MASTER

LOFT TECHNICAL REPORT LTR 1144-30

EG&G REPORT NUMBER RE-A-77-040

JULY 7, 1977

450°F STEP TRANSIENT THERMAL ANALYSIS OF THE LOFT PRESSURIZER SURGE AND SPRAY LINE PIPING

B. J. TOLAN

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IDAHO NATIONAL ENGINEERING LABORATORY

DEPARTMENT OF ENERGY

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THERMAL ANALYSIS

TECHNICAL REPORT

450°F STEP TRANSIENT THERMAL ANALYSIS OF THE LOFT PRESSURIZER SURGE AND SPRAY LINE PIPING

Bobby J. Tolen

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IDAHO NATIONAL ENGINEERING LABORATORY
LOFT TECHNICAL REPORT
LOFT PROGRAM

TITLE	REPORT NO.
450°F Step Transient Thermal Analysis of the LOFT Pressurizer Surge and Spray Line Piping	LTR # 1144-30

AUTHOR	GWA NO.
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SUMMARY

The LOFT pressurizer spray and surge line piping was analyzed for a 450°F step change in fluid temperature. This transient was chosen to conservatively represent several pressurizer operating transients that had not previously been analyzed[1]. These include temperature transients resulting from a 300°F ΔT between pressurizer temperature and cold leg temperature, injection of a cooled (70°F) slug of stagnant fluid into the hot (540°F) spray line piping, and inflow of 100°F primary coolant system water into the hot (480°F) surge line piping[5]. If the thermal stresses in the spray and surge line piping as determined by the Applied Mechanics Branch yield a lower number of cycles than is required, analysis of a less conservative transient than the 450°F step temperature change would probably yield a higher allowable number of thermal cycles. The use of a less conservative transient would have to be justified by an analysis of LOFT pressurizer operating conditions and procedures.

Piping DT values for the 450°F step transient were calculated using COUPLE/MOD2[2] for input into the ASME Section III pipe equations[3]. DT values for the piping are tabulated in this report and have been forwarded to the Applied Mechanics Branch for stress analysis. Maximum DT values for the spray line were DT1 = 295°F at 1.5 seconds and DT2 = 84°F at .5 seconds. Maximum DT values for the surge line were DT1 = 360°F at 2.0 seconds and DT2 = 161°F at .5 seconds. DT3 values were calculated to be zero for both lines. Complete microfiche copies of both computer runs are contained in Appendix B of this report.

1.0 INTRODUCTION

Section 3.1.4.2.(5) of the LOFT Technical Specifications[4] states:

"The design limit on pressurizer temperature above cold leg temperature is 300°F as specified in ANC-60044."

Since pressurizer spray and surge line piping adjacent to the pressurizer will be nearly the same temperature as the pressurizer, fluid temperature transients of up to 300°F could be experienced by the piping in these regions. In order to conservatively analyze this transient and to allow more flexibility in plant operation, a 450°F step transient was chosen.[5] Other transients for which the pressurizer spray and surge lines have not previously been analyzed include injection of a cooled (70°F) slug of stagnant fluid into the hot (540°F) spray line piping, and inflow of 100°F primary coolant system water into the hot (480°F) surge line piping. A more complete discussion of these transients is contained in Reference 5. After an analysis of the spray and surge nozzles showed that the 450°F step transient produced much more significant thermal stresses than the other transients not previously analyzed,[6] it was chosen as conservatively representing all of the above mentioned transients, and only the 450°F step transient was analyzed. Using COUPLE/MOD2,[2] a finite element heat conduction code, DT's were calculated for input into the ASME Section III pipe equations.[3] It should be noted that since the pressurizer spray line piping does not exceed 1" nominal pipe, an ASME Code Section III Class 1 analysis is not required. However, the spray line piping analysis contained in this report was requested by LOFT personnel due to the importance of some weld areas in the piping adjacent to the pressurizer.[12]

2.0 ANALYSIS

Figures 1 and 2 show the axisymmetric finite element models of the pressurizer spray and surge line piping, respectively. Since the piping

adjacent to the pressurizer will have the highest initial temperature, analysis of the piping near the pressurizer will yield conservative results for the surge and spray lines. Neither the surge or spray lines have tee's or elbow's near the pressurizer, therefore the models in Figures 1 and 2 are one dimensional axisymmetric finite element models of straight SA312 Grade 316 stainless steel piping having the properties given in Table I. Both the spray and surge line piping are conservatively assumed to be at 650°F (pressurizer operating temperature), and 200°F water flows through the piping to initiate the transient. Flowrates used in this analysis were the design flowrates[9] for the pressurizer surge and spray lines of 296 gpm and 20 gpm, respectively. Forced convection heat transfer coefficients for the surge and spray line piping inside surfaces are given in Table II and were calculated using the following forced convection turbulent heat transfer correlation:

$$h_{f.c.} = .023 \frac{K}{D} Re_D^{.8} Pr^{.4} \qquad \text{(Ref. 8)}$$

Heat transfer coefficients which contained the effects of 1-1/2 inches of molded calcium silicate insulation,[10] and natural convection and radiation from the insulation to the air, were applied to the outside surface of the piping. An ambient air temperature of 70°F was assumed and temperature difference of 50°F was assumed between the insulation surface and the air for purposes of calculating the film coefficient. Based on this assumption, a combined convection and radiation heat transfer coefficient (h_{c+r}) of 1.84 Btu/hr-ft^2-°F was obtained[8] and combined with the insulation thermal resistance to give the overall heat transfer coefficients listed in Table II. The following equation was used to calculate the overall heat transfer coefficients:

$$h_{overall} = \frac{1}{D_{pipe}} \frac{1}{\frac{1}{h_{c+r}} \frac{D_{pipe+ins}}{D_{pipe}} + \frac{X_{ins}}{K_{ins}} \frac{D_{pipe+ins}}{D_m}} \qquad \text{(Ref. 8, p.179)}$$

TABLE I

Material Properties of SA312 Grade 316 Stainless Steel[7]

T (°F)	ρ (lbm/in^3)	C_p (Btu/lbm)	K (Btu/in-sec-°F)
70	.2841	.1080	1.924×10^{-4}
100	.2841	.1108	1.974×10^{-4}
200	.2841	.1174	2.075×10^{-4}
300	.2841	.1222	2.175×10^{-4}
400	.2841	.1255	2.276×10^{-4}
500	.2841	.1278	2.377×10^{-4}
600	.2841	.1296	2.477×10^{-4}
700	.2841	.1310	2.579×10^{-4}

