

LOFT TECHNICAL REPORT LTR 1119-37
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LOFT REACTOR VESSEL HEAD INSTRUMENT PENETRATION
FLANGE THERMAL ANALYSIS

S. K. Howell



EG&G Idaho, Inc.



IDAHO NATIONAL ENGINEERING LABORATORY

DEPARTMENT OF ENERGY

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

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RESEARCH, ENGINEERING AND CONSTRUCTION REPORT ENGINEERING ANALYSIS DIVISION

THERMAL ANALYSIS BRANCH

LOFT REACTOR VESSEL HEAD INSTRUMENT PENETRATION
FLANGE THERMAL ANALYSIS

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IDAHO NATIONAL ENGINEERING LABORATORY
LOFT TECHNICAL REPORT
LOFT PROGRAM

TITLE LOFT Reactor Vessel Head Instrument Penetration		REPORT NO. 1119-37
Flange Thermal Analysis		
AUTHOR S. K. Howell <i>S.K. Howell</i>	<i>R.P. Riordan/SKH</i>	GWA NO. 52121-300-400
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SUMMARY

A redesign of the LOFT instrument penetration necessitated a reanalysis of the thermal conditions existing in the nozzle and flange during a Loss of Coolant Experiment (LOCE). The maximum temperature gradient existing in the instrument flange will be used to determine the thermal stresses and maximum number of allowable cycles for the instrument flange. Based upon the specification^[1] and thermal conditions predicted by RELAP4/MOD5^[2], the maximum temperature gradient through the flange will not exceed 216 °F. The thermal conditions predicted by RELAP4/MOD2 for the nozzle head penetration assembly were less severe than those used in the original thermal-stress analysis^[3], so only the flange was analyzed here. If the thermal stresses are marginal with the 216 °F ΔT , a more detailed analysis should be done as the heat slab model used in RELAP is only one dimensional.

Conservative hand calculations were performed for a heatup rate of 100 °F per hour and it was determined that the worst temperature gradient through the flange will be less than 81 °F.

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LOFT INSTRUMENT PENETRATION NOZZLE THERMAL ANALYSIS

I. INTRODUCTION

Design modifications to the LOFT reactor vessel instrument penetration resulted in a change in thermal conditions occurring during a LOCE inside the nozzle penetration stalk (see Fig. 1). As the reactor vessel pressure falls during a blowdown, the water inside the penetration assembly will boil, resulting in nucleate boiling and/or two phase flow heat transfer and a corresponding large heat transfer coefficient. Until the volume of stagnant liquid in the stalk is vaporized and expelled, these high coefficients will generate large thermal gradients and corresponding high stresses. The original configuration was such that the volume of water inside the nozzle was very small and vaporized almost immediately following initiation of the blowdown. However, modifications to the flange sealing assembly resulted in the entire center stalk volume of water being available to two-phase convection and nucleate boiling heat transfer as it was expelled through the outer annulus during a blowdown.

Only a LOCE transient was analyzed in detail because all other transients are insignificant compared with the LOCE. This is especially true with the instrument penetration nozzle since all inside surfaces are exposed to a stagnant fluid during all transients except a LOCE. This results in a low convection boundary coefficient so any temperature transients in the boundary fluid will not cause a significant thermal gradient in the components.

Hand calculations were performed using the Heisler^[4] charts for a semi-infinite slab with a heatup-cooldown rate of 100 °F/hour.

II. ANALYSIS

1. LOCE TRANSIENT

RELAP4/MOD5 was used to determine the thermal conditions in the nozzle during blowdown. The details of the RELAP4 model are described in detail in Appendix A. RELAP4 calculates inside and outside temperatures for all surfaces using a one-dimensional slab model, fluid boundary coefficients and temperatures based upon the time dependent pressure and volume input to the code.

2. HEATUP AND COOLDOWN

A hand calculation was performed for the instrument penetration nozzle flange to determine the temperature gradient occurring during a heatup or cool-down thermal cycle at a rate of 100 °F/hr. A one-dimensional semi-infinite slab model was used, which is a conservative model, since this ignores the effect of natural convection on the outside surface. The following assumptions were made.

1. One-dimensional semi-infinite slab (outside surface convection was ignored).
2. $L = 3$ inches (0.25 ft).
3. Since inside fluid boundary is stagnant during heatup and cool-down, an inside convection boundary coefficient of 200 Btu/hr-ft²-°F was assumed.
4. A heatup - cooldown rate of 100 °F/hour was used from 70 °F to 610 °F.
5. For Inconel 600 alloy; $\alpha = 0.159$ ft²/hr, $k = 10.75$ Btu/hr-ft-°F.
6. The Heisler charts for a semi-infinite slab^[4] were used to evaluate the temperature 3 inches from the inside surface.

$$\frac{x}{2\sqrt{\alpha\tau}} = \frac{0.25}{2\sqrt{.159(5.4)}} = 0.13$$

assuming $\tau = 5.4$ hour

$$\frac{T - T_i}{T_\infty - T_i} = \frac{T - 70}{610 - 70} = \frac{T - 70}{540}$$

assuming an initial temperature of 70 °F and heatup rate of 100 °F/hour

$$\frac{h\sqrt{\alpha\tau}}{K} = \frac{200\sqrt{0.159(5.4)}}{10.75} = 17.24$$

assuming a convection coefficient of 200 Btu/hr-ft²-°F
from the Heisler charts at the above points,

$$\frac{T - T_i}{T_\infty - T_i} = 0.85$$

Therefore, $T = 459.0 + 70 = 529.0$ °F

$\Delta T = 81$ °F which is the maximum temperature gradient through the flange wall (assumes inside surface temperature equals fluid temperature).

III. RESULTS

1. NOZZLE FLANGE GRADIENT DURING LOCE TRANSIENT

RELAP4 calculated the convection boundary coefficient for all inside surfaces as a function of time. The boundary coefficients as a function of time are shown in Figures 2 and 3 for the flange and nozzle penetration surfaces, respectively. The coefficient is initially high due to nucleate boiling and two-phase forced convection heat transfer. This is the limiting regime in terms of thermal stresses since nucleate boiling is followed by saturated steam convection and corresponding small heat transfer coefficients. The highest thermal gradients will then be observed either during or immediately following the nucleate boiling two-phase heat transfer regime.

Fluid boundary temperatures as a function of time are shown in Figures 4 and 5 for the flange surface and inside instrument penetration stalk surface, respectively.

RELAP4/MOD5 calculates the inside and outside slab surface temperatures as a function of time. This is a conservative calculation since a one-dimensional slab model is assumed and convection from the outside surface is ignored. The time-temperature plot for the flange is shown in Figure 6. As would be expected, the greatest temperature difference occurs during the nucleate boiling regime at a time of 26 seconds. This temperature difference is 216.6 °F.

Since a detailed two-dimensional finite element analysis has already been performed^[3] for the instrument nozzle, a comparison was made with the boundary conditions predicted by RELAP4 and those used in the original thermal-stress analysis. These conditions are presented in Table I. The RELAP4 model predicted a higher fluid temperature and lower convection coefficients than those used in the Avery analysis^[3]. Therefore, the original analysis is conservative in predicting thermal stresses, so a detailed thermal analysis will not be redone on the instrument nozzle.

2. NOZZLE FLANGE GRADIENT DURING HEATUP AND COOLDOWN

Based upon the preceding assumptions and calculations, a maximum temperature gradient of 81 °F will result in the flange during a heatup or cooldown transient of 100 °F/hour.

IV. CONCLUSIONS

Upon comparing the convection coefficient-time plot and inside surface temperature-time plot (Figs. 2 and 6), one can see a definite correlation between the boundary coefficient and surface temperature. Nucleate boiling is the predominant heat transfer mechanism for the first 25 seconds and a large heat transfer coefficient results until all of the liquid is vaporized. The inside surface temperature falls rapidly during this phase of the transient. After nucleate boiling ends, the surface temperature at 26 seconds corresponds to the largest thermal gradient during the transient since the outside surface temperature is essentially constant at 619 °F during the first 30 seconds of the transient.

All gradients calculated in this report are conservative due to the one-dimensional slab model used to compute them.

V. REFERENCES

1. LOFT Reactor Vessel 290° Downsomer Stalk Instrument Penetration Flange Assembly, EG&G Idaho, Inc., Specification ES-60246.
2. RELAP4/MOD5 A Computer Program for Transient Thermal-Hydraulic Analysis of Nuclear Reactors and Related Systems Users' Manual, ANCR-NUREG-1335, September 1976.
3. McPherson Associates, Inc., Analysis of ECCS Head Nozzle, Instrument Penetration Nozzle, CRDM Nozzle, and Nozzle Canopies, for P. F. Avery Corp. #794000-8, January 1973.
4. Holman. J. P., Heat Transfer, McGraw-Hill Book Co., New York, 1972.

TAB E I

BOUNDARY CONDITIONS INSIDE INSTRUMENT PENETRATION STALK

Time (sec)	(Avery Analysis) T (°F)	(RELAP4) T (°F)	(Avery Analysis) h (Btu/hr-ft ² -°F)	(RELAP4) h (Btu/hr-ft ² -°F)
0	609.8	620.0	10,000	9000.0
1.5	560.0	--	10,000	--
2.0	--	588.4	--	163.1
7.0	490.0	588.2	10,000	52.0
10.0	380.7	582.8	50	58.3
14.0	235.0	568.4	50	57.0
20.0	↓	543.8	↓	54.1
25.0	↓	520.3	↓	52.1
30.0	↓	549.6	↓	5.0

