	.35	11	1	1.1	0.0	1
11	16	1.037	.4	20	16	1.7	.75	3
11	14	1.1	.35	20	14	1.7	.7	3
30	16	2.45	0.0	30	14	2.4	0.0	1
9	1	.9755	0.0	9	16	.9755	.4	1
8	1	.944	0.0	1	1	0.0	0.0	1

1	1	11	1	14	0.0
1	1	8	14	16	0.0
1	10	30	14	16	0.0
2	8	10	14	16	0.0

MATERIAL

2 1
1 1.0 316 STAINLESS STEEL
2.3148E-5 2.3148E-5 578.70E-6 1 1 2
2 1.0 GAP IN WALL
1.0E-7 1.0E-7 1.0E-7

STEP
0.0 100. 2.0 1 540. -10 2

FUNCTIONS

4	1	8	2
200.	8.9	300.	9.35
450.	10.	500.	10.23
600.	10.7	650.	10.9
2	8	2	
200.	57.494	300.	58.842
450.	61.013	500.	61.664
600.	62.683	650.	63.335
3	11	1	
0.0	540.	7.3	535.
21.9	480.	29.2	415.
49.6	340.	52.6	280.
73.0	320.	110.	310.
4	3	1	
0.0	400.	25.	400.

CONVECTSETS

000000000111111111112222222222333333333344444444445555555555666666666677777777778
1234567890123456789012345678901234567890123456789012345678901234567890

6 of 10
1714107

0000000001111111112222222222333333333344444444445555555555666666666677777777778
 12345678901234567890123456789012345678901234567890123456789012345678901234567890

175

1	1	1	16	1.9290E-6	4	1.0	3
1	16	8	16	1.9290E-6	4	1.0	3
8	14	8	16	1.9290E-6	4	1.0	3
8	14	10	14	1.9290E-6	4	1.0	3
10	14	10	16	1.9290E-6	4	1.0	3
10	16	30	16	1.9290E-6	4	1.0	3
11	1	11	14	1.9290E-6	4	1.0	3
11	14	30	14	1.9290E-6	4	1.0	3

PLOTS

4 -1

3

600.	500.	450.	400.	350.	300.	250.	200.
150.	100.	50.					
1	6	11	16	21	26	31	41

COUPLE

END OF DATA

0000000001111111112222222222333333333344444444445555555555666666666677777777778
 1234567890123456789012345678901234567890123456789012345678901234567890