TABLE II

Heat Transfer Coefficients

h (Btu/hr-ft^2-°F)	Application/Type
6,000	Surge line piping inside surface forced convection heat transfer coefficient
3,500	Spray line piping inside surface forced convection heat transfer coefficient
.546	Surge line piping outside surface heat transfer coefficient
.692	Spray line piping outside surface heat transfer coefficient

where

X_{in} = thickness of insulation

K_{ins} = .05 Btu/hr-ft-°F[10] = thermal conductivity of insulation

D_{pipe} = outside pipe diameter

$D_{pipe+ins}$ = outside diameter of insulated pipe

$$D_m = \frac{\pi (D_{pipe+ins} - D_{pipe})}{\ln (D_{pipe+ins}/D_{pipe})} = \text{mean diameter of insulation}$$

It should be noted that this procedure neglects the heat capacity of the insulation. However, the insulation heat capacity is small, and neglecting it will have little, if any, effect on the results.

3.0 RESULTS

Table III gives the DT's for the pressurizer spray and surge line piping. The input and output summary to the computer runs from which these DT's were obtained is contained in Appendix A. The maximum value of DT1 occurred 1.5 seconds after the start of the transient for the spray line piping and 2.0 seconds after the start of the transient for the surge line piping. DT3 values were calculated to be zero for both lines. The computer output results for both the pressurizer spray and surge line piping have been sent to the Applied Mechanics Branch for thermal stress analysis. Complete microfiche copies of both spray and surge line computer runs are contained in Appendix B of this report.

TABLE III

Maximum DT's In LOFT Pressurizer Spray and Surge Line Piping For 450°F Step Transient

	Maximum DT1	Time (secs)	Maximum DT2	Time (secs)
Surge Line	360.46	2.0	160.92	.5
Spray Line	295.42	1.5	84.13	.5

4.0 REFERENCES

1. R. A. Lindley, LOFT Pressurizer Surge and Spray Line Thermal Analysis, TR-451, TA-10, Aerojet Nuclear Company, Engineering Division (November 2, 1973).

2. E. C. Lemmon and R. L. Moore, COUPLE/MOD2 - A Two-Dimensional Finite Element Steady State and Transient Heat Conduction Code With Inverse Capabilities for Use on a CDC Cyber 76/Cyber 173 Computer, RE-A-77-017, EG&G Idaho, Inc., Engineering Division (June 1977).

3. American Society of Mechanical Engineers, ASME Boiler and Pressure Vessel Code, Section III, Nuclear Power Plant Components (1974).

4. LOFT Technical Specifications, Aerojet Nuclear Company, Idaho Falls, Idaho (January 1976).

5. D. H. VanHaaften, Steady State and Transient Thermal Analysis of the LOFT Pressurizer Surge and Spray Nozzles, RE-E-77-187, EG&G Idaho, Inc. (May 2, 1977).

6. Personal communication with J. W. Muffett, EG&G Idaho, Inc. (May 1977).

7. Nuclear Systems Materials Handbook, Vol. 1, Part 1, Group 1, Section 4, Hanford Engineering Development Laboratory, Richland, Washington (September 30, 1976 revision).

8. W. H. McAdams, Heat Transmission, McGraw Hill Book Company, Inc., New York (1954).

9. LOFT Preliminary System Design Description for the Primary Coolant System and Subsystems, SDD 1.1.4G, May (1972).

10. Personal communication with J. Tangway, EG&G Idaho Inc., Idaho Falls, Idaho (April 1977).

11. J. Sucec, Heat Transfer, Simon and Schuster, Inc., New York (1975).

12. Personal communication with J. W. Muffett, EG&G Idaho, Inc. (July 8, 1977).

COUPLE MOD 2 (MAY-23,77) UPDATE 1 MAY-23,77) ECL
LOFT PRESSURIZER SPRAY LINE PIPING ANALYSIS
UNITS(LB,INCH,SECOND,BTU,DEGREE F)