25 6 11 19 87

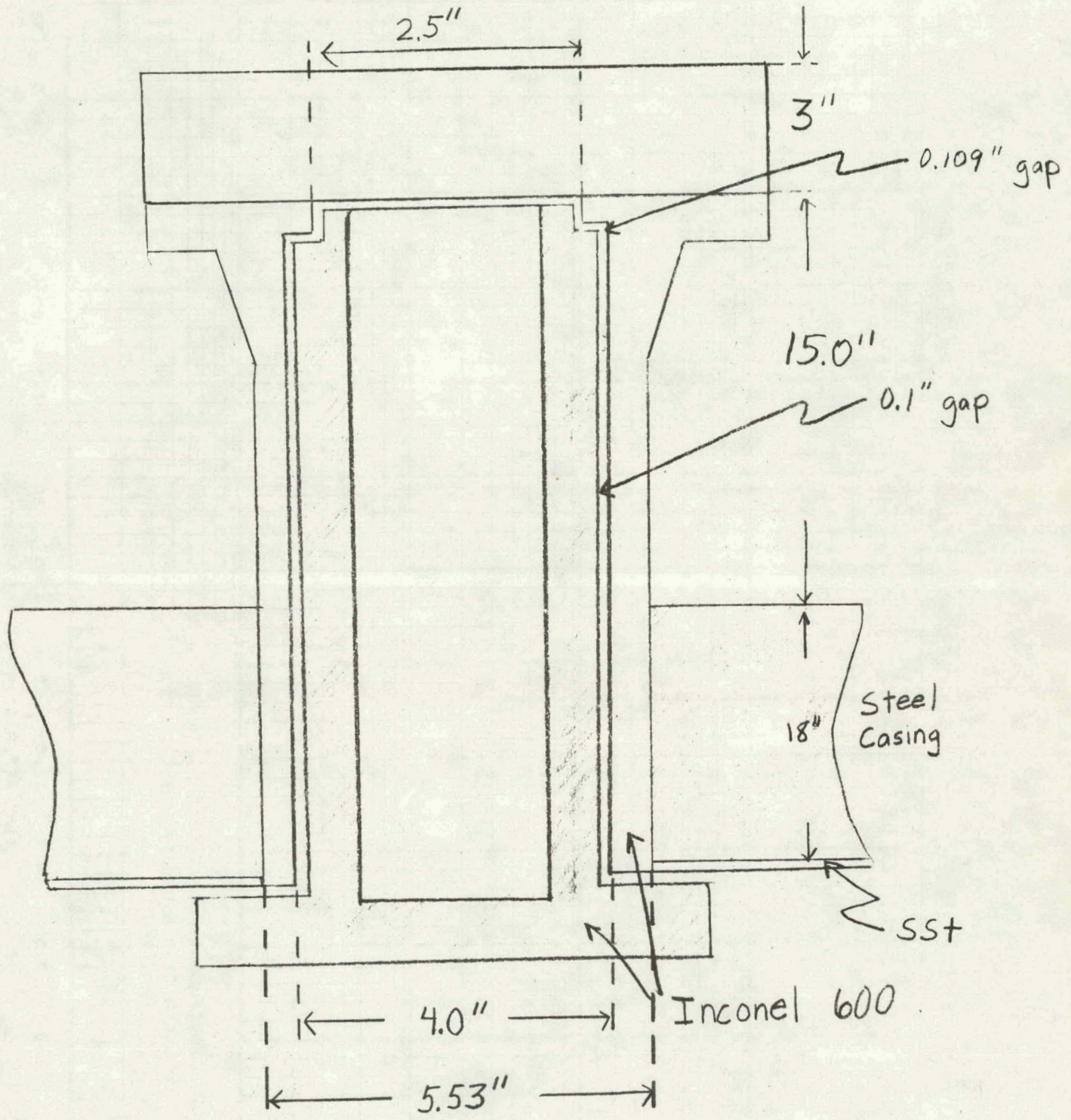


Figure 1. Cross Section of Instrumentation Penetration Nozzle Assembly

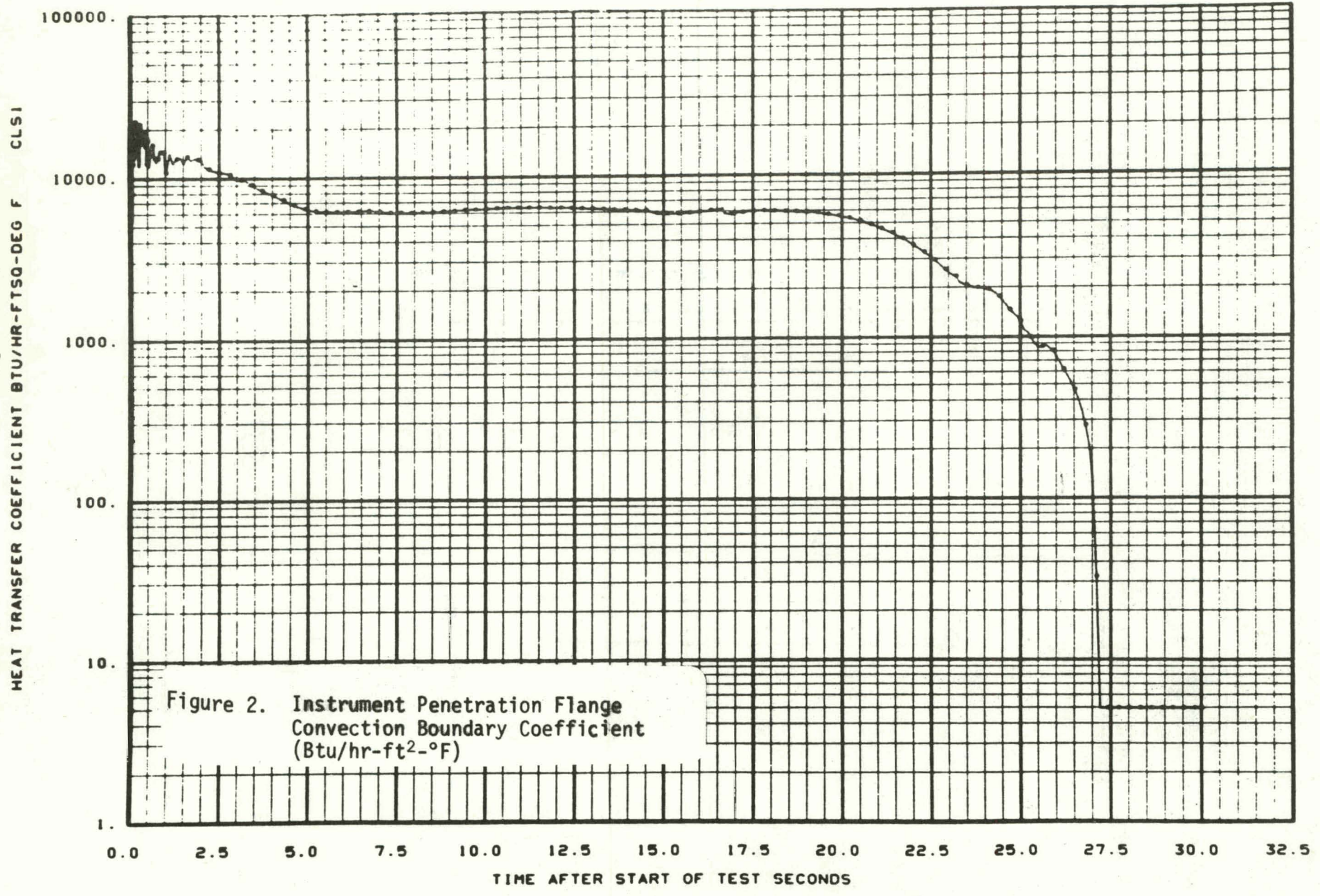
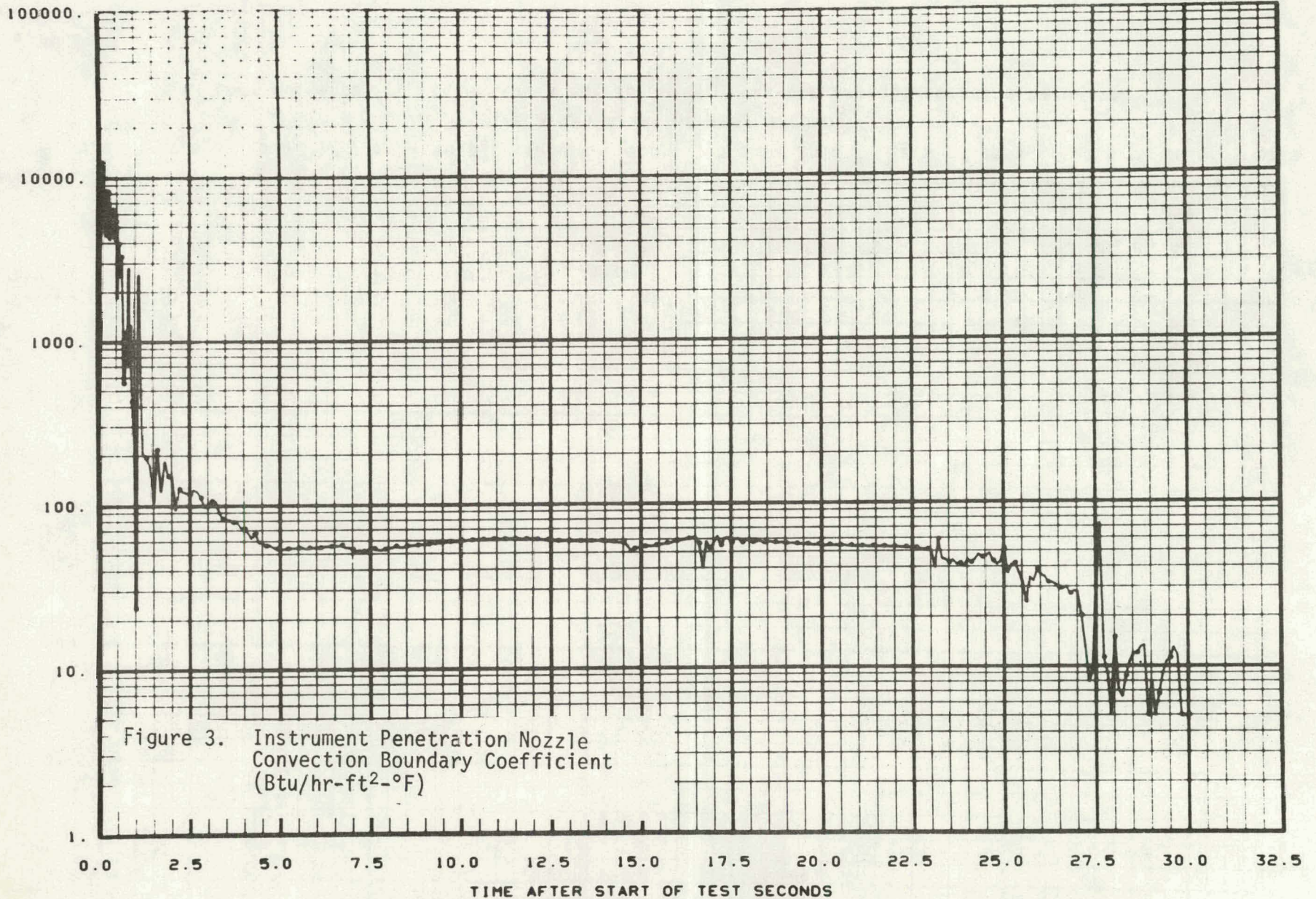


Figure 2. Instrument Penetration Flange
Convection Boundary Coefficient
(Btu/hr-ft²-°F)

