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PRE-TEST EVALUATION OF LLTR SERIES II TEST A-7

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1.0 SUMMARY

The purpose of this report is to present pre-test predictions of pressure histories for the A-7 test to be conducted in the Large Leak Test Rig (LLTR) at the Energy Technology Engineering Center (ETEC) in April 1981.

Pressure Prediction

Table 1 contains predictions of peak pressure at points near test pressure transducer locations. The maximum predicted pressure was 572 psia occuring in the LLTV. The predicted pressure histories at points near pressure transducer locations are presented in Figures 13-39.* A summary of the rupture disc parameters is presented below.

Rupture Disc Prediction - See Summary Below

RUPTURE DISC PREDICTION				
Parameter	1st Rupture Disc		2nd Rupture Disc	
	Pressure ∿ psia	Time ∿ msec	Pressure ∿ psia	Time ∿ msec
Start of Buckling	345	2.4	377	65.4
Contact with Knife Edges	70	8	92	69

Comparisons between the A-2 post test predictions and the A-7 pretest predictions are given in Figures 40-53 and discussed in Section 4.4.

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* The pressures in these figures are absolute pressures, i.e. psia.

TABLE 1

PEAK PREDICTED PRESSURES

LLTR TEST A-7

LOCATION	NEAREST PRESSURE TRANSDUCER	PEAK PRESSURES (PSIA)			
		1st Peak	Time, ms.	2nd Peak	Time, ms.
Upper LLTI	PT - 02 - 1 & 2	453	3.3	480*	4-12
↓	PT - 01 - 8	462	2	473*	4-12
	PT - 01 - 7A&7B	538	1.7	478	4-12
↓	PT - 01 - 2	270	1.5	475	3.8-12
Lower LLTI	PT - 01 - 5	512	1.2	435	2.8-12
↓	PT - A - 10	471	1.7	462	5.2
Upper LLTV Wall	P-614	479*	3-11	303	19.8
↓	P-615	461*	4.4-9.2	273	10.4-12.4
Mid LLTV Wall	P-616	480*	4.4-9.2	428	10.5
↓	P-617	396	1.2	485	10.2 6-8
	P-618	572	1.2	434	4.4-9.2
Lower LLTV Wall	P-619	464*	1.4	438	8.7
Sodium Piping	P-507	493	6-15	473	21
↓	P-508	493	5.14	386	21
	P-509	493	4-8	465	19-24
	P-510	487	17.6	287	17.6
	P-516	455*	8.8	245*	17.6
	P-517	516*	19.6	252	77.5
	P-519	392*	4.0	250	66
	P-520	357*	6-5	315	66.6
	P-521	436	5.8	372	68
	P-524	489	15-22	298	76
↓	P-525	346	3.4	377	65.4
1st Rupture Disc	-	337	3	386	65.3
Rupture Disc Cavity	-	-	-	347	65.3

* Prior, intervening and/or subsequent peaks of similar magnitude also present

2.0 INTRODUCTION & OBJECTIVES

This report presents a pre-test evaluation of Test A-7, which is the sixth test in the Series II Large Leak Test Program being performed at the Energy Technology Engineering Center. This test program is being conduted to evaluate the effects of intermediate size to large size leaks produced by a double-ended guillotine (DEG) rupture of a single tube. Test A-1a and A-1b were inert gas injection tests of the DEG size and were conducted in July 1979 and October 1979, respectively. The GE evaluation of these tests is reported in Reference 1. The balance of Series II tests are sodium-water reaction (SWR) tests beginning with the DEG size leak Test A-2, which was conducted in February 1980 (reported in Reference 2). The test article employed in Series II simulates the CRBR steam generator but is of shorter length.

The principal objectives of the Series II program (Reference 3) are to define the potential for secondary tube failures in order to establish a basis for selection of design basis leaks (DBL's), to determine experimentally the peak pressures produced from large leak events and to provide data for confirming or modifying design analysis methods.

The specific benefits of Test A-7 are as follows:

(1) The test will show the effects of elevated sodium pressure at the initiation of the DEG on CRBR prototypical double rupture disc performance and sodium system pressures. Elevated initial sodium pressures could be expected if a small leak of some duration were to precede the DEG.

(2) The test allows comparison of non-reactive and reactive effects (A-1b versus A-7).

(3) The test provides data for comparison with smaller vessel (i.e., Series I, Test SWR-2) to gain an insight into vessel diameter scaling effects.

(4) The test provides additional data to confirm the Large Leak Standard Methodology presented in Reference 4.*

This report provides a pre-test prediction of the thermal-hydraulic phenomena associated with the SWR events in the A-7 test.

3.0 TEST CONFIGURATION

The ETEC Large Leak Test Rig is shown in Figures 1-5.

The A-7 test configuration differs from the A-2 test configuration in the following respect:

(1) The sodium side pressure, at the initiation of the DEG, was set at 264.7 psia for test A-7 rather than at $\sim$ 150 psia for test A-2.

(2) Some minor changes were made in the water side piping. (See attachment 4.1)

(3) A number of instrumentation changes were made (See Reference 5).

(4) The A-7 leak site is 127.75" above the bottom of the LLTI shroud as compared to 122.25" above the bottom of the LLTI shroud for Test A-2 (see Figure 5A). Thus, A-7 leak site is 2 inches above Spacer #4 and A-2 leak site is 2 inches below Spacer #4.

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* But including the modification discussed in Section 4 of this report.

4.0 TRANSWRAP ANALYTICAL MODEL

The TRANSWRAP Analytical Model used in this analysis is shown in Figure 6. The analytical model used by the TRANSWRAP code differed from that used for the A-2 post test predictions in the following respects:

(1) The sodium pressure at the initiation of the DEG was set at 264.7 psia rather than ~140 psia (test A-2).