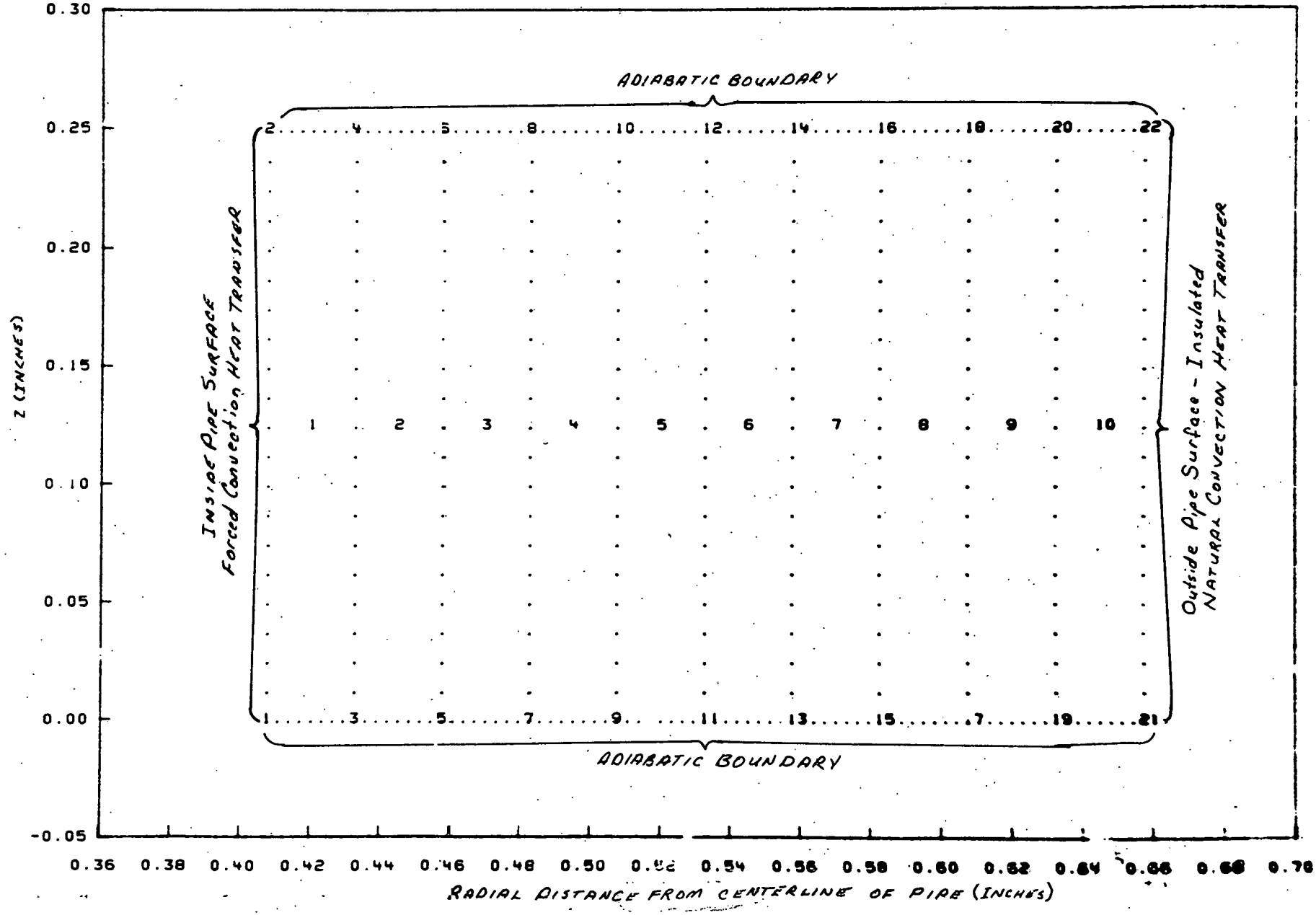
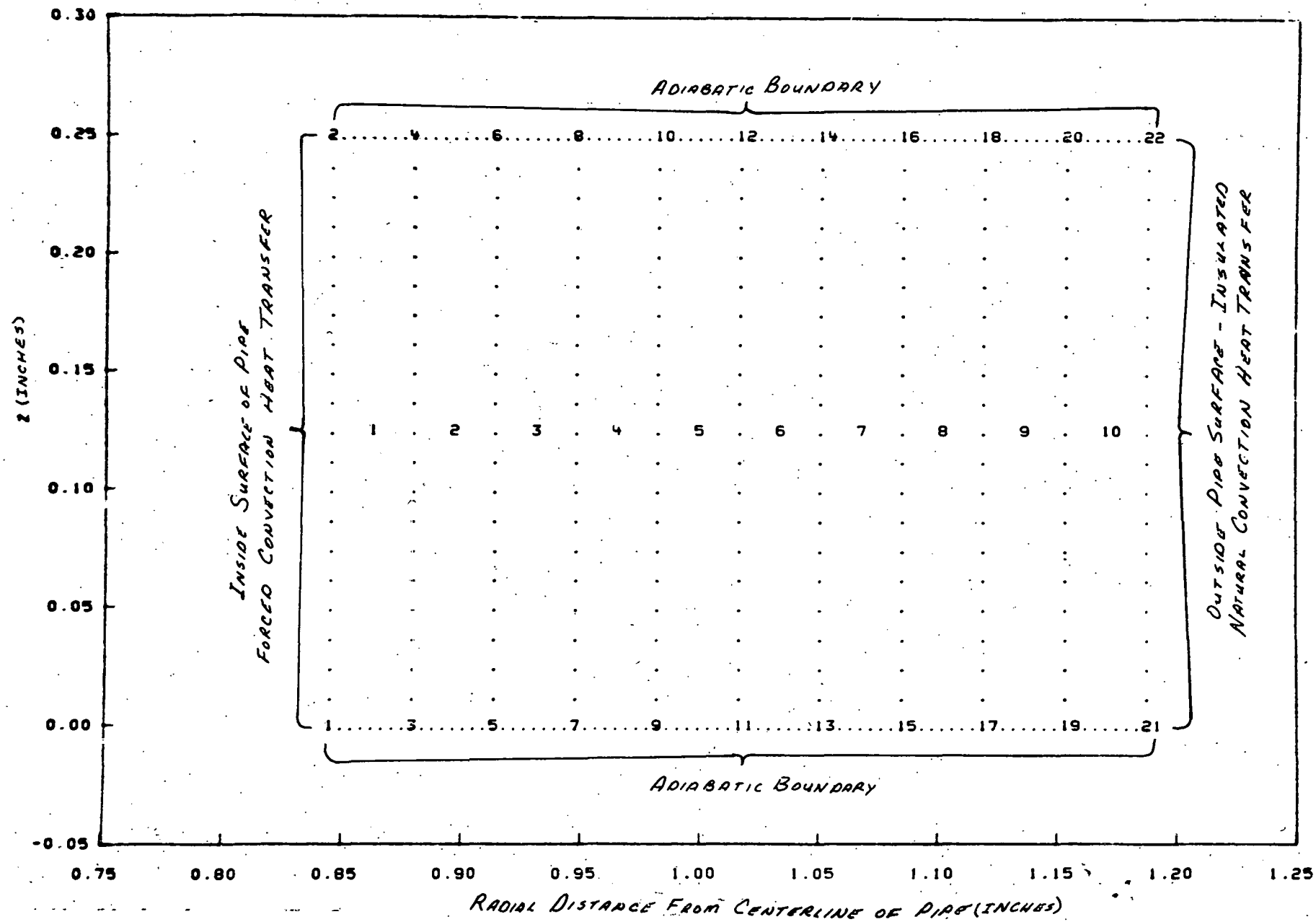


FIG:1 : LOFT PRESSURIZER SPRAY LINE FINITE ELEMENT MODEL

COUPLE MOD 2 (MAY-23,77) UPDATE 1 (MAY-23,77) ECL
OFT PRESSURIZER SURGE LINE PIPING ANALYSIS
UNITS(LB,INCH,SECOND,BTU,DEGREE F)