HEAT TRANSFER COEFFICIENT BTU/HR-FTSQ-DEG F

CLS4



LOFT-NUCL-003 200 CL BK 47.13 MW 16 KW/FT XX-ORELAP4/C05 09/03/76 02/02/78

LTR1119 3Z

FLUID TEMPERATURE IN THE INSTRUMENT STALK ATV2

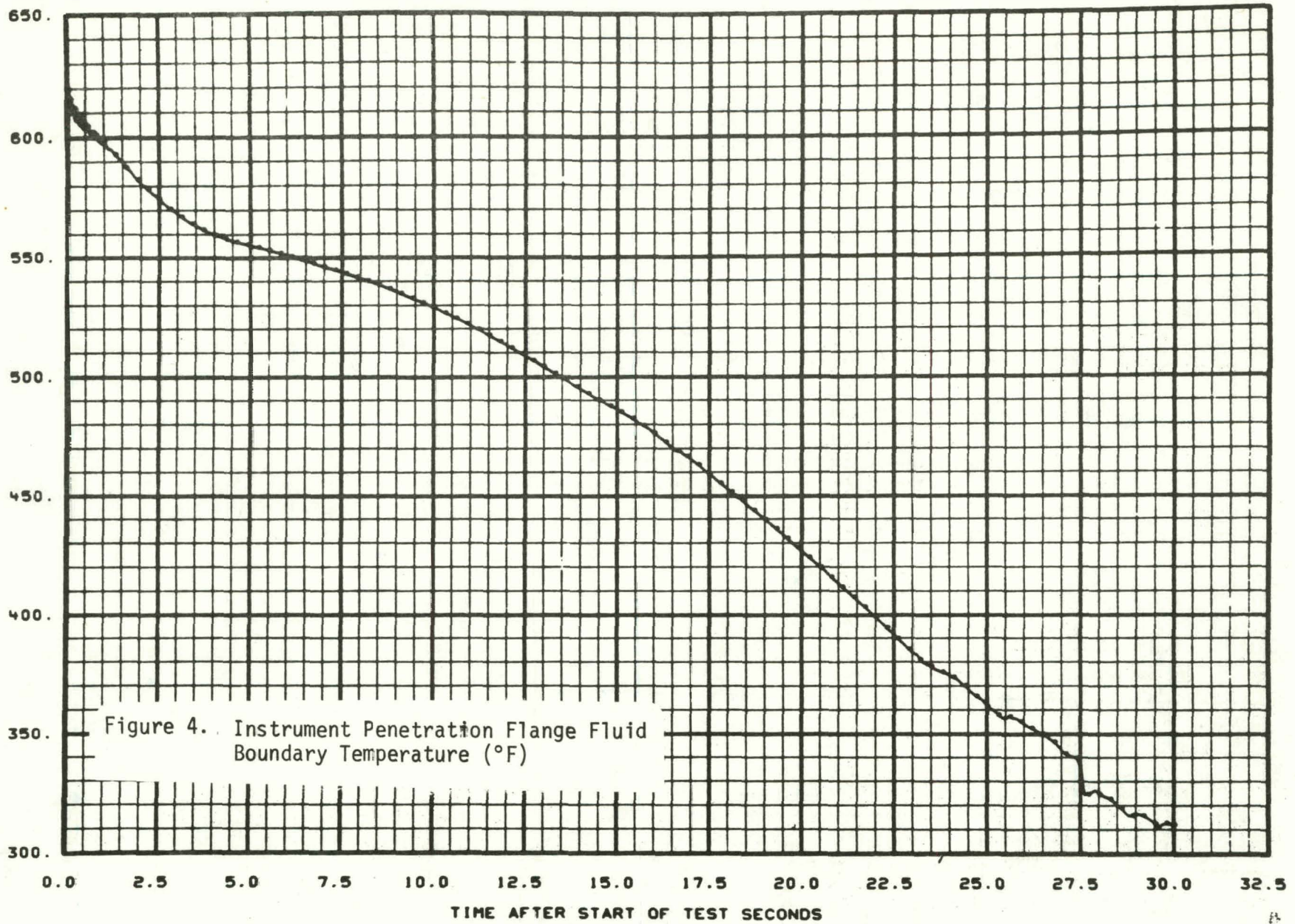
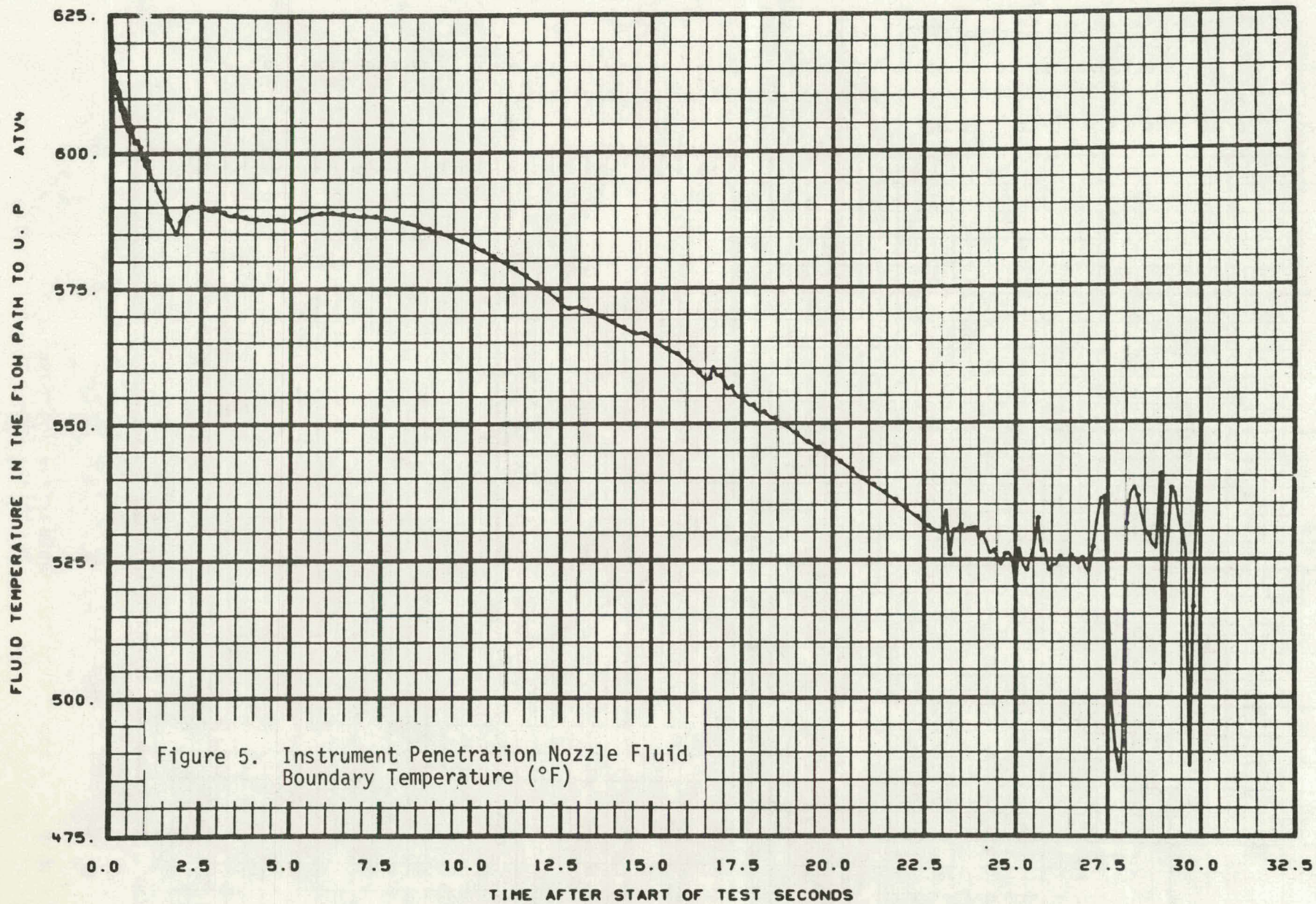


Figure 4. Instrument Penetration Flange Fluid Boundary Temperature (°F)

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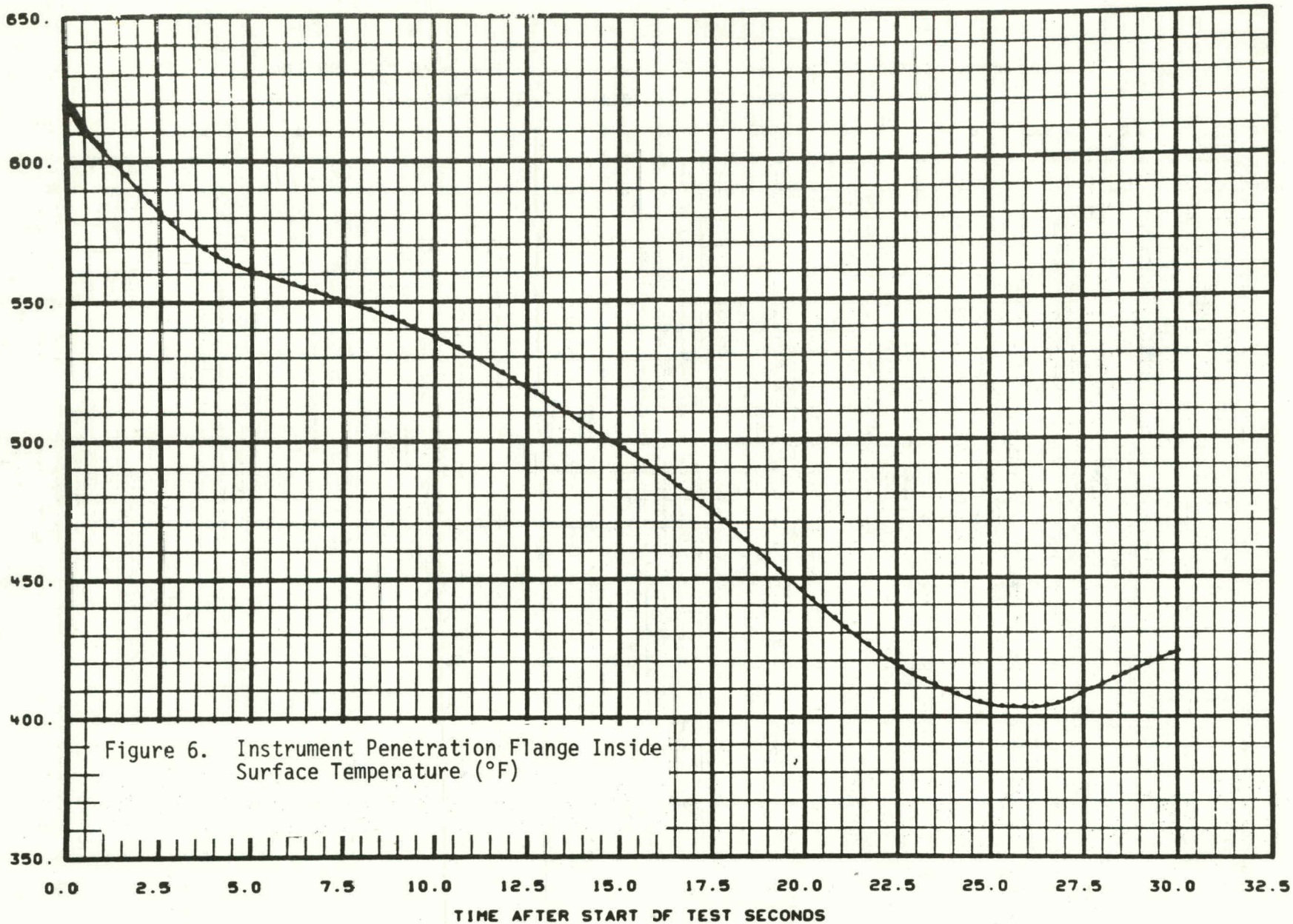
LTR1119 32



LOFT-NUCL-003 200 CL BK 47.13 MW 16 KW/FT XX-ORELAP4/C05 09/03/76 02/02/78

LR1119-3Z

LEFT SIDE SURFACE TEMPERATURE SLAB 1 DEG F SLSI



LOFT-NUCL-003 200 CL BK 47.13 MW 16 KW/FT XX-ORELAP4/C05 09/03/76 02/02/78

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APPENDIX A

RELAP4 ANALYSIS OF THE LOFT UPPER
HEAD INSTRUMENTATION PENETRATION

by

R. P. Riordan

A RELAP4 analytical model of the LOFT pressure vessel upper head instrumentation penetrations was developed to analyze the transient thermal-hydraulic behavior of one such penetration during a loss-of-coolant experiment. The instrumentation penetration was analyzed using previously predicted upper plenum conditions as the boundary conditions for the analytical model. The upper plenum conditions are from a previous RELAP4 calculation. This RELAP4 model was a preliminary study of a 200% cold leg break simulation by the LOFT facility. This analysis was performed to determine the fluid properties of the fluid in the instrumentation penetrations during a transient. These results were used to analyze the thermal stress resulting from this transient.

The RELAP4 calculation is a preliminary scoping analysis for L2-4 and was performed using a non-standard version of RELAP4/MOD5 update 2(ET3) with the LOFT CHF - correlation update.

MODEL DESCRIPTION

The nodal diagram of the RELAP4 analytical model is shown in Figure A-1. This model consists of 4 volume nodes, 3 flow junctions, and 5 passive heat slabs. Volume Node 1 describes the upper plenum region of the LOFT pressure vessel and is the time dependent volume for which the fluid conditions as a function of time, are retrieved from a previous RELAP4 data tape. This data tape was created by a RELAP4 analysis of the LOFT system response to a simulated 200% cold leg break, loss-of-coolant experiment^[1]. The nodal diagram of this RELAP4 model of the LOFT system is shown in Figure A-2.

Nodal Volumes 2, 3, and 4 model the fluid volumes associated with the upper lead penetration nozzle and instrumentation stalk. Volume 2 models the fluid volume inside the instrumentation stalk less the volume of the instrument heads. Volumes 3 and 4 model the fluid volume within the annular space between the outside walls of the instrumentation stalk and the inside wall of the upper head penetration nozzle. Table A-1 gives a tabular listing of the nodal volume descriptions.