(2) The rupture disc model was changed as described in Section 4.2.

In all other respects the A-7 pre-test prediction TRANSWRAP analytical model is the same as the one used for the A-2 post test analytical predictions.

4.1 Water Flow Rates

The water flow rates from the tube break into the sodium side of the vessel are the same as those used for the A-2 test and were predicted using the RELAP 4 computer code described in Reference 6. The RELAP models used for the analysis are shown in Figures 7 (T1 Lower) and 8 (T2 upper). Figure 9 shows the postulated leak opening area history used in this and previous analyses.

The tube break was made at the same vertical location as in the A1A test (127.75" above the bottom of the lower shroud). Some minor changes have been made in the upstream water piping in the test facility subsequent to the A-2 test. These changes are not, however, reflected in the analytical model nor are they expected to significantly change the results. The resulting water flow histories predicted by the RELAP runs for the upper and lower section (divided at the break) were added to obtain the gross water flow histories into the reaction zone. The resulting water flow history was modified as follows to obtain the water flow history input into TRANSWRAP.

$$\overset{\circ}{W}_{net} = \left(\overset{\circ}{W}_{T1} + \overset{\circ}{W}_{T2} \right) * \underbrace{\overbrace{\left(\frac{1700 + 460}{2600 + 460} \right)}^{0.706} * 0.65}_{0.459}$$

into Reaction Zone — *RELAP (Lower)* — *RELAP (Upper)*

The first term in the modifying factor was to correct for reaction zone bubble temperature and the second term assumes that only 65% of the water in the LLTV reacts with the sodium. These corrections are based upon prior knowledge of the sodium water reaction and are part of the standard methodology. The water flow histories for the lower and upper sections are given in Figures 10a and 10b respectively. Comparisons of the water flow histories for LLTR Tests A-2, A-6 & A-7 are given in Figure 11.

4.2 Rupture Disc Modeling

The present analytical modeling of the phenomena associated with the rupture discs has been evolved over time by incorporating empirical parameters* into the TRANSWRAP code which were developed from the results of prior Sodium Water Reaction Tests (See Figure 12). This partial empirical treatment of the rupture disc phenomena was further refined to correlate the results of the A-2 test. In addition, subsequent to the publication of the A-2 Test Report, the rupture disc model was changed from an elastic model to an elastic-plastic model. The elastic-plastic rupture disc model used was taken from the SWAAM computer code which is described in Reference 8. All of these changes have been preserved in the TRANSWRAP model of the rupture disc phenomena used for the subject A-7 pre-test predictions. The values used for the various rupture disc parameters, including the empirical parameters, are given in Table II.

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* The empirical parameters used are identified in reference 7.

TABLE II

RUPTURE DISC MODEL PARAMETERS - ETEC LLTR TEST SERIES

PARAMETER		VALUE OF PARAMETER USED FOR	
Type of Disc Model		First Disc Elastic-Plastic	Second Disc Elastic-Plastic
Diameter	(in)	18	18
Radius of Curvature	(in)	12.675	12.675
Knife to Disc Clearance	(in)	1.5	1.5
Disc Thickness	(in)	.060	.060
*Open Area Fraction	(PARD)	.50	0.6
*Recovery Pressure(HHOLD)	(psi)	150	135
*Hold Time (TØPEN-RISETH)	(sec)	.025	.002
*Rise Time (RISETH)	(sec)	.010	.003
*Tearing Time(TMØPEN1)-Disc 1 (TIMØPEN)-Disc 2	(sec)	.014	0.012
Young's Modulus	(psi)	29.2×10^6	29.2×10^6
Poisson's Ratio		0.320	0.323
Density	(lbm/ft^3)	512	512
Plastic Modulus	(psi)	2.9×10^5	2.9×10^5
Yield Stress	(psi)	5.25×10^4	4.75×10^4
Ultimate Stress	(psi)	9.3×10^4	9.3×10^4
Number of Finite Elements		20	20

*Empirical Parameter used in Rupture Disc Modeling.

4.3 Reaction Zone Modeling

The transition between a spherical and cylindrical reaction zone bubble was arbitrarily set to take place during the first calculation time step. This was done to avoid fictitious bubble shape transition pressure spikes being introduced into the analytical model.

4.4 Comparison with A-2 Post Tests Predictions

The difference in the TRANSWRAP analytical models between A-2 and A-7 were in the initial sodium pressure assumed and in the type of analytical model used for the rupture disc (i.e., elastic-plastic for A-7 versus elastic for A-2).

Initial Sodium Pressure

Raising the initial sodium pressure as expected reduced the time from the DEG until the first disc buckles from 4.6 msec to 3.3 msec. Slightly higher LLTI and LLTV maximum pressures were predicted by the A-7 model reflecting the higher initial system pressure.

RUPTURE DISC MODELS

Buckling Pressure

When using the elastic rupture disc model for A-2 it was necessary to reduce the disc thickness (e.g., 0.0495 inches as compared to the actual 0.06), in order to reduce the buckling pressure. Even so the predicted buckling pressure was still considerably higher than the measured (e.g., 425 psia predicted vs. 335 psia measured 1st disc; 598 psia predicted vs. 385 psia measured 2nd disc), see figure 53. In the A-7 Pretest prediction the actual rupture disc thickness (0.06") was used and with the elastic plastic rupture disc model buckling pressures of 345 psia and 377 psia were predicted for the first and second rupture discs respectively. See figure 53.