C O U P L E II

LOFT DRAG DISK THREE DTT RAKE ASSEMBLY RUN 05
 LOCE - ECC FEB. 7 1977 COUPLE II

B L A N K C A R D

7
 of 10
 LTR 141-61

MESH O PUT DATA
COUPLE I

** MODEL NODES ** LOFT DTT **

LOFT DRAG DISK THREE DTT PAKE ASSEMBLY
LJCE - ECC FEB. 7 1977

PUN 05
COUPLE II

NODE DATA

NODE NUMBERS, I-J, R-Z COORDINATE INFORMATION

I	J	NODE	R	Z	I	J	NODE	R	Z	I	J	NODE	R	Z
1	1	1	0.0	0.0	2	1	2	1.349E-01	0.0	3	1	3	2.697E-01	0.0
4	1	4	4.046E-01	0.0	5	1	5	5.394E-01	0.0	6	1	6	6.743E-01	0.0
7	1	7	8.091E-01	0.0	8	1	8	9.440E-01	0.0	9	1	9	9.755E-01	0.0
10	1	10	1.007E 00	0.0	11	1	11	1.100E 00	0.0					
1	2	12	0.0	2.667E-02	2	2	13	1.349E-01	2.667E-02	3	2	14	2.697E-01	2.667E-02
4	2	15	4.046E-01	2.666E-02	5	2	16	5.394E-01	2.667E-02	6	2	17	6.743E-01	2.666E-02
7	2	18	8.091E-01	2.667E-02	8	2	19	9.440E-01	2.667E-02	9	2	20	9.755E-01	2.667E-02
10	2	21	1.007E 00	2.667E-02	11	2	22	1.100E 00	2.692E-02					
1	3	23	0.0	5.333E-02	2	3	24	1.349E-01	5.334E-02	3	3	25	2.697E-01	5.333E-02
4	3	26	4.046E-01	5.333E-02	5	3	27	5.394E-01	5.333E-02	6	3	28	6.743E-01	5.333E-02
7	3	29	8.091E-01	5.333E-02	8	3	30	9.440E-01	5.333E-02	9	3	31	9.755E-01	5.333E-02
10	3	32	1.007E 00	5.333E-02	11	3	33	1.100E 00	5.385E-02					
1	4	34	0.0	8.000E-02	2	4	35	1.348E-01	7.999E-02	3	4	36	2.697E-01	7.999E-02
4	4	37	4.046E-01	7.999E-02	5	4	38	5.394E-01	8.000E-02	6	4	39	6.743E-01	8.000E-02
7	4	40	8.091E-01	8.000E-02	8	4	41	9.440E-01	8.000E-02	9	4	42	9.755E-01	8.000E-02
10	4	43	1.007E 00	8.000E-02	11	4	44	1.100E 00	8.077E-02					
1	5	45	0.0	1.067E-01	2	5	46	1.349E-01	1.067E-01	3	5	47	2.697E-01	1.067E-01
4	5	48	4.046E-01	1.067E-01	5	5	49	5.394E-01	1.067E-01	6	5	50	6.743E-01	1.067E-01
7	5	51	8.091E-01	1.067E-01	8	5	52	9.440E-01	1.067E-01	9	5	53	9.755E-01	1.067E-01
10	5	54	1.007E 00	1.067E-01	11	5	55	1.100E 00	1.077E-01					
1	6	56	0.0	1.333E-01	2	6	57	1.349E-01	1.333E-01	3	6	58	2.697E-01	1.333E-01
4	6	59	4.046E-01	1.333E-01	5	6	60	5.394E-01	1.333E-01	6	6	61	6.743E-01	1.333E-01
7	6	62	8.091E-01	1.333E-01	8	6	63	9.440E-01	1.333E-01	9	6	64	9.755E-01	1.333E-01
10	6	65	1.007E 00	1.333E-01	11	6	66	1.100E 00	1.346E-01					
1	7	67	0.0	1.600E-01	2	7	68	1.349E-01	1.600E-01	3	7	69	2.697E-01	1.600E-01
4	7	70	4.046E-01	1.600E-01	5	7	71	5.394E-01	1.600E-01	6	7	72	6.743E-01	1.600E-01
7	7	73	8.091E-01	1.600E-01	8	7	74	9.440E-01	1.600E-01	9	7	75	9.755E-01	1.600E-01
10	7	76	1.007E 00	1.600E-01	11	7	77	1.100E 00	1.615E-01					
1	8	78	0.0	1.867E-01	2	8	79	1.349E-01	1.867E-01	3	8	80	2.697E-01	1.867E-01
4	8	81	4.046E-01	1.867E-01	5	8	82	5.394E-01	1.867E-01	6	8	83	6.743E-01	1.867E-01
7	8	84	8.091E-01	1.867E-01	8	8	85	9.440E-01	1.867E-01	9	8	86	9.755E-01	1.867E-01
10	8	87	1.007E 00	1.867E-01	11	8	88	1.100E 00	1.885E-01					
1	9	89	0.0	2.133E-01	2	9	90	1.349E-01	2.133E-01	3	9	91	2.697E-01	2.133E-01
4	9	92	4.046E-01	2.133E-01	5	9	93	5.394E-01	2.133E-01	6	9	94	6.743E-01	2.133E-01
7	9	95	8.091E-01	2.133E-01	8	9	95	9.440E-01	2.133E-01	9	9	97	9.755E-01	2.133E-01
10	9	98	1.007E 00	2.133E-01	11	9	99	1.100E 00	2.154E-01					
1	10	100	0.0	2.400E-01	2	10	101	1.349E-01	2.400E-01	3	10	102	2.697E-01	2.400E-01
4	10	103	4.046E-01	2.400E-01	5	10	104	5.394E-01	2.400E-01	6	10	105	6.743E-01	2.400E-01
7	10	106	8.091E-01	2.400E-01	8	10	107	9.440E-01	2.400E-01	9	10	108	9.755E-01	2.400E-01
10	10	109	1.007E 00	2.400E-01	11	10	110	1.100E 00	2.423E-01					
1	11	111	0.0	2.667E-01	2	11	112	1.349E-01	2.667E-01	3	11	113	2.697E-01	2.667E-01
4	11	114	4.046E-01	2.667E-01	5	11	115	5.394E-01	2.667E-01	6	11	116	6.743E-01	2.667E-01
7	11	117	8.091E-01	2.667E-01	8	11	118	9.440E-01	2.667E-01	9	11	119	9.755E-01	2.667E-01