The junctions connect the volume nodes to create the flow path for the fluid to leave the instrumentation stalk and enter the upper plenum during a LOCE. Table A-2 is a tabulation of the important data regarding these junctions. These junctions are modeling the two major flow constrictions and the connection of two similar volumes. Junction 1 is the flow path from the instrumentation stalk to the annular space between the instrument stalk walls and the inside walls of the upper head penetration nozzle. Junction 2 is the connection of the two annular volumes modeling the gap between the walls of the upper head penetration nozzle and the instrumentation nozzle. The third junction models the connection between the upper plenum and this annular volume in the upper head penetration nozzle.

The heat slabs were modeled to describe all the metal walls of the instrumentation nozzle in contact with the fluid. Heat Slab 1 models the blind flange on the penetration nozzle. The instrumentation stalk is modeled as Slabs 2 and 3. Slabs 4 and 5 model the penetration nozzle walls and the upper head surrounding it.

RESULTS

The time dependent pressure response of the upper plenum is shown in Figure A-3. Figure A-4 is the average pressure predicted for the instrumentation stalk. Comparing these two figures no differences in pressure can be seen.

The average fluid temperature in the instrumentation stalk, Figure A-5, and the average surface temperature of the penetration nozzle flange, Figure A-6, were used in the thermal analysis of the flange. The heat transfer coefficient for this heat transfer surface is shown in Figure A-7.

Figure A-8 shows the average fluid temperature of the fluid in contact with both heat Slabs 3 and 5. Figure A-9 shows the surface temperature of the outside surface of the instrumentation stalk tube wall, which is modeled as heat Slab 3. The heat transfer coefficient for this surface is shown in Figure A-10.

The penetration nozzle surface temperature is shown in Figure A-11 and the heat transfer coefficient is shown in Figure A-12. Heat Slab 5 models the penetration nozzle where it passes through the upper head. It is for this portion of the penetration nozzle that the surface temperature is shown in Figure A-11.

The analysis of the upper head penetration was performed using a released version of RELAP4/MOD5^[A-4]. The results of this analysis are stored on a magnetic tape in the computer science laboratory, tape number T9V584. The analysis uses the results of an analysis of the LOFT facility which was done using an unconfigured version of RELAP4/MOD5 which was created by updating RELAP4/MOD5 (E73)^[A-3].

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1. A preliminary scoping analysis of the LOFT system for L2-4, the data deck as submitted is under historical reference with the Code Configuration Control and assigned number H00280 IB.
2. RELAP4/MOD5 A Computer Program for the Transient Thermal-Hydraulic Analysis of Nuclear Reactors and Related Systems, User's Manual, Volumes I and II, ANCR-NUREG-1335, September 1976.
3. RELAP4/MOD5 (E73) A Version of RELAP4/MOD5 under Historical Reference with Code Configuration Control and assigned number H00007 IB, October 5, 1976.
4. RELAP4/MOD5 (Update 2) A Released Version and Full Configuration Control Assigned Code Configuration Control number C0010001.

TABLE A-1

Nodal Volume description data used for this analysis

Volume NUMBER	Volume Cu. Ft.	Height FT	FLOW AREA Sq. FT	EQUIV. DIAM. FT	ELEVATION FT
1	19.92535578	11.6024	2.1918700	1.1396	-6.75625
2	.07308274	2.8500	.0256431	.020255	4.82610
3	.01269730	1.3000	.0101578	.0200	6.380333
4	.01608320	1.6000	.0101578	.0200	4.79000

A-5

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TABLE A-2

Flow Junction DATA used to describe THE FLOW PATHS
Between nodal volumes

Junction Number	Flow Area Sq. Ft.	Inertia L/A	Loss Coef. Forward	Loss Coef. Reverse	Junction Orientation	Elevation Ft
1	0.1000	117.1	5.010	4.510	VERTICAL	7.6761
2	0.0105178	139.5	0.000	0.000	HORIZONTAL	6.38033
3	0.0105178	80.0	1.110	1.610	VERTICAL	4.7900

A-6

TABLE A-3

Basic Heat SLAB DATA and model description

HEAT SLAB NUMBER	VOLUME LEFT SIDE	VOLUME RIGHT SIDE	LEFT SIDE H. T. AREA SQ. FT.	RIGHT SIDE H. T. AREA SQ. FT.	SLAB VOLUME CU. FT.	SLAB GEOMETRY TYPE	Descriptive Comments
1	2	0	0.034088	0.000	0.0085221	RECTANGULAR	Models THE FLANGE AT THE TOP OF THE PENETRATION NOZZLE
2	2	3	0.869814	1.976156	0.0754675	ANNULAR	TOP HALF OF THE WALLS OF THE INSTRUMENTATION STALK
3	2	4	0.773168	1.312138	0.0670777	ANNULAR	BOTTOM HALF OF THE WALLS OF THE INSTRUMENTATION STALK
4	3	0	1.350080	0.000	0.033752	ANNULAR	TOP HALF OF THE PENETRATION NOZZLE (PART ABOVE THE UPPER HEAD PLATE)
5	4	0	1.570796	0.000	5.201970	ANNULAR	PORTION OF THE PENETRATION NOZZLE THAT PASSES THROUGH THE UPPER HEAD PLATE AND INCLUDES A 10 INCH RADIAL THICKNESS OF THE UPPER HEAD PLATE AROUND THE PENETRATION NOZZLE

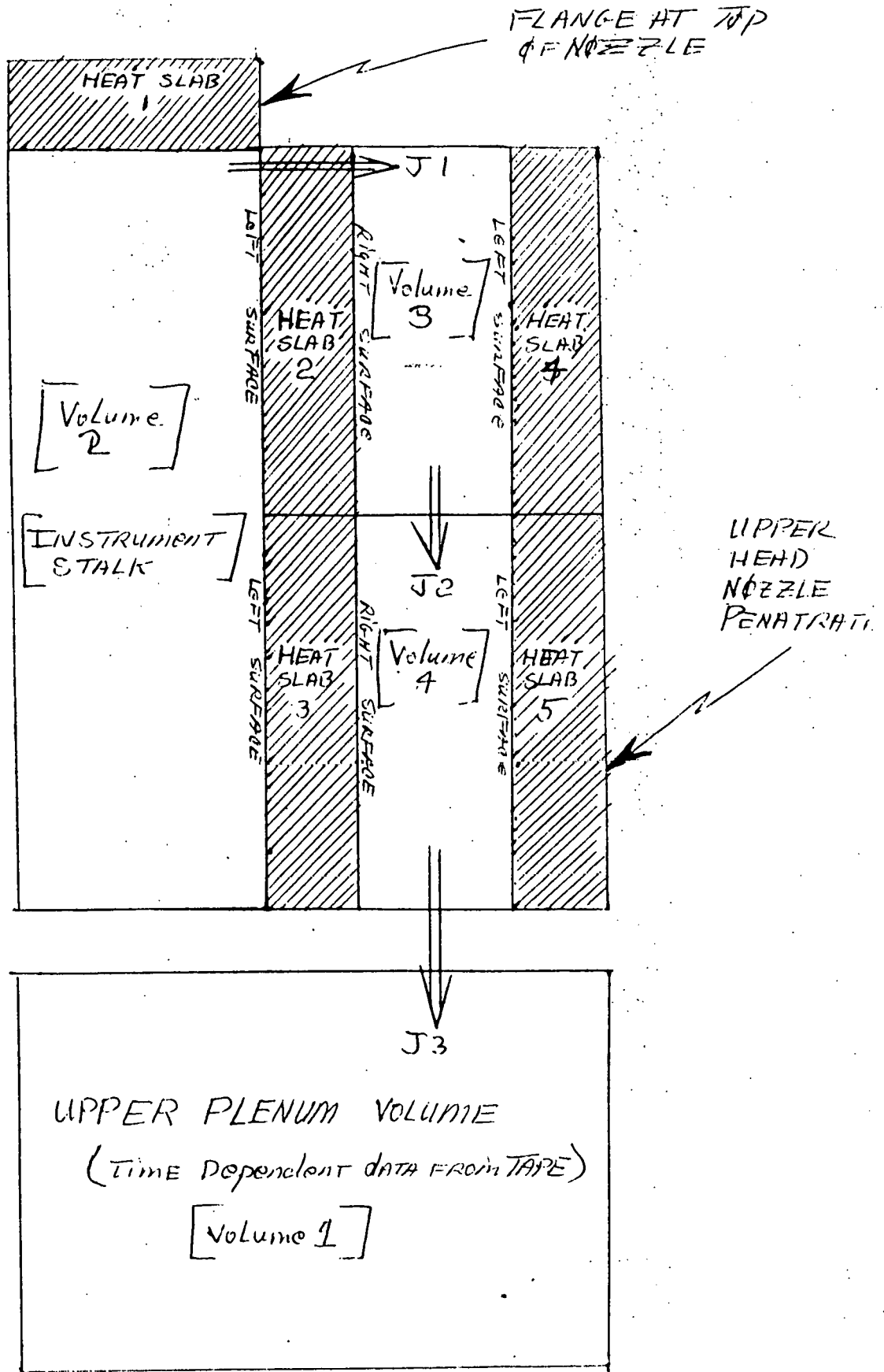
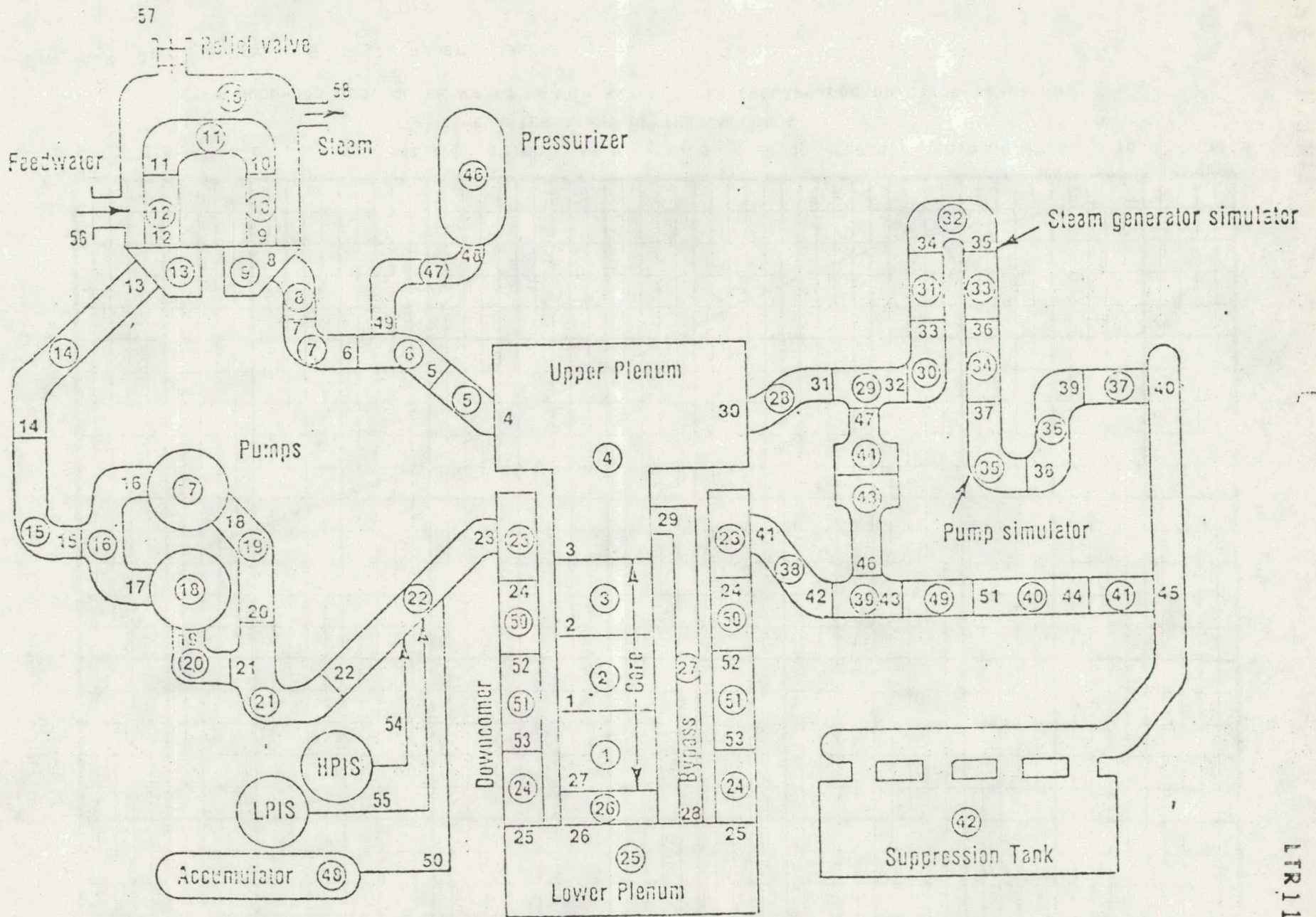