Second Disc Loading

Also the pressure loading of the second disc was much more rapid as was its unloading. The A-2 test data indicates that the loading and unloading of the second disc is actually slower than predicted using the elastic-plastic rupture disc model. This may be caused by the assumption of adiabatic (i.e., no heat transfer) compression of the gas in the rupture disc cavity rather than a isentropic[1] (i.e., constant temperature) which if used would change the exponent in the perfect gas equation of state from 1.7 to 1.08, which could be expected to reduce the pressurization and depression rates for the second disc.

The rate at which the pressure loading and unloading of the second disc takes place will have an effect on the predicted piping loads with lower loading and unloading rates expected to result in lower piping forces.

5.0 RESULTS

In Table III the locations of the points and figure numbers where the pressure history predictions are plotted are presented along with the identification and locations of the nearest test pressure transducers.

Also in Table III the last column identifies the figure numbers where comparisons are made between the A-7 pretest pressure history predictions and the A-2 Post test predictions and test results. The comparisons are discussed in section 4.4 above.

All predicted pressures are in pounds per square inch absolute while the test results are given in pounds per square inch gage.

The early sharp drop in LLTI/LLTV predicted pressures near the leak site are thought to be caused by numerical instability in starting the transient and not reflective of any real phenomenon(s).

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[1] or a polytropic relation in between those limits.

TABLE III

TRANSWRAP MODEL VS A7 TEST PRESSURE TRANSDUCER LOCATIONS

PRESSURE TRANSDUCER NUMBER	TUBE NUMBER OR LOCATION	PRESSURE TRANSDUCER LOCATION: ELEVATION ABOVE BOTTOM OF SHROUD ~ INCHES	PRESSURE TRANSDUCER LOCATION: RADIAL LOCATION ~ INCHES	PRESSURE TRANSDUCER LOCATION: FIG. NO. (SHOWING TRANDUCERS LOCATION)	NEAREST TRANSWRAP OUTPUT LOCATION: PIPE NUMBER	NEAREST TRANSWRAP OUTPUT LOCATION: NODE NUMBER	NEAREST TRANSWRAP OUTPUT LOCATION: TYPE OF PIPING	NEAREST TRANSWRAP OUTPUT LOCATION: ELEVATION OF TRANSWRAP NODE ~ INCHES	PREDICTED PRESSURE HISTORY FIGURE NUMBER	PREDICTED PRESSURE* HISTORY A-7 COMPARED W/ PREDICTED & MEASURED PRESSURE HISTORIES A-2 FIGURE NO.
PT-02-1	4059	315.25	4.88	5	12	6	LLTI	314.84	13	
PT-02-2	4146	315.25	17.09	↓	12	6	↓	314.84	14	
PT-01-8	4006	243.25	6.1		10	3		243.91	15	
PT-01-7A	2176	195.25	17.09		9	4		194.76	16	
PT-01-7B	4188	195.25	16.79		9	4		194.76	17	
PT-01-2	2107	101.00	8.55		2	4		99.11	18	40
PT-01-5	1119	51.00	11.65		3	4		55.96	19	
PT-A -10	Lower Tube-sheet Edge				4	6		4.18	20	
P-614	Vessel Wall	288.00	LLTV WALL		12	3	LLTV	288.95	21	
P-615	↓	244.00	↓		10	3	↓	245.87	22	41
P-616		172.00			8	1		168.13	23	42
P-617		120.00			2	2		116.37	24	43
P-618		72.00			3	2		73.22	25	44
P-619		40.00			4	2		38.70	26	45
P507	Sodium System Piping	N.A.	Piping Wall	3 & 4	15	4	Sodium Piping	N.A.	27	46
P508	↓	↓	↓	↓	14	6	↓	↓	28	47
P509					16	7			29	48
P510					20	7			30	
P516					18	7			31	
P517					23	2			32	
P519					28	3			33	49
P520					29	9			34	50
P521					30	11			35	51
P524					21	2			36	52
P525					31	6			37	53
Rupture Disc					31	7			38	
Rupture Disc Cavity									39	

N.A. ~ Not Applicable *Measured Pressures are in PSIG

REFERENCES

1. B. F. Shoopak, et al., "Evaluation of the LLTR Series II, A-1a and A-1b Test Results," March 1980, transmitted by GE letter XL-611-00026, March 31, 1980.

2. J. C. Whipple et al., "Evaluation of LLTR Series II Test A-2 Results," July 1980, transmitted by GE letter, XL-796-00096.

3. "LLTR Series II Test Request," GE Specification 23A2062, Revision 1, April 10, 1979.

4. J. O. Sane, et al., "Evaluation of Sodium Water Reaction Tests No. 1 through 6 Data and Comparison with TRANSWRAP Analyses Series I Large Leak Test Program," Vols. I and II, GEFR 00420, June 1980.

5. H. H. Neely, "Instrumentation Refurbishment of LLTI Post A-3 Test," ETEC Doc. #P-051E-J90-RE016 Rev. A dated, August 18, 1980.

6. "RELAP4/MOD5 A Computer Program for Transient Thermal-Hydraulic Analysis of Nuclear Reactors and Related Systems," ANCR-NERG-1335, September 1976.

7. D. E. Knittle, "TRANSWRAP II Users Manual", D. E. Knittle, "TRANSWRAP II Problem Definition Manual," both February 1981 and transmitted by GE letter XL-611-10011, February 20, 1981.

8. Y. W. Shin, "SWAAM-I: A Computer Code for Large Leak Scale Sodium Water Reaction Analysis in LMFBR Secondary Systems," ANL-79-(In Preparation).

9. J. P. Den Hartog, "Mechanical Vibrations," McGraw-Hill Book Company, New York, 1956, pages 165-166.

10. W. J. Freede and H. H. Neely, "Progress Report on LLTR Series II Test A-2 (Part II)," ETEC-TDR-80-9, May 16, 1980.

11. Personal Communication, W. J. Freede (ETEC) to J. C. Whipple (GE), June 26, 1980.

12. A. E. Miller and H. H. Neely, "Experimental Results of Sodium-Water Reaction Test No. 6," ETEC Report LMEC-TDR-78-3, February 6, 1978.