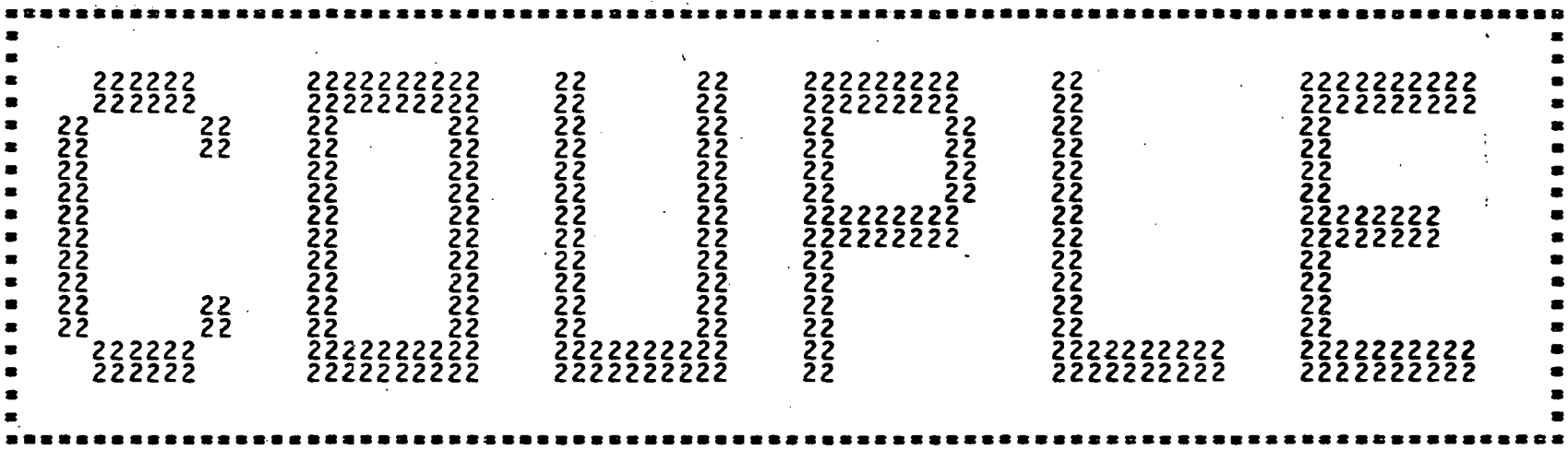
NODES AND ELEMENTS-SCALE MAX

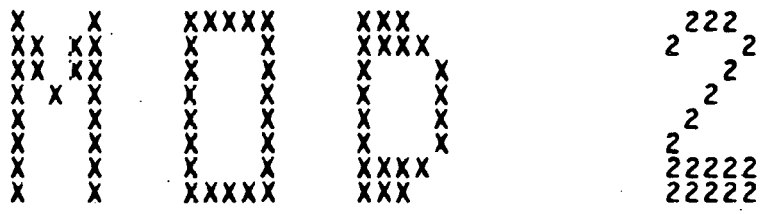
FIG. 2: LOFT PRESSURIZER SURGE LINE FINITE ELEMENT MODEL

LTR1144 30

APPENDIX A

COMPUTER INPUT


COMMODORE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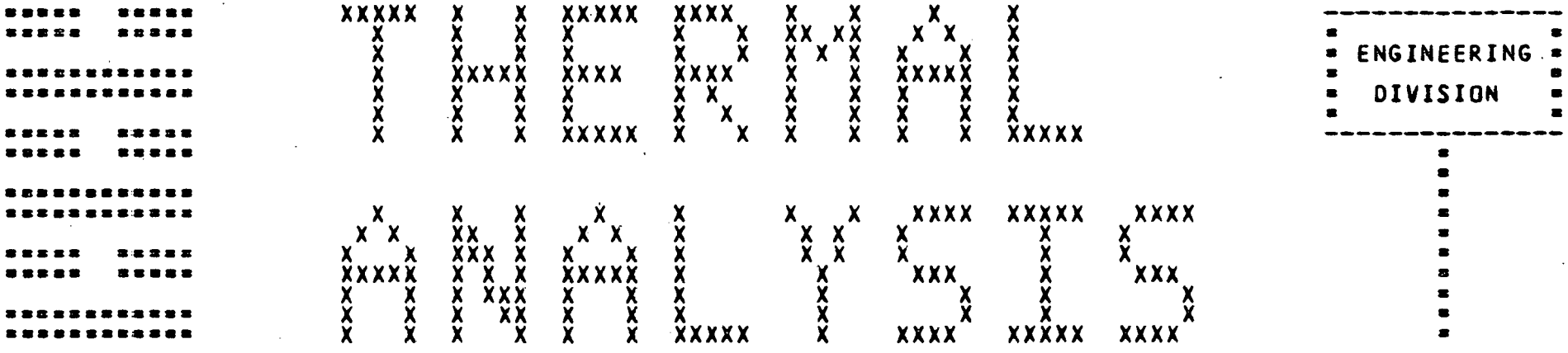
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DIVISION
CLARK LEMMON - MAINTENANCE SUPERVISOR

```
0        1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

TITLE
LOFT PRESSURIZER SPRAY LINE PIPING ANALYSIS
UNITS(LB,INCH,SECOND,BTU,DEGREE F)

MATERIAL
    1    1
    1          .2841  SA 312 GRADE 316 SS
1.0       1.0        1.0              1    1    2

NODES
   22
    1   .4075       0.        10
    2   .6575       0.
    2   .4075       .25       10
    2   .6575       .25

ELEMENTS
   10
    1    1    3    4    2    1              2
   10   19   21   22   20    1

STEP
         0.       300.              3        650.             1


FUNCTIONS
    3
    1     8     2
      70. 1.924E- 4       100. 1.974E- 4       200. 2.075E- 4
     300. 2.175E- 4       400. 2.276E- 4       500. 2.377E- 4
     600. 2.477E- 4       700. 2.579E- 4
    2     8     2
      70.   .108          100.   .1108          200.   .1174
     300.   .1222         400.   .1255          500.   .1278
     600.   .1296         700.   .1310
    3     8     1
       0.          .5      19.9          .5       20.          5.
      59.         5.        60.         10.      299.         10.
     300.        60.       600.         60.

CONVECTSETS
    4
    1   -1    2    1   6.72E-3              200.
   21   -1   22    1   1.33E-6              70.

DT123
    1
    .4075      .125     .4075      0.      .6575      0.
    .6575      .125     .6575      .25     .4075      .25

0        1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

```
      0         1         2         3         4         5         6         7         8
      12345678901234567890123456789012345678901234567890123456789012345678901234567890