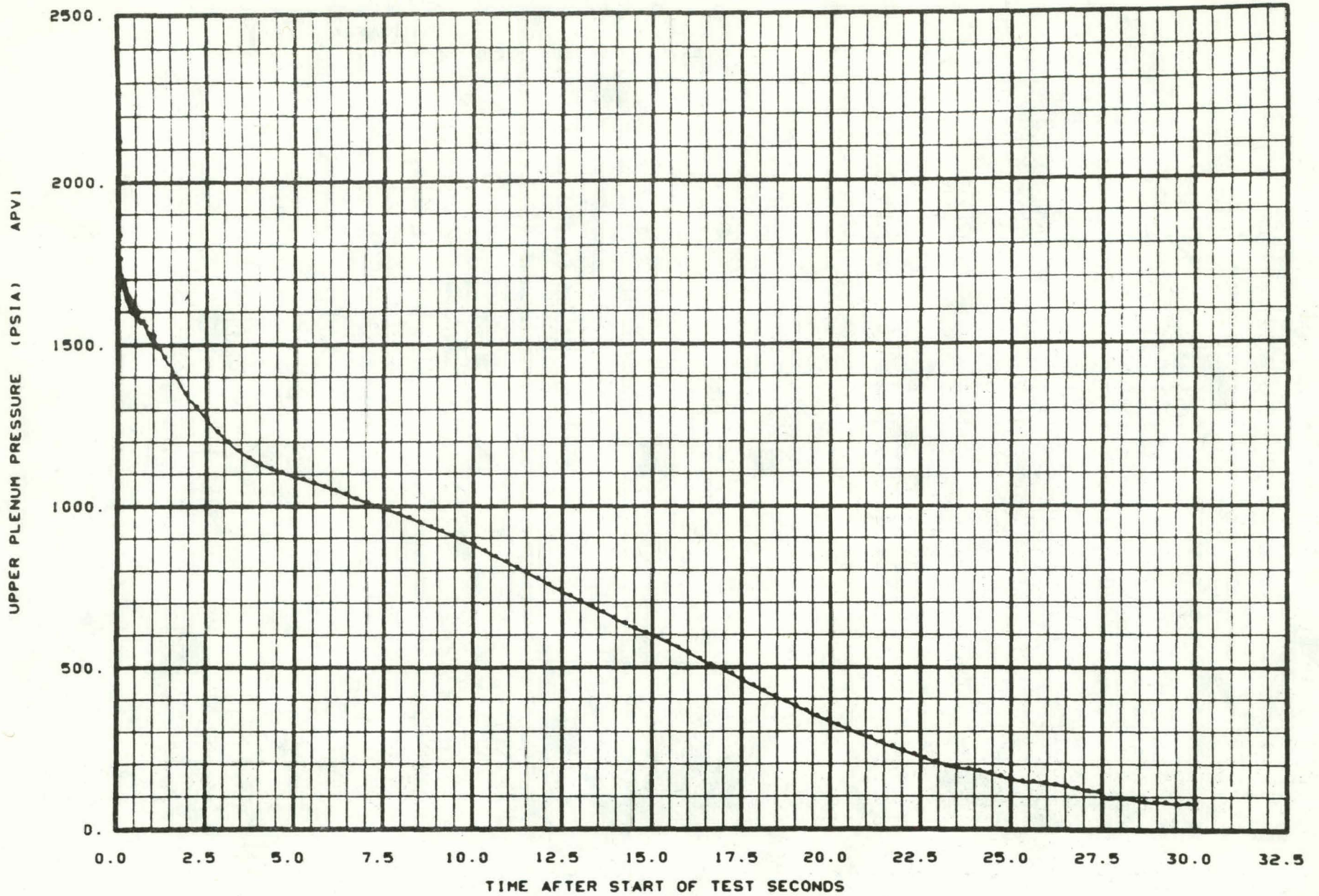
Fig. A-1 Nodalization diagram for the model of the upper head instrumentation penetration nozzle.



A-9

Fig. A-2 Nodalization diagram of the LOFT system.

A-10

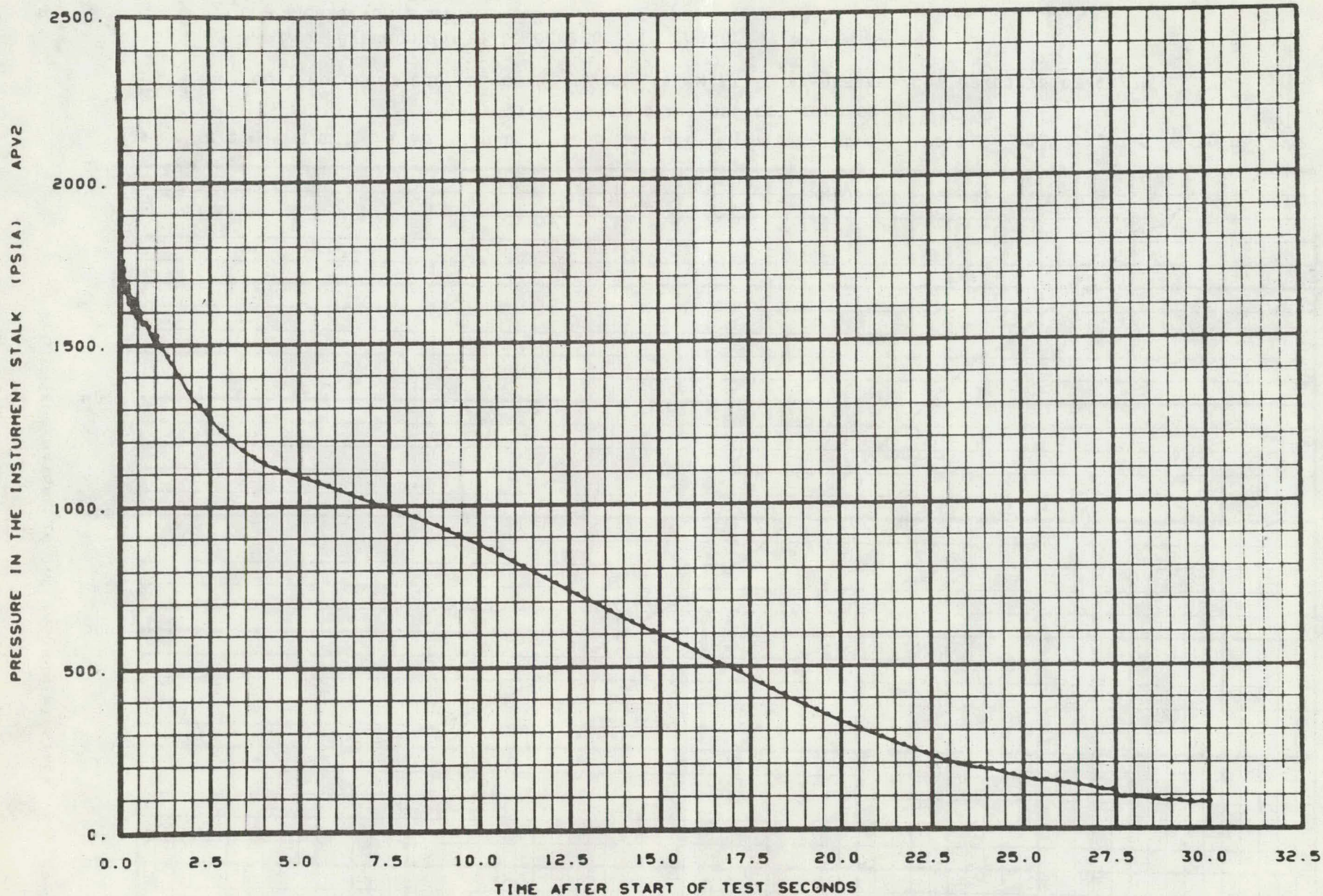


LOFT-NUCL-003 200 CL BK 47.13 MW 15 KW/FT. XX-ORELAP4/C05 09/03/76 02/02/78

Fig. A-3 Average pressure in the upper plenum.

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A-11

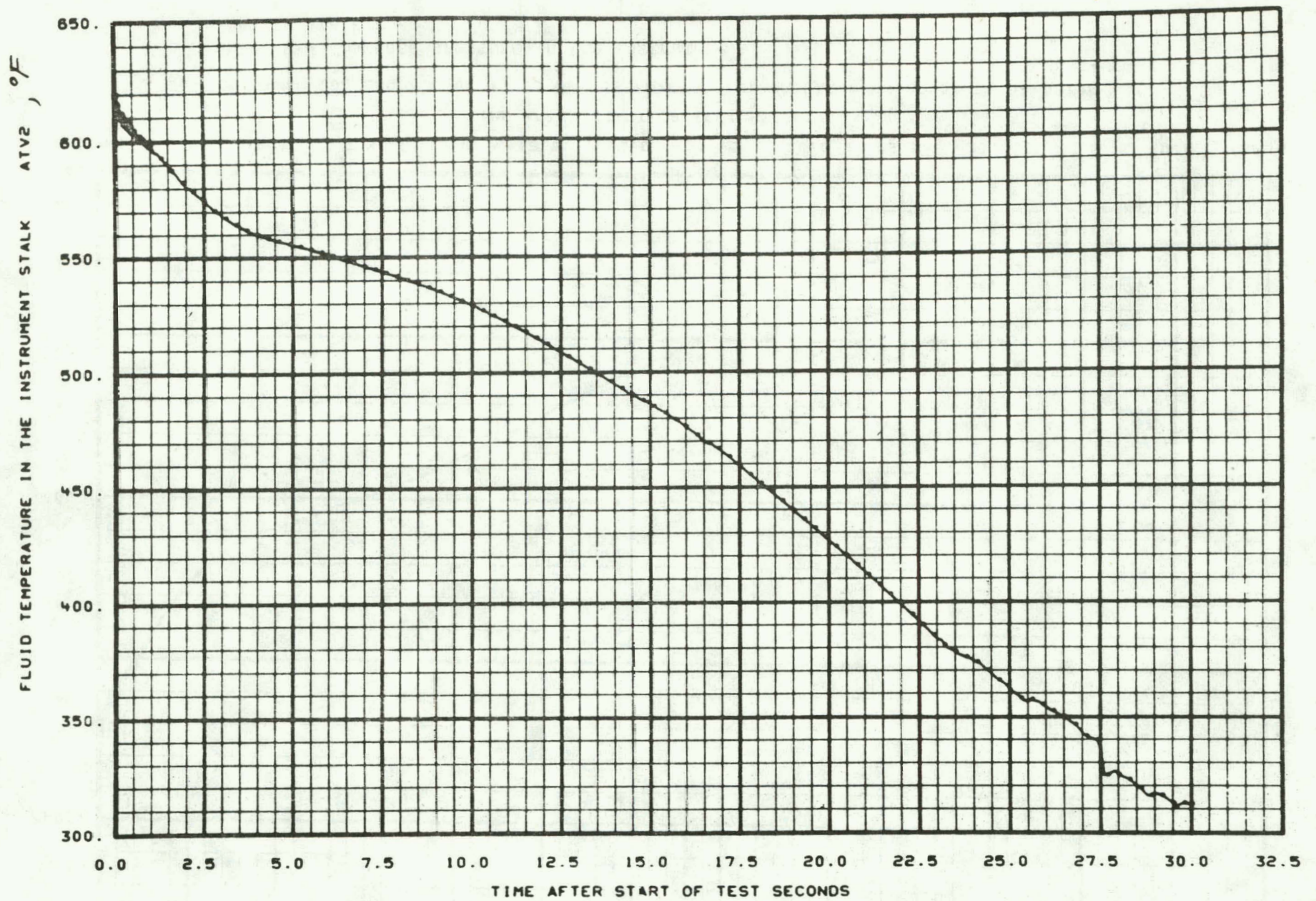


LOFT-NUCL-003 200 CL BK 47.13 MW 16 KW/FT XX-ORELAP4/C05 09/03/76 02/02/78

Fig. A-4 Average pressure in the instrumentation stalk.