13. D. E. Knittle, "Pre-Test Evaluation of LLTR Series II Test A-6," November 1980, transmitted by GE letter XL-611-00134, November 26, 1980.

ATTACHMENT (Figure 1 thru 39)

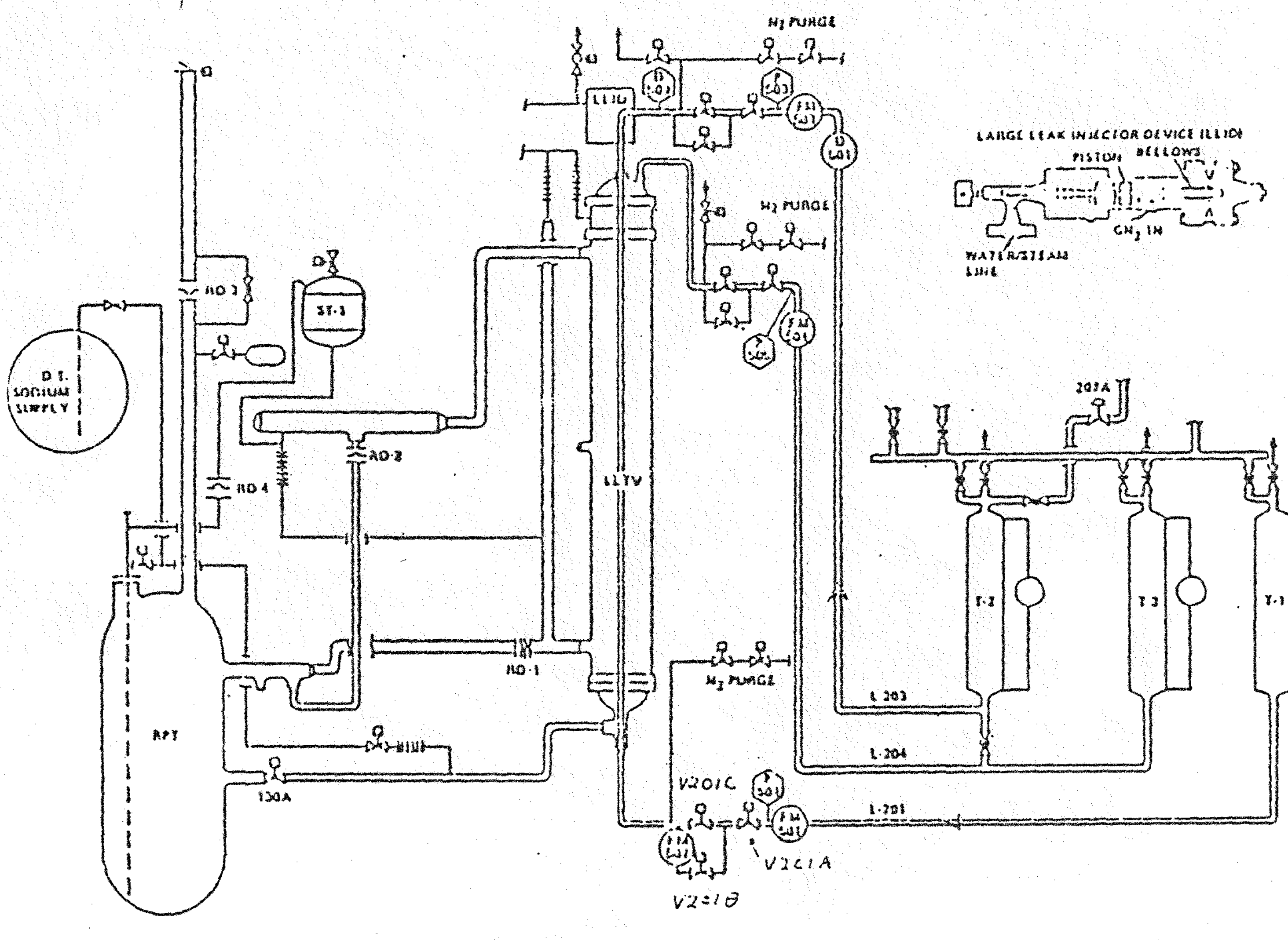


Figure 1 LARGE LEAK TEST RIG (LLTR) SERIES 2

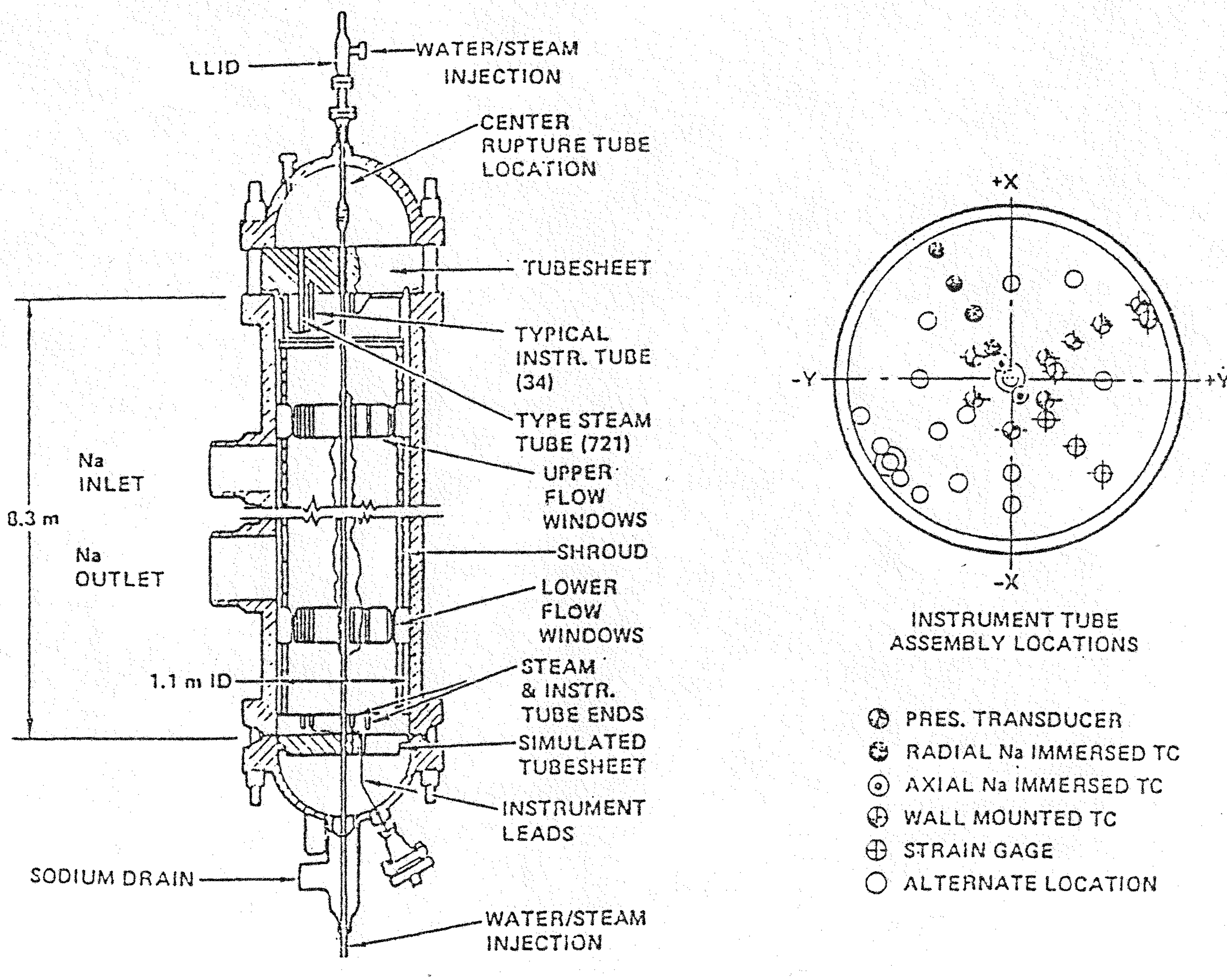


Figure 2 LLTI/LLTV ASSEMBLY

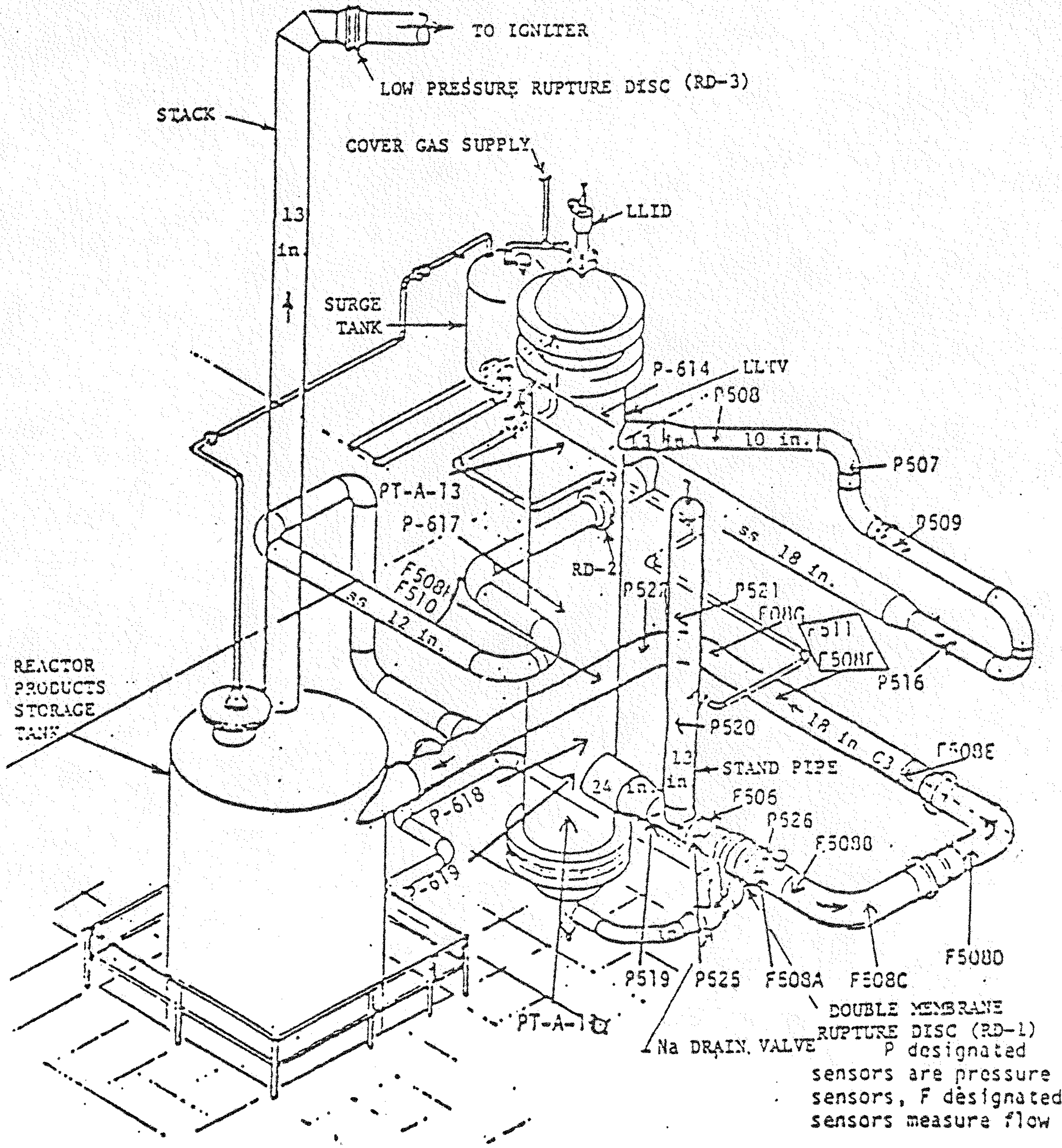