8 of 10
VIRI 41 67

I	J	NODE	P	Z	I	J	NODE	P	Z	I	J	NODE	P	Z
10	11	120	1.007E-00	2.667E-01	11	11	121	1.100E-00	2.692E-01	3	12	124	2.697E-01	2.933E-01
1	12	122	0.0	2.933E-01	2	12	123	1.349E-01	2.933E-01	6	12	127	6.743E-01	2.933E-01
4	12	125	4.046E-01	2.933E-01	5	12	126	5.394E-01	2.933E-01	9	12	130	9.755E-01	2.933E-01
7	12	128	8.091E-01	2.933E-01	8	12	129	9.440E-01	2.933E-01					
10	12	131	1.007E-00	2.933E-01	11	12	132	1.100E-00	2.962E-01	3	13	135	2.697E-01	3.200E-01
1	13	133	0.0	3.200E-01	2	13	134	1.349E-01	3.200E-01	6	13	138	6.743E-01	3.200E-01
4	13	136	4.046E-01	3.200E-01	5	13	137	5.394E-01	3.200E-01	9	13	141	9.755E-01	3.200E-01
7	13	139	8.091E-01	3.200E-01	8	13	140	9.440E-01	3.200E-01					
10	13	142	1.007E-00	3.200E-01	11	13	143	1.100E-00	3.231E-01	3	14	146	2.697E-01	3.467E-01
1	14	144	0.0	3.467E-01	2	14	145	1.349E-01	3.467E-01	6	14	149	6.743E-01	3.467E-01
4	14	147	4.046E-01	3.467E-01	5	14	148	5.394E-01	3.467E-01	9	14	152	9.755E-01	3.467E-01
7	14	150	8.091E-01	3.467E-01	8	14	151	9.440E-01	3.467E-01	12	14	155	1.153E-00	4.299E-01
10	14	153	1.007E-00	3.500E-01	11	14	154	1.100E-00	3.500E-01	15	14	158	1.372E-00	6.157E-01
13	14	156	1.217E-00	5.017E-01	14	14	157	1.291E-00	5.640E-01	18	14	161	1.646E-00	6.976E-01
16	14	159	1.459E-00	6.556E-01	17	14	160	1.551E-00	6.831E-01	21	14	164	1.931E-00	6.620E-01
19	14	162	1.743E-00	6.989E-01	20	14	163	1.838E-00	6.870E-01	24	14	167	2.177E-00	5.147E-01
22	14	165	2.019E-00	6.244E-01	23	14	166	2.102E-00	5.750E-01	27	14	170	2.343E-00	2.808E-01
25	14	168	2.243E-00	4.447E-01	26	14	169	2.298E-00	3.662E-01	30	14	173	2.400E-00	0.0
28	14	171	2.375E-00	1.902E-01	29	14	172	2.394E-00	9.596E-02	3	15	176	2.697E-01	3.733E-01
1	15	174	0.0	3.733E-01	2	15	175	1.349E-01	3.733E-01	6	15	179	6.743E-01	3.733E-01
4	15	177	4.046E-01	3.733E-01	5	15	178	5.394E-01	3.733E-01	9	15	182	9.755E-01	3.733E-01
7	15	180	8.091E-01	3.733E-01	8	15	181	9.440E-01	3.733E-01	12	15	185	1.130E-00	4.528E-01
10	15	183	1.007E-00	3.733E-01	11	15	184	1.069E-00	3.750E-01	15	15	188	1.359E-00	6.371E-01