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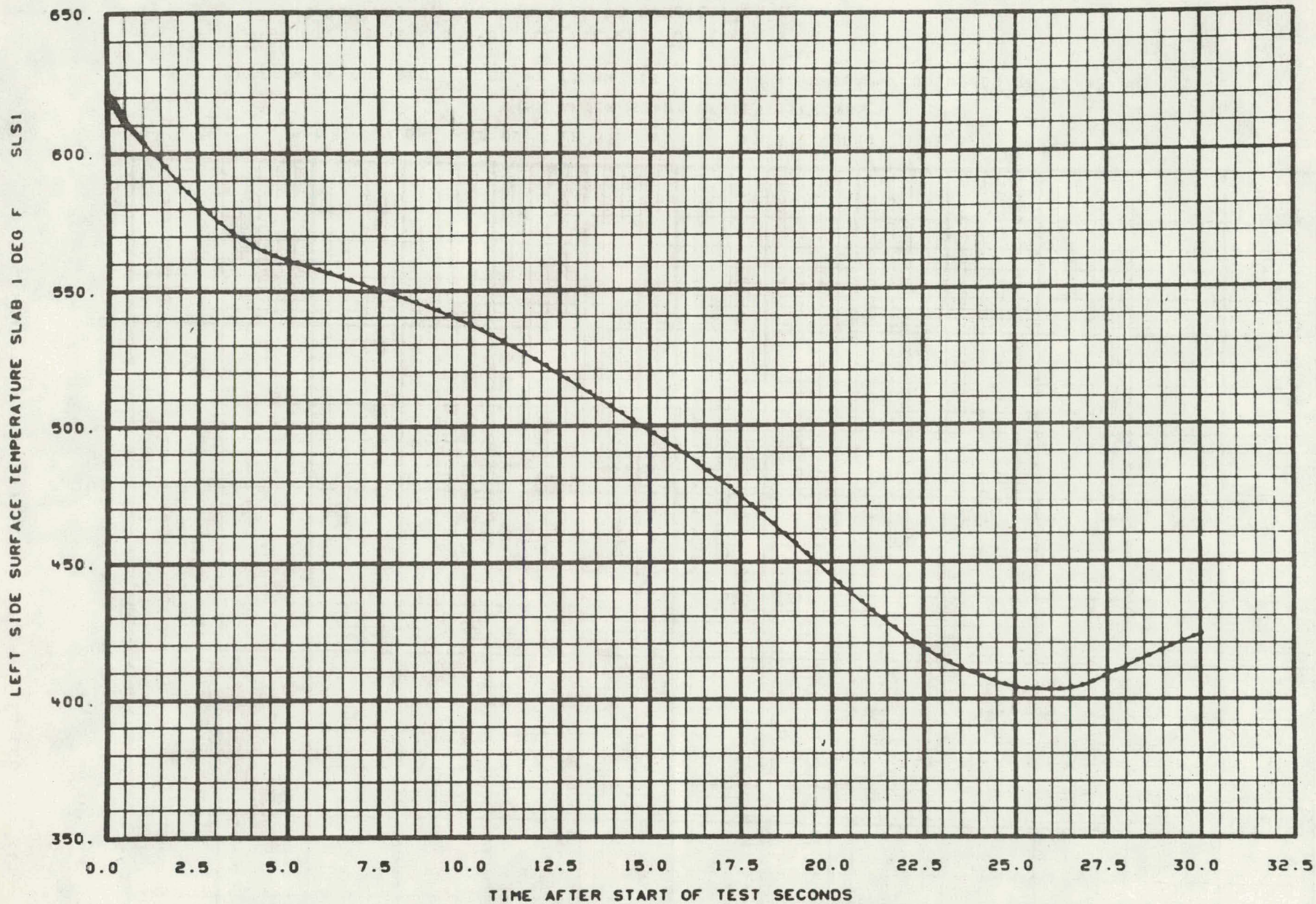
A-12



LOFT-NUCL-003 200 CL BK 47.13 MW 16 KW/FT XX-ORELAP4/C05 09/03/76 02/02/78

Fig. A-5 Average fluid temperature in the instrumentation stalk.

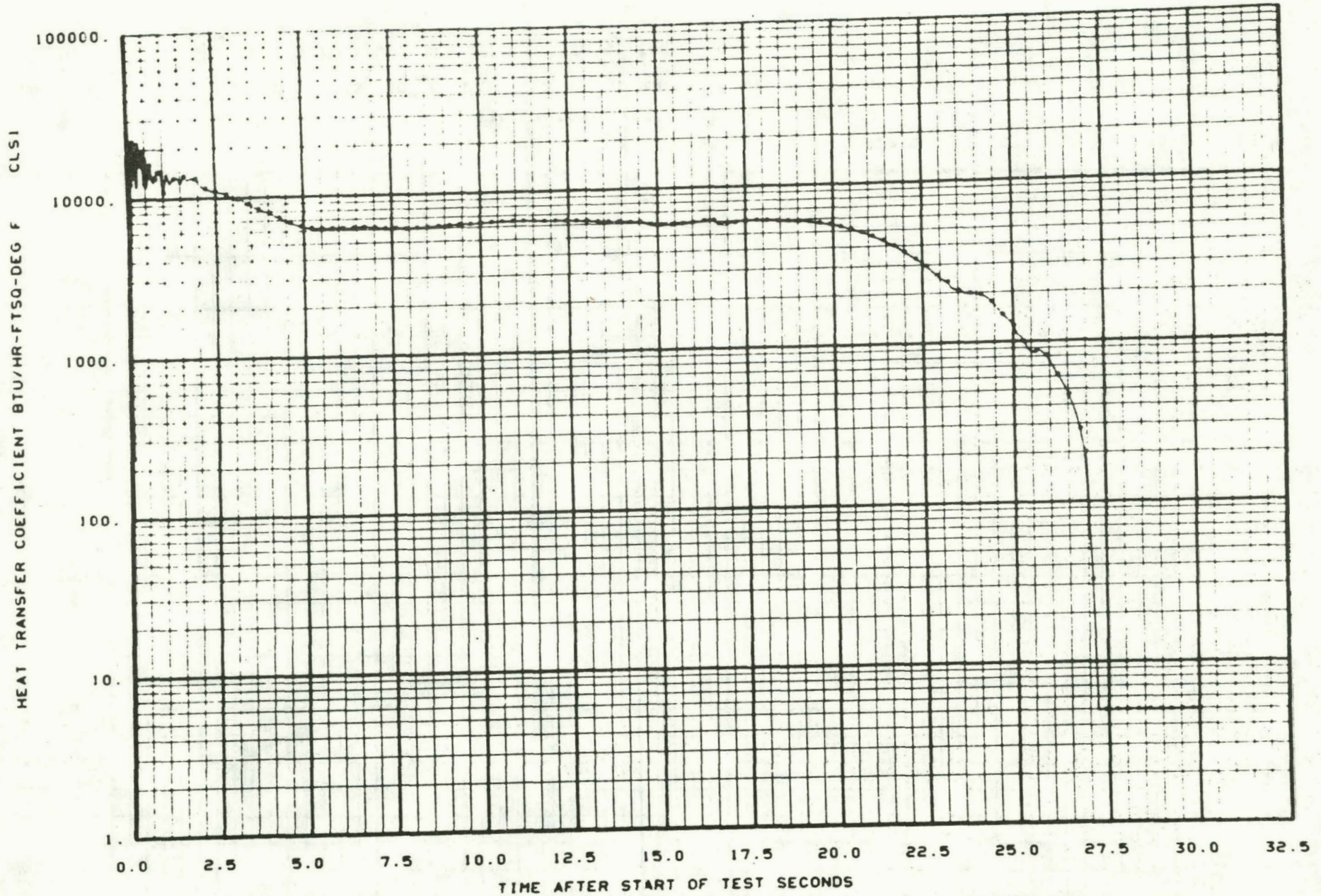
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Fig. A-6 Average surface temperature of the penetration nozzle flange.

A-14



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Fig. A-7 Heat transfer coefficient for the inside surface of the penetration nozzle flange