Figure 3 LLTR SODIUM AND RELIEF SYSTEMS
FLOW AND PRESSURE SENSOR LOCATIONS

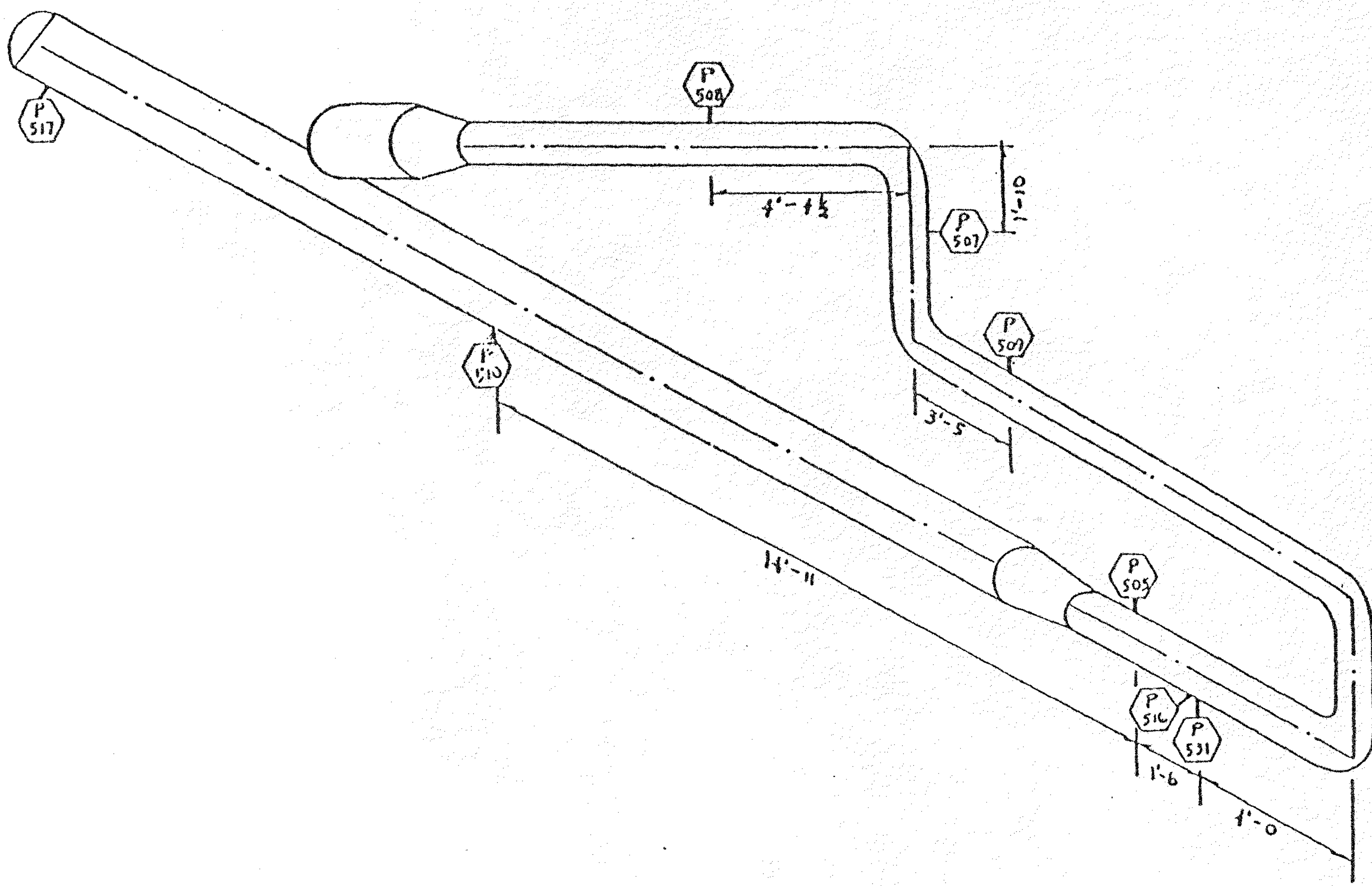
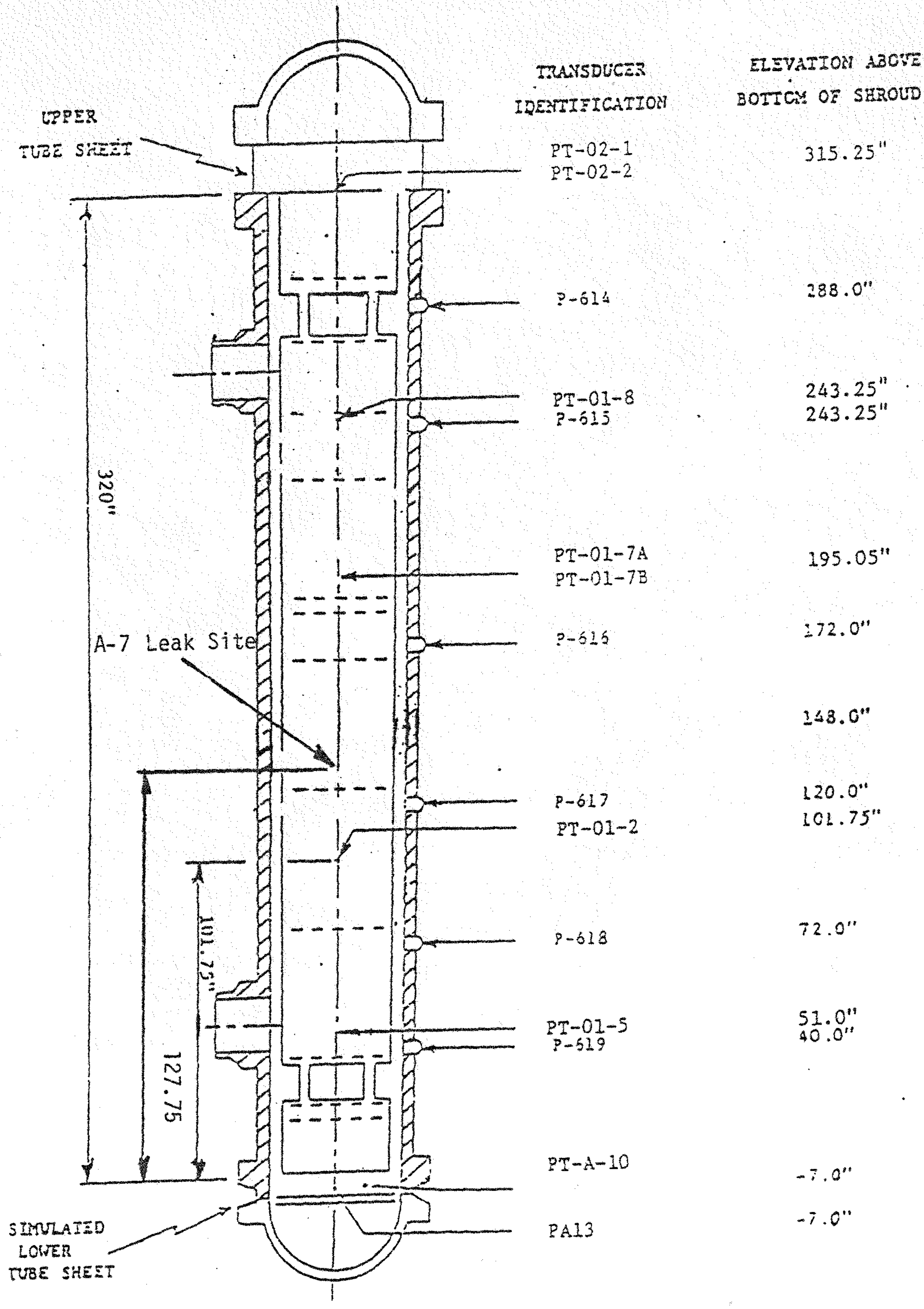