51    PLOTS
52        1           1
53
54    COUPLE
55
56    END OF DATA
      0         1         2         3         4         5         6         7         8
      12345678901234567890123456789012345678901234567890123456789012345678901234567890
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COUPLE MOD 2 (MAY-23,77) UPDATE 1 (MAY-23,77) ECL
LOFT PRESSURIZER SPRAY LINE PIPING ANALYSIS
UNITS(LB,INCH,SECOND,BTU,DEGREE F)
SUMMARY DT TABLE FOR DTSET 1

DTSET	TIME	DT1	DT2	DT2I	DT2O	TAVE	TA	TB	DT3
1	.5000	231.0815	84.1291	84.1291	-52.2297	580.4826	579.2438	579.2438	0.0000
1	1.0000	283.7473	75.4173	75.4173	-55.8032	543.7896	542.8141	542.8141	0.0000
1	1.5000	295.4186	63.6048	63.6048	-52.6292	515.0131	514.1972	514.1972	0.0000
1	2.0000	290.7289	54.8267	54.8267	-48.5616	490.3626	489.6465	489.6465	0.0000
1	2.5000	278.7776	48.4588	48.4588	-44.7295	468.4764	467.8325	467.8325	0.0000
1	3.0000	263.7628	43.6160	43.6160	-41.2902	448.6728	448.0865	448.0865	0.0000
1	3.5000	247.8117	39.7175	39.7175	-38.2013	430.5607	430.0228	430.0228	0.0000
1	4.0000	231.8749	36.4277	36.4277	-35.4001	413.8923	413.3966	413.3966	0.0000
1	4.5000	216.4627	33.5543	33.5543	-32.8387	398.4964	398.0383	398.0383	0.0000
1	5.0000	201.8027	30.9864	30.9864	-30.4813	384.2471	383.8232	383.8232	0.0000
1	5.5000	187.9829	28.6582	28.6582	-28.3028	371.0430	370.6504	370.6504	0.0000
1	6.0000	175.0201	26.5282	26.5282	-26.2842	358.7971	358.4334	358.4334	0.0000
1	6.5000	162.8925	24.5701	24.5701	-24.4104	347.4335	347.0963	347.0963	0.0000
1	7.0000	151.5557	22.7660	22.7660	-22.6716	336.8823	336.5697	336.5697	0.0000
1	7.5000	140.9719	21.1001	21.1001	-21.0570	327.0838	326.7940	326.7940	0.0000
1	8.0000	131.1007	19.5591	19.5591	-19.5570	317.9837	317.7149	317.7149	0.0000
1	8.5000	121.8996	18.1631	18.1328	-18.1631	309.5322	309.2829	309.2829	0.0000
1	9.0000	113.3273	16.8677	16.8114	-16.8677	301.6828	301.4515	301.4515	0.0000
1	9.5000	105.3432	15.6638	15.5872	-15.6638	294.3928	294.1782	294.1782	0.0000
1	10.0000	97.9089	14.5448	14.4524	-14.5448	287.6220	287.4230	287.4230	0.0000
1	10.5000	90.9876	13.5047	13.4004	-13.5047	281.3335	281.1488	281.1488	0.0000
1	11.0000	84.5444	12.5378	12.4252	-12.5378	275.4925	275.3212	275.3212	0.0000
1	11.5000	78.5441	11.6393	11.5216	-11.6393	270.0662	269.9073	269.9073	0.0000
1	12.0000	72.9565	10.8048	10.6844	-10.8048	265.0249	264.8775	264.8775	0.0000
1	12.5000	67.7555	10.0295	9.9083	-10.0295	260.3418	260.2051	260.2051	0.0000
1	13.0000	62.9161	9.3093	9.1886	-9.3093	255.9918	255.8650	255.8650	0.0000
1	13.5000	58.4143	8.6402	8.5212	-8.6402	251.9516	251.8340	251.8340	0.0000
1	14.0000	54.2277	8.0187	7.9022	-8.0187	248.1997	248.0906	248.0906	0.0000
1	14.5000	50.3351	7.4414	7.3281	-7.4414	244.7156	244.6144	244.6144	0.0000
1	15.0000	46.7154	6.9053	6.7957	-6.9053	241.4806	241.3867	241.3867	0.0000
1	15.5000	43.3529	6.4075	6.3018	-6.4075	238.4771	238.3901	238.3901	0.0000
1	16.0000	40.2272	5.9452	5.8438	-5.9452	235.6888	235.6081	235.6081	0.0000
1	16.5000	37.3229	5.5160	5.4190	-5.5160	233.1004	233.0256	233.0256	0.0000
1	17.0000	34.6246	5.1175	5.0250	-5.1175	230.6978	230.6284	230.6284	0.0000
1	17.5000	32.1181	4.7476	4.6595	-4.7476	228.4678	228.4034	228.4034	0.0000
1	18.0000	29.7900	4.4043	4.3206	-4.4043	226.3980	226.3383	226.3383	0.0000
1	18.5000	27.6278	4.0856	4.0063	-4.0856	224.4771	224.4217	224.4217	0.0000
1	19.0000	25.6199	3.7898	3.7148	-3.7898	222.6945	222.6431	222.6431	0.0000
1	19.5000	23.7555	3.5153	3.4445	-3.5153	221.0403	220.9926	220.9926	0.0000
1	20.0000	22.0244	3.2605	3.1938	-3.2605	219.5052	219.4611	219.4611	0.0000
1	25.0000	12.2691	1.8273	1.7864	-1.8273	210.8714	210.8467	210.8467	0.0000
1	30.0000	6.7776	1.0218	.9974	-1.0218	206.0216	206.0078	206.0078	0.0000
1	35.0000	3.6906	.5696	.5551	-.5696	203.2991	203.2914	203.2914	0.0000
1	40.0000	1.9569	.3158	.3071	-.3158	201.7713	201.7671	201.7671	0.0000
1	45.0000	.9836	.1734	.1680	-.1734	200.9141	200.9118	200.9118	0.0000
1	50.0000	.4375	.0935	.0900	-.0935	200.4332	200.4320	200.4320	0.0000
1	55.0000	.1311	.0487	.0463	-.0487	200.1634	200.1628	200.1628	0.0000
1	60.0000	-.0408	.0235	-.0191	.0235	200.0121	200.0118	200.0118	0.0000
1	70.0000	-.1749	.0039	-.0026	.0039	199.8941	199.8940	199.8940	0.0000
1	80.0000	-.2271	.0049	.0049	-.0037	199.8481	199.8482	199.8482	0.0000