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A-15

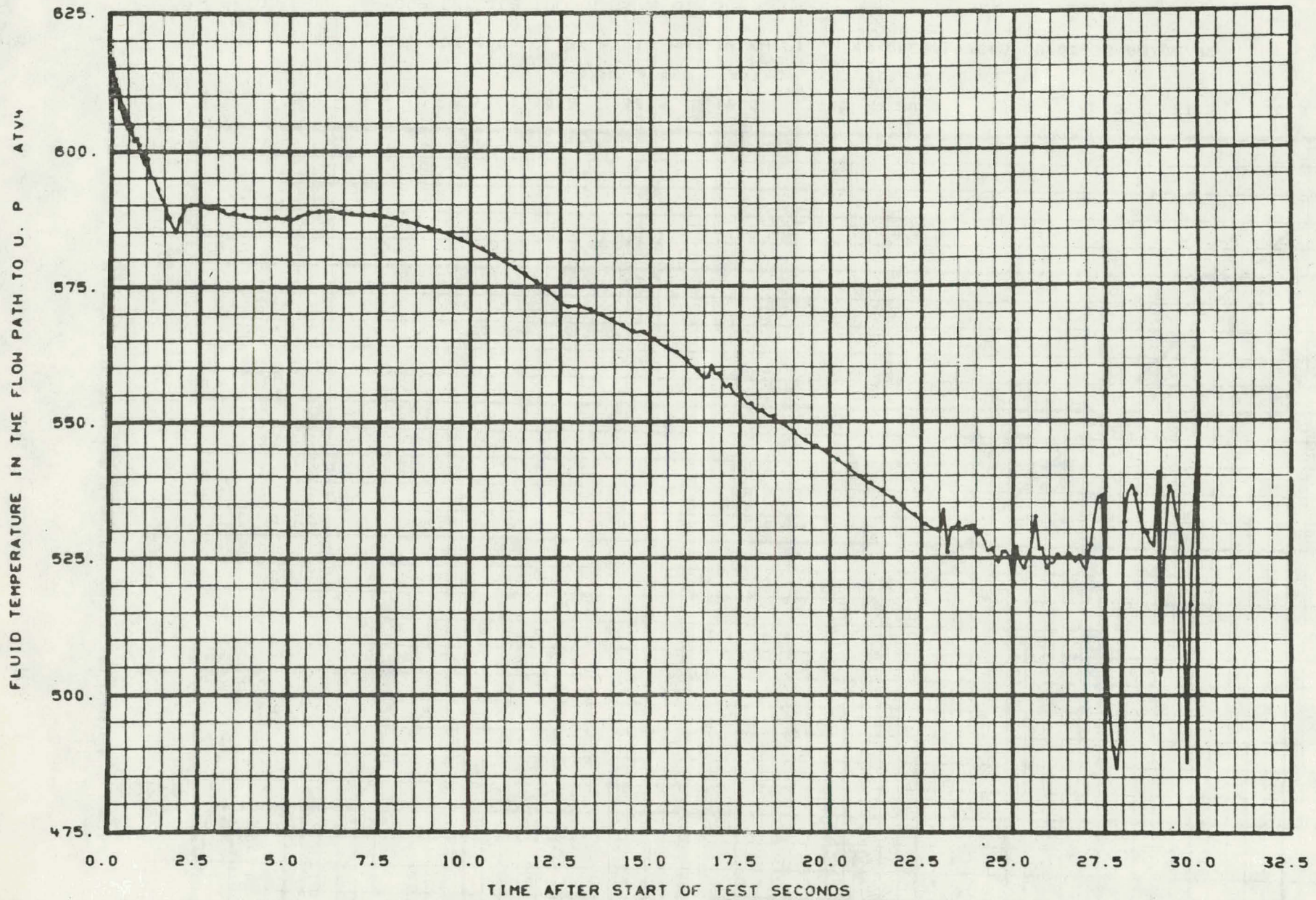
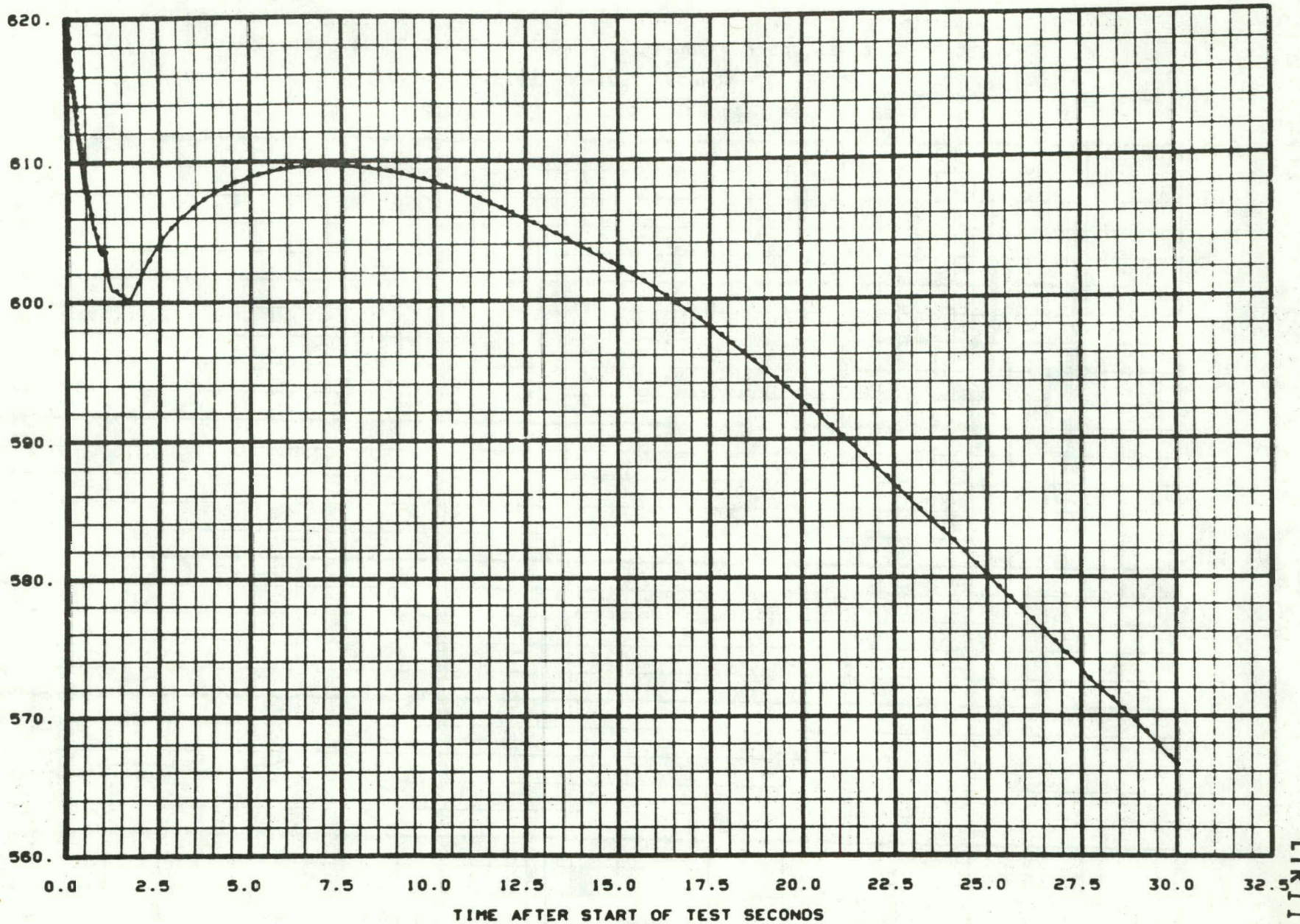


Fig. A-8 Average fluid temperature in the flow path between the instrumentation stalk and the upper plenum.

XX-ORELAP4/C05 09/03/76 02/02/78

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RIGHT SIDE SURFACE TEMPERATURE SLAB 3 DEG F SRS3



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Fig. A-9 Average surface temperature of the outside surface of the instrumentation stalk.

A-17

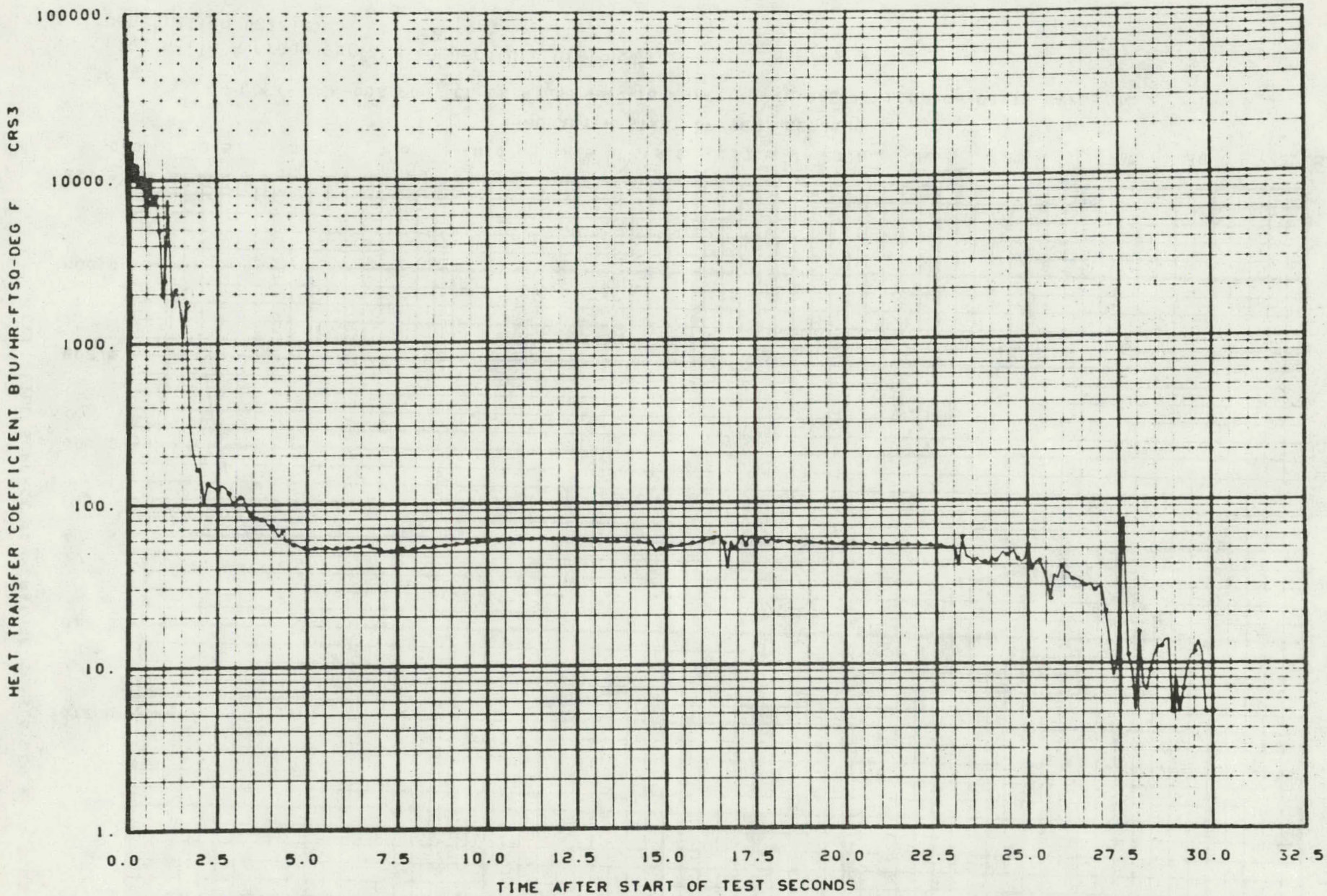
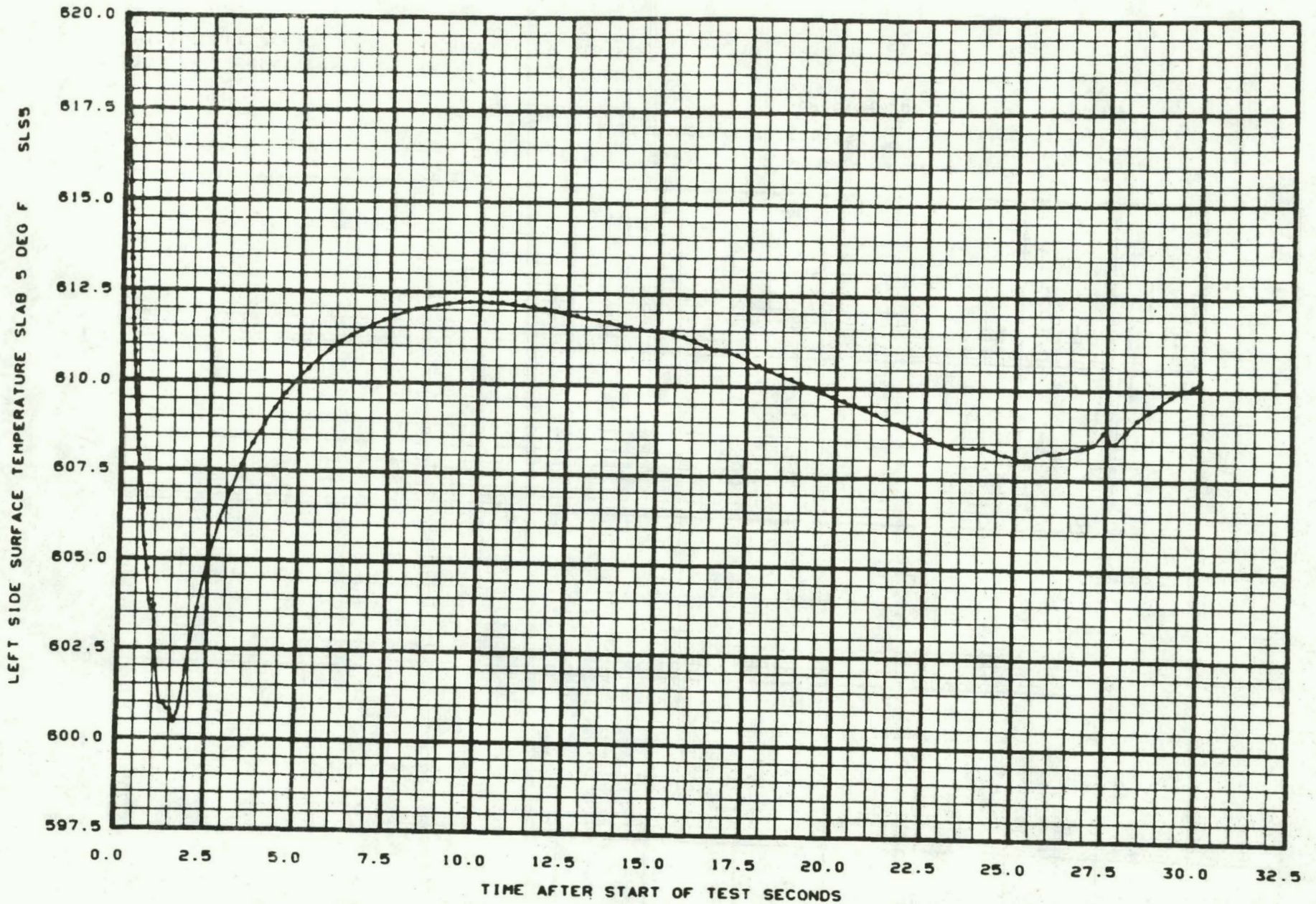


Fig. A-10 Heat transfer coefficient of the outside surface of the instrumentation stalk.