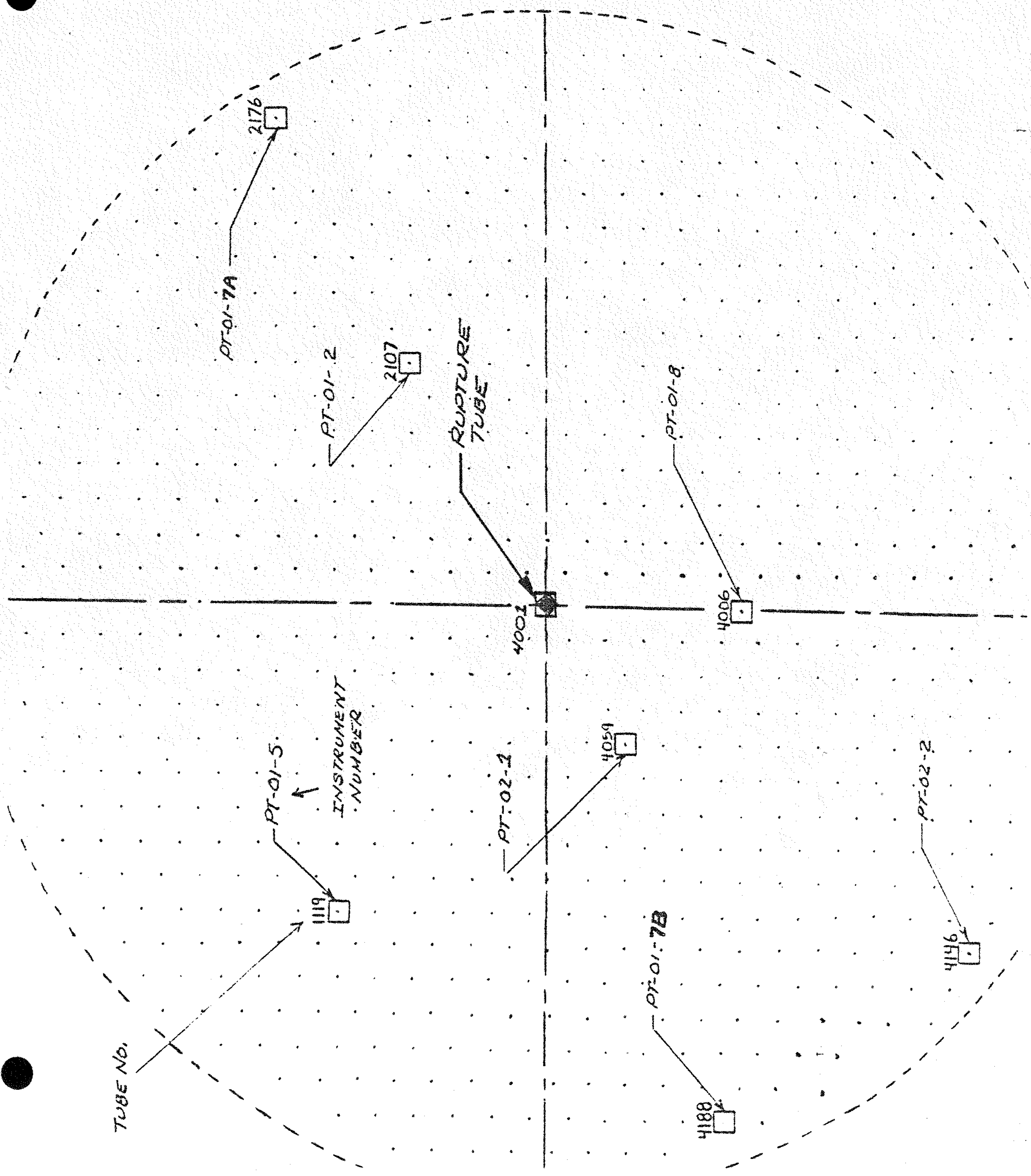
Figure 4 PIPE-LINE 107-10"-A & 106-18"-A
PRESSURE TRANSDUCERS LOCATIONS