COUPLE MOD 2 (MAY-23,77) UPDATE 1 (MAY-23,77) ECL
LOFT PRESSURIZER SPRAY LINE PIPING ANALYSIS
UNITS(LB,INCH,SECOND,BTU,DEGREE F)
SUMMARY DT TABLE FOR DTSET 1

DTSET	TIME	DT1	DT2	DT2I	DT2O	TAVE	TA	TB	DT3
1	90.0000	-.2475	.0078	.0078	-.0067	199.8302	199.8303	199.8303	0.0000
1	100.0000	-.2554	.0089	.0089	-.0079	199.8232	199.8233	199.8233	0.0000
1	110.0000	-.2585	.0093	.0093	-.0083	199.8205	199.8206	199.8206	0.0000
1	120.0000	-.2597	.0095	.0095	-.0085	199.8194	199.8195	199.8195	0.0000
1	130.0000	-.2602	.0096	.0096	-.0086	199.8190	199.8191	199.8191	0.0000
1	140.0000	-.2604	.0096	.0096	-.0086	199.8188	199.8189	199.8189	0.0000
1	150.0000	-.2604	.0096	.0096	-.0086	199.8188	199.8189	199.8189	0.0000
1	160.0000	-.2605	.0096	.0096	-.0086	199.8187	199.8189	199.8189	0.0000
1	170.0000	-.2605	.0096	.0096	-.0086	199.8187	199.8189	199.8189	0.0000
1	180.0000	-.2605	.0096	.0096	-.0086	199.8187	199.8188	199.8188	0.0000
1	190.0000	-.2605	.0096	.0096	-.0086	199.8187	199.8188	199.8188	0.0000
1	200.0000	-.2605	.0096	.0096	-.0086	199.8187	199.8188	199.8188	0.0000
1	210.0000	-.2605	.0096	.0096	-.0086	199.8187	199.8188	199.8188	0.0000
1	220.0000	-.2605	.0096	.0096	-.0086	199.8187	199.8188	199.8188	0.0000
1	230.0000	-.2605	.0096	.0096	-.0086	199.8187	199.8188	199.8188	0.0000
1	240.0000	-.2605	.0096	.0096	-.0086	199.8187	199.8188	199.8188	0.0000
1	250.0000	-.2605	.0096	.0096	-.0086	199.8187	199.8188	199.8188	0.0000
1	260.0000	-.2605	.0096	.0096	-.0086	199.8187	199.8188	199.8188	0.0000
1	270.0000	-.2605	.0096	.0096	-.0086	199.8187	199.8188	199.8188	0.0000
1	280.0000	-.2605	.0096	.0096	-.0086	199.8187	199.8188	199.8188	0.0000
1	290.0000	-.2605	.0096	.0096	-.0086	199.8187	199.8188	199.8188	0.0000
1	300.0000	-.2605	.0096	.0096	-.0086	199.8187	199.8188	199.8188	0.0000

CURRENT EXTREME VALUES ARE

DT1-MAX	DT1-MIN	DT2-MAX	DT3-MAX	DT3-MIN
295.4186	-.2605	84.1291	.0000	-.0000

COUPLE MOD 2 (MAY-23,77) UPDATE 1 (MAY-23,77) ECL
LOFT PRESSURIZER SPRAY LINE PIPING ANALYSIS
UNITS(LB,INCH,SECOND,BTU,DEGREE F)

H E A T C O N D U C T I O N S O L U T I O N

TIME = .50000 DT = .50000 STEP = 1

NODE	TEMPERATURE	NODE	TEMPERATURE	NODE	TEMPERATURE
1	3.8081E+02	2	3.8081E+02	3	4.8277E+02
6	5.4497E+02	7	5.8353E+02	8	5.8353E+02
11	6.2278E+02	12	6.2278E+02	13	6.3225E+02
16	6.3808E+02	17	6.4152E+02	18	6.4152E+02
21	6.4379E+02	22	6.4379E+02		

NODE	TEMPERATURE	NODE	TEMPERATURE
4	4.8277E+02	5	5.4497E+02
9	6.0764E+02	10	6.0764E+02
14	6.3225E+02	15	6.3808E+02
19	6.4330E+02	20	6.4330E+02

COUPLE MOD 2 (MAY-23,77) UPDATE 1 (MAY-23,77) ECL
LOFT PRESSURIZER SPRAY LINE PIPING ANALYSIS
UNITS(LB,INCH,SECOND,BTU,DEGREE F)

H E A T C O N D U C T I O N S O L U T I O N

TIME = 1.50000 DT = .50000 STEP = 3

NODE	TEMPERATURE	NODE	TEMPERATURE	NODE	TEMPERATURE
1	3.0370E+02	2	3.0370E+02	3	3.7774E+02
6	4.3890E+02	7	4.8794E+02	8	4.8794E+02
11	5.5550E+02	12	5.5550E+02	13	5.7713E+02
16	5.9249E+02	17	6.0262E+02	18	6.0262E+02
21	6.1009E+02	22	6.1009E+02		

NODE	TEMPERATURE	NODE	TEMPERATURE
4	3.7774E+02	5	4.3890E+02
9	5.2628E+02	10	5.2628E+02
14	5.7713E+02	15	5.9249E+02
19	6.0832E+02	20	6.0832E+02

```
0        1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

TITLE
LOFT PRESSURIZER SURGE LINE PIPING ANALYSIS
UNITS(LB,INCH,SECOND,BTU,DEGREE F)

MATERIAL
    1    1
    1          .2841  SA 312 GRADE 316 SS
1.0       1.0        1.0              1    1    2

NODES
   22
    1   .8445      0.          10
    2  1.1875       0.
    2   .8445        .25       10
    2  1.1875        .25

ELEMENTS
   10
    1    1    3    4    2    1                2
   10   19   21   22   20    1

STEP
          0.       300.                3        650.             1

FUNCTIONS
    3
    1     8     2
        70. 1.924E- 4       100. 1.974E- 4       200. 2.075E- 4
       300. 2.175E- 4       400. 2.276E- 4       500. 2.377E- 4
       600. 2.477E- 4       700. 2.579E- 4
    2     8     2
        70.   .108          100.   .1108         200.   .1174
       300.   .1222         400.   .1255         500.   .1278
       600.   .1296         700.   .1310
    3     8     1
         0.          .5       19.9          .5       20.          5.
        59.          5.        60.         10.      299.         10.
       300.         60.       600.         60.

CONVECTSETS
    4
    1   -1    2    1   1.52E-2              200.
   21   -1   22    1   1.05E-6               70.

DT123
    1
    .8445    .125    .8445     0.         1.1875     0.
    1.1875   .125    1.1875     .25       .8445      .25

0        1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