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Fig. A-11 Average surface temperature of the penetration nozzle.

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A-19

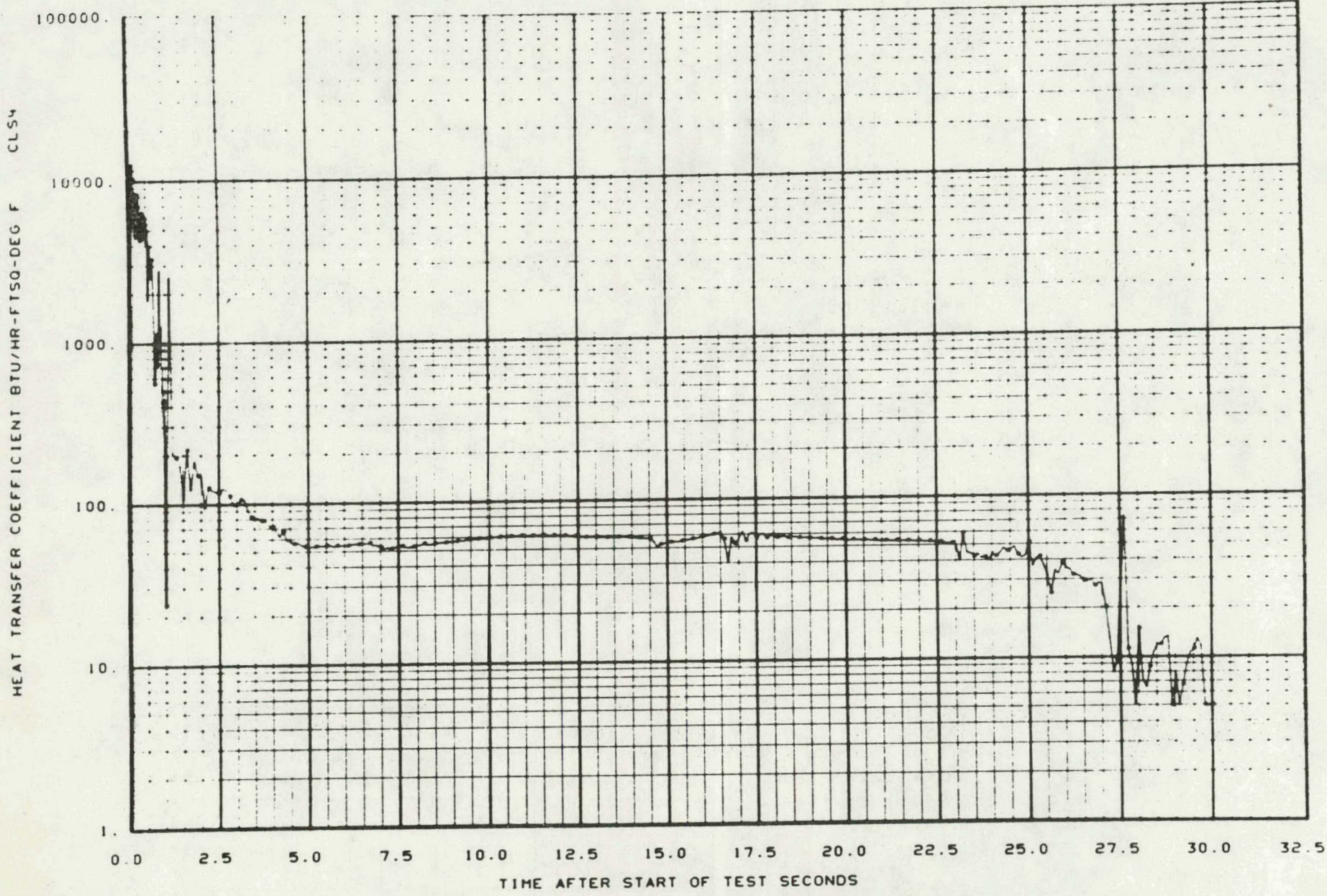


Fig. A-12 Heat transfer coefficient for the penetration nozzle.

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=LOFT-NUCL-007 200: CL BK 47.13 MW 16 KW/FT YX-010-XY

*
*-----SEPERATE EFFECTS MODEL OF THE UPPER HEAD PENETRATION
* AND INSTRUMENTATION STALK DURING A BLOWDOWN TEST
*
* ** THE TEST SIMULATED IS -- L2-4 -- **

*
*-----LOMP NTC NVGL ATDV NPMPC VKL NSL NMAT NHTX
* NEDI NTRP NBUS NUUV NCKV WELL NGOM NCOR ISPROG
010001 -2 9 3 2 4 0 0 0 0 0 0 5 4 2 0 0 0

*
* POWER GENERATION AND SOLUTION METHOD

010002 J.0000 1.0

*
* 9 MINOR EDIT VARIABLES

020000 AT 2 CR 1 CL 1 SR 1 AT 3 CR 5 CL 5 SR 5 AP 2

*
* 25 WATER PACKING EDITS PER VOLUME PRINTED

030000 25

*
* TIME STEP CONTROL CARDS

	MINOR	PRINT	DTMAX	INTERVAL	
	MAJOR	REST	DTMIN		CPU TRIP
030010	5	4	1	0.001	100.00
030020	5	4	1	0.002	2.0
030030	10	10	1	0.005	40.0

*
* TRIP CONTROL CARDS

040010	1	1	0	0	10.000	0.000	* END ON TIME TRIP
040020	2	-4	4	0	100.000	1.000	* END ON LOW PRESSURE

*
* VOLUME DATA CARDS

* BJB	PRESSURE	TEMP	VOLUME (FT ³)	HEIGHT (FT)	MXLEVEL (FT)
050011	2265.3991	617.53	19.92535573	11.60240000	11.6024000
050021	2265.3291	620.00	17.07318274	2.85000	2.85000
050031	2265.1091	620.00	10.01269737	1.30000	1.30000
050041	2265.5191	620.00	10.01602320	1.60000	1.60000

* CONTINUATION OF VOLUME DATA CARDS

* ID	FLOW AREA	DIAMETER	ELEVATION	IAMBO
050012	0.1916700	1.13960	6.756250	4
050022	0.0256431	0.02255	4.826100	0
050032	0.0101578	0.02000	6.381333	0
050042	0.0101578	0.02000	4.75000	3

* JUNCTION DATA CARDS

* VT	PLF	FLOW	ELEV	K(F)
VF	VAL	FLOW AREA	INERTIA	K(P)
030011	3 0 0	0.0000	0.1000000	7.6761 117.1 5.010 4.510
030021	3 4 0	0.0000	0.0101578	6.38133 130.5 0.000 0.000
030031	4 1 0	0.0000	0.0101578	4.7500 00.0 1.110 1.610

* CONTINUATION OF JUNCTION DATA CARDS

* JVRT	JCALC	DIAMETER	ICHO	SPCOS
JCHO	MVHX	CONCO	HACCP	ADJJ
030012	1 5 0 0	0.11284	0. 11 0	1.00 0
030022	1 5 1 1	0.020	0. 11 0	1.00 0
030032	1 5 0 0	0.020	0. 11 0	1.00 0

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5 HEATS - SLABS

IXL

	VL	VR	G	X	LC	RC	L HTA	R HTA	VOLS	L HYDIA
150011	2	3	1	0	0	0	0.334088	0.00000	0.0085221	0.020225
150021	2	3	2	0	0	0	0.869214	1.476156	0.0754675	0.020225
150031	2	4	2	1	0	0	0.773168	1.312138	0.0670777	0.020255
150041	3	3	1	0	0	0	1.350080	0.00000	0.133752	0.020
150051	4	3	4	0	0	0	1.571796	0.00000	5.201470	0.020

CONTINUATION OF THE HEAT SLAB DATA CARDS

	R HYDIA	L EQDIA	R EQDIA	L CHAN	R CHAN	Z BOT	Z TOP
150012	0.000	0.020255	0.000	2.91667	0.00000	0.000	0.000
150022	0.000	0.020255	0.020	2.91667	2.91667	0.000	0.000
150032	0.020	0.020255	0.020	2.91667	2.91667	0.000	0.000
150042	0.020	0.020	0.000	2.91667	0.00000	0.000	0.000
150052	0.000	0.020	0.000	2.91667	0.00000	0.000	0.000

HEAT SLAB GEOMETRY DATA CARDS

170101	1	1	1	5	1.0506	0.250	0.000	* INCONEL 600
170201	2	1	1	5	0.0922917	0.0643333	0.000	* INCONEL 600
170301	2	1	1	5	0.1666667	0.06375	0.000	* INCONEL 600
170401	2	2	1	5	0.1666667	0.06375	0.000	* INCONEL 600
170402	2	2	2	10		0.8333333	0.000	* CARBON STEEL

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 * MATERIAL PROPERTIES DATA CARDS *
 *

* THERMAL CONDUCTIVITY DATA *
 *

* INCONEL 600 *
 *

	NPTS	DATA (T)	DATA	DATA (T)	DATA	DATA (T)	DATA
190101	-6	100.	8.55	300.	9.58	600.	11.15
190102		1100.	13.65	1600.	15.20	3600.	26.30

* CARBON STEEL *
 *

	NPTS	DATA (T)	DATA	DATA (T)	DATA	DATA (T)	DATA
190201	-9	70.	31.50	200.	30.00	400.	28.10
130202		600.	26.20	800.	24.30	1000.	22.40
130203		1200.	20.50	1400.	18.70	1500.	17.70

* HEAT CAPACITY DATA *
 *

* INCONEL 600 *
 *

	NPTS	DATA (T)	DATA	DATA (T)	DATA	DATA (T)	DATA
190101	-9	100.	57.13	400.	61.14	600.	63.77
190102		800.	66.41	1000.	69.57	1200.	73.79
190103		1400.	76.42	1600.	79.53	3600.	99.61

* CARBON STEEL *
 *

	NPTS	DATA (T)	DATA	DATA (T)	DATA	DATA (T)	DATA
190201	-7	130.	64.33	350.	60.80	450.	62.60
190202		530.	65.2	600.	67.20	710.	70.20
190203		800.	77.50				

END OF DATA DECK