13	15	186	1.198E-00	5.240E-01	14	15	187	1.275E-00	5.859E-01	18	15	191	1.642E-00	7.166E-01
16	15	189	1.450E-00	6.763E-01	17	15	190	1.544E-00	7.030E-01	21	15	194	1.933E-00	6.774E-01
19	15	192	1.741E-00	7.168E-01	20	15	193	1.838E-00	7.037E-01	24	15	197	2.185E-00	5.260E-01
22	15	195	2.024E-00	6.385E-01	23	15	196	2.108E-00	5.877E-01	27	15	200	2.356E-00	2.971E-01
25	15	198	2.253E-00	4.544E-01	26	15	199	2.310E-00	3.742E-01	30	15	203	2.425E-00	0.0
28	15	201	2.390E-00	1.945E-01	29	15	202	2.412E-00	9.819E-02	3	16	206	2.697E-01	4.000E-01
1	16	204	0.0	4.000E-01	2	16	205	1.349E-01	4.000E-01	6	16	209	6.743E-01	4.000E-01
4	16	207	4.046E-01	4.000E-01	5	16	208	5.394E-01	4.000E-01	9	16	212	9.755E-01	4.000E-01
7	16	210	8.091E-01	4.000E-01	8	16	211	9.440E-01	4.000E-01	12	16	215	1.099E-00	4.923E-01
10	16	213	1.007E-00	4.000E-01	11	16	214	1.037E-00	4.000E-01	15	16	218	1.340E-00	6.703E-01
13	16	216	1.171E-00	5.556E-01	14	16	217	1.252E-00	6.186E-01	18	16	221	1.637E-00	7.489E-01
16	16	219	1.435E-00	7.097E-01	17	16	220	1.535E-00	7.360E-01	21	16	224	1.940E-00	7.055E-01
19	16	222	1.739E-00	7.480E-01	20	16	223	1.841E-00	7.335E-01	24	16	227	2.202E-00	5.471E-01
22	16	225	2.034E-00	6.646E-01	23	16	226	2.122E-00	6.114E-01	27	16	230	2.382E-00	2.987E-01
25	16	228	2.273E-00	4.726E-01	26	16	229	2.333E-00	3.893E-01	30	16	233	2.450E-00	0.0
28	16	231	2.418E-00	2.025E-01	29	16	232	2.441E-00	1.023E-01					

B L A N K C A R D

C-41

LOFT-NUCL-003 200 C.L. BK 47.13 MM

EXPJPN/C E 12/21/76 02/14/77

LTR141 67

C-42

LOFT-NUCL-003 200 C.L. BK 47.13 MW

EXPJP4/C E 12/21/76 02/14/77

1414107

C-43

LOFT-NUCL-003 200 C.L. BK 47.13 MW

EXPJP4/C E 12/21/76 02/14/77

79 14717

C-44

LOFT-NUCL-003 200 C.L. BK 47.13 MW

EXPJP4/C E 12/21/76 02/14/77

29 17 T MAT

C-45

LOFT-NUCL-003 200 C.L. BK 47.13 MW

EXPJP4/C E 12/21/76 02/14/77

LTR141 67

C-46

FLUID TEMP-BROKEN LOOP HOT LEG (F) AT29

LOFT-NUCL-003 200 C.L. BK 47.13 MW

EXPJP4/C E 12/21/76 02/14/77

14167

C-47
FLUID TEMP-INTACT LOOP BETWEEN S.G. PUMP (F) AT15

LOFT-NUCL-003 200 C.L. BK 47.13 MW

EXPJP4/C E 12/21/76 02/14/77

LIR141 6