```
      0         1         2         3         4         5         6         7         8
      12345678901234567890123456789012345678901234567890123456789012345678901234567890

51    PLOTS
52         1          1
53
54    COUPLE
55
56    END OF DATA
      0         1         2         3         4         5         6         7         8
      12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

COUPLE MOD 2 (MAY-23,77) UPDATE 1 (MAY-23,77) ECL
LOFT PRESSURIZER SURGE LINE PIPING ANALYSIS
UNITS(LB,INCH,SECOND,BTU,DEGREE F)
SUMMARY DT TABLE FOR DTSET 1

DTSET	TIME	DT1	DT2	DT2I	DT20	TAVE	TA	TB	DT3
1	.5000	251.3218	160.9213	160.9213	-64.8969	587.3811	573.9177	573.9177	0.0000
1	1.0000	321.9767	136.0326	136.0326	-74.1855	556.2491	546.0470	546.0470	0.0000
1	1.5000	350.8081	110.6333	110.6333	-73.5618	532.4455	524.2979	524.2979	0.0000
1	2.0000	360.4587	92.5060	92.5060	-70.2143	512.3710	505.4163	505.4163	0.0000
1	2.5000	359.5948	79.6819	79.6819	-66.2639	494.7082	488.5366	488.5366	0.0000
1	3.0000	352.7323	70.3701	70.3701	-62.4108	478.7668	473.1631	473.1631	0.0000
1	3.5000	342.4653	63.3701	63.3701	-58.8480	464.1370	458.9747	458.9747	0.0000
1	4.0000	330.3418	57.9096	57.9096	-55.5918	450.5618	445.7608	445.7608	0.0000
1	4.5000	317.3057	53.4910	53.4910	-52.6077	437.8703	433.3767	433.3767	0.0000
1	5.0000	303.9369	49.8538	49.7929	-49.8538	425.9439	421.7198	421.7198	0.0000
1	5.5000	290.5916	47.2936	46.6049	-47.2936	414.6961	410.7133	410.7133	0.0000
1	6.0000	277.4825	44.8992	43.7907	-44.8992	404.0615	400.2984	400.2984	0.0000
1	6.5000	264.7348	42.6504	41.2599	-42.6504	393.9893	390.4287	390.4287	0.0000
1	7.0000	252.4222	40.5300	38.9507	-40.5300	384.4384	381.0659	381.0659	0.0000
1	7.5000	240.5826	38.5255	36.8213	-38.5255	375.3745	372.1780	372.1780	0.0000
1	8.0000	229.2315	36.6270	34.8426	-36.6270	366.7679	363.7366	363.7366	0.0000
1	8.5000	218.3701	34.8263	32.9936	-34.8263	358.5920	355.7162	355.7162	0.0000
1	9.0000	207.9907	33.1168	31.2591	-33.1168	350.8226	348.0936	348.0936	0.0000
1	9.5000	198.0803	31.4926	29.6273	-31.4926	343.4376	340.8472	340.8472	0.0000
1	10.0000	188.6219	29.9485	28.0894	-29.9485	336.4160	333.9567	333.9567	0.0000
1	10.5000	179.5949	28.4820	26.6388	-28.4820	329.7381	327.4029	327.4029	0.0000
1	11.0000	170.9840	27.0880	25.2687	-27.0880	323.3866	321.1691	321.1691	0.0000
1	11.5000	162.7730	25.7626	23.9732	-25.7626	317.3456	315.2395	315.2395	0.0000
1	12.0000	154.9456	24.5021	22.7474	-24.5021	311.5994	309.5991	309.5991	0.0000
1	12.5000	147.4856	23.3031	21.5866	-23.3031	306.1336	304.2336	304.2336	0.0000
1	13.0000	140.3769	22.1627	20.4871	-22.1627	300.9346	299.1297	299.1297	0.0000
1	13.5000	133.6038	21.0779	19.4453	-21.0779	295.9892	294.2747	294.2747	0.0000
1	14.0000	127.1511	20.0458	18.4577	-20.0458	291.2849	289.6561	289.6561	0.0000
1	14.5000	121.0043	19.0640	17.5215	-19.0640	286.8101	285.2627	285.2627	0.0000
1	15.0000	115.1491	18.1299	16.6338	-18.1299	282.5534	281.0833	281.0833	0.0000
1	15.5000	109.5721	17.2411	15.7920	-17.2411	278.5042	277.1075	277.1075	0.0000
1	16.0000	104.2601	16.3955	14.9936	-16.3955	274.6522	273.3251	273.3251	0.0000
1	16.5000	99.2004	15.5908	14.2363	-15.5908	270.9878	269.7268	269.7268	0.0000
1	17.0000	94.3803	14.8252	13.5182	-14.8252	267.5014	266.3033	266.3033	0.0000
1	17.5000	89.7877	14.0973	12.8374	-14.0973	264.1842	263.0458	263.0458	0.0000
1	18.0000	85.4127	13.4050	12.1916	-13.4050	261.0281	259.9463	259.9463	0.0000
1	18.5000	81.2457	12.7465	11.5790	-12.7465	258.0253	256.9974	256.9974	0.0000
1	19.0000	77.2773	12.1200	10.9976	-12.1200	255.1686	254.1918	254.1918	0.0000
1	19.5000	73.4987	11.5241	10.4458	-11.5241	252.4509	251.5227	251.5227	0.0000
1	20.0000	69.9010	10.9573	9.9219	-10.9573	249.8655	248.9835	248.9835	0.0000
1	25.0000	46.0496	7.2126	6.4905	-7.2126	232.7835	232.2050	232.2050	0.0000
1	30.0000	30.2641	4.7433	4.2489	-4.7433	221.5200	221.1406	221.1406	0.0000
1	35.0000	19.8386	3.1173	2.7832	-3.1173	214.1020	213.8531	213.8531	0.0000
1	40.0000	12.9643	2.0472	1.8235	-2.0472	209.2202	209.0569	209.0569	0.0000
1	45.0000	8.4366	1.3435	1.1945	-1.3435	206.0091	205.9021	205.9021	0.0000
1	50.0000	5.4568	.8807	.7818	-.8807	203.8976	203.8275	203.8275	0.0000
1	55.0000	3.4966	.5765	.5109	-.5765	202.5094	202.4636	202.4636	0.0000
1	60.0000	2.2077	.3766	.3330	-.3766	201.5969	201.5670	201.5670	0.0000
1	70.0000	.9454	.1808	.1590	-.1808	200.7036	200.6893	200.6893	0.0000
1	80.0000	.3275	.0850	.0739	-.0850	200.2664	200.2597	200.2597	0.0000

COUPLE MOD 2 (MAY-23,77) UPDATE 1 (MAY-23,77) ECL
LOFT PRESSURIZER SURGE LINE PIPING ANALYSIS
UNITS(LB,INCH,SECOND,BTU,DEGREE F)
SUMMARY DT TABLE FOR DTSET 1

DTSET	TIME	DT1	DT2	DT2I	DT2O	TAVE	TA	TB	DT3
1	90.0000	.0250	.0322	.0322	.0131	200.0524	200.0494	200.0494	0.0000
1	100.0000	-.1230	.0152	-.0119	.0152	199.9477	199.9465	199.9465	0.0000
1	110.0000	-.1954	.0039	-.0019	.0039	199.8964	199.8962	199.8962	0.0000
1	120.0000	-.2309	.0030	.0030	-.0016	199.8713	199.8715	199.8715	0.0000
1	130.0000	-.2482	.0054	.0054	-.0043	199.8591	199.8595	199.8595	0.0000
1	140.0000	-.2567	.0066	.0066	-.0056	199.8530	199.8536	199.8536	0.0000
1	150.0000	-.2609	.0071	.0071	-.0062	199.8501	199.8507	199.8507	0.0000
1	160.0000	-.2629	.0074	.0074	-.0065	199.8487	199.8493	199.8493	0.0000
1	170.0000	-.2639	.0075	.0075	-.0067	199.8480	199.8486	199.8486	0.0000
1	180.0000	-.2644	.0076	.0076	-.0068	199.8476	199.8482	199.8482	0.0000
1	190.0000	-.2646	.0076	.0076	-.0068	199.8475	199.8481	199.8481	0.0000
1	200.0000	-.2648	.0077	.0077	-.0068	199.8474	199.8480	199.8480	0.0000
1	210.0000	-.2648	.0077	.0077	-.0068	199.8473	199.8480	199.8480	0.0000
1	220.0000	-.2648	.0077	.0077	-.0068	199.8473	199.8479	199.8479	0.0000
1	230.0000	-.2649	.0077	.0077	-.0068	199.8473	199.8479	199.8479	0.0000
1	240.0000	-.2649	.0077	.0077	-.0068	199.8473	199.8479	199.8479	0.0000
1	250.0000	-.2649	.0077	.0077	-.0068	199.8473	199.8479	199.8479	0.0000
1	260.0000	-.2649	.0077	.0077	-.0068	199.8473	199.8479	199.8479	0.0000
1	270.0000	-.2649	.0077	.0077	-.0068	199.8473	199.8479	199.8479	0.0000
1	280.0000	-.2649	.0077	.0077	-.0068	199.8473	199.8479	199.8479	0.0000
1	290.0000	-.2649	.0077	.0077	-.0068	199.8473	199.8479	199.8479	0.0000
1	300.0000	-.2649	.0077	.0077	-.0068	199.8473	199.8479	199.8479	0.0000

CURRENT EXTREME VALUES ARE

DT1-MAX	DT1-MIN	DT2-MAX	DT3-MAX	DT3-MIN
360.4587	-.2649	160.9213	.0000	-.0000

COUPLE MOD 2 (MAY-23,77) UPDATE 1 (MAY-23,77) ECL
LOFT PRESSURIZER SURGE LINE PIPING ANALYSIS
UNITS(LB,INCH,SECOND,BTU,DEGREE F)

H E A T C O N D U C T I O N S O L U T I O N

TIME = .50000 DT = .50000 STEP = 1

NODE	TEMPERATURE	NODE	TEMPERATURE	NODE	TEMPERATURE
1	3.0080E+02	2	3.0080E+02	3	4.6494E+02
6	5.5011E+02	7	5.9556E+02	8	5.9556E+02
11	6.3356E+02	12	6.3356E+02	13	6.4088E+02
16	6.4484E+02	17	6.4693E+02	18	6.4693E+02
21	6.4815E+02	22	6.4815E+02		

NODE	TEMPERATURE	NODE	TEMPERATURE
4	4.6494E+02	5	5.5011E+02
9	6.2016E+02	10	6.2016E+02
14	6.4088E+02	15	6.4484E+02
19	6.4791E+02	20	6.4791E+02

COUPLE MOD 2 (MAY-23,77) UPDATE 1 (MAY-23,77) ECL
LOFT PRESSURIZER SURGE LINE PIPING ANALYSIS
UNITS(LB,INCH,SECOND,BTU,DEGREE F)

H E A T C O N D U C T I O N S O L U T I O N

TIME = 2.00000 DT = .50000 STEP = 4

NODE	TEMPERATURE	NODE	TEMPERATURE	NODE	TEMPERATURE
1	2.3964E+02	2	2.3964E+02	3	3.3210E+02
6	4.1010E+02	7	4.7287E+02	8	4.7287E+02
11	5.5781E+02	12	5.5781E+02	13	5.8406E+02
16	6.0221E+02	17	6.1392E+02	18	6.1392E+02
21	6.2239E+02	22	6.2239E+02		

NODE	TEMPERATURE	NODE	TEMPERATURE
4	3.3210E+02	5	4.1010E+02
9	5.2147E+02	10	5.2147E+02
14	5.8406E+02	15	6.0221E+02
19	6.2038E+02	20	6.2038E+02

APPENDIX B

MICROFICHE COPIES OF

COMPUTER RUNS

(See Distribution)

The following microfiche are complete copies of the surge and spray lines thermal analyses computer runs.