LLTV/LLTI PRESSURE TRANSDUCER LOCATIONS

FIGURE 5A

Figure 5B LLTV/LLTI CROSS SECTIONAL PRESSURE TRANSDUCER LOCATIONS & LEAK TUBE



TRANSWRAP MODEL
FOR A-7 TEST

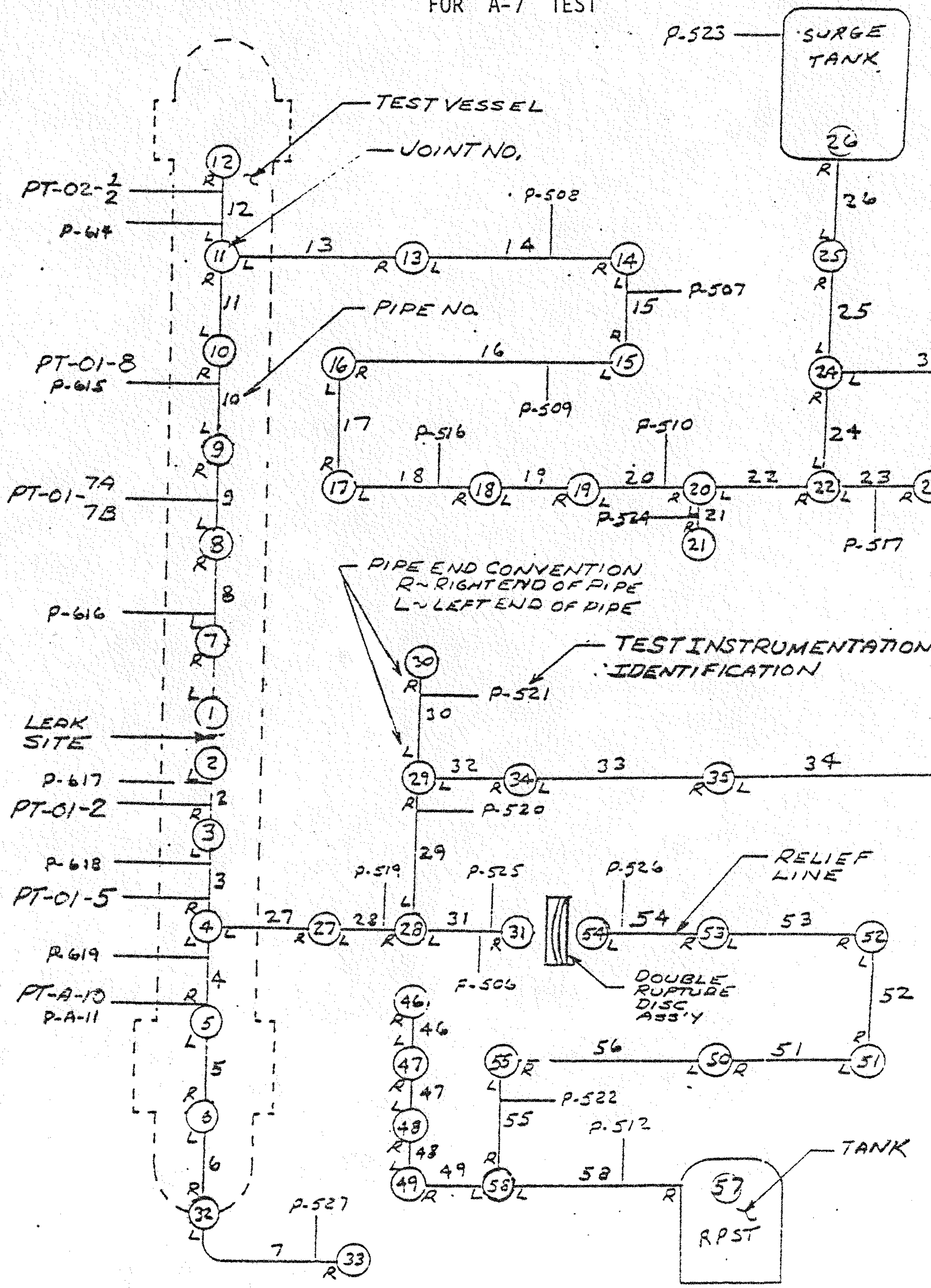


FIGURE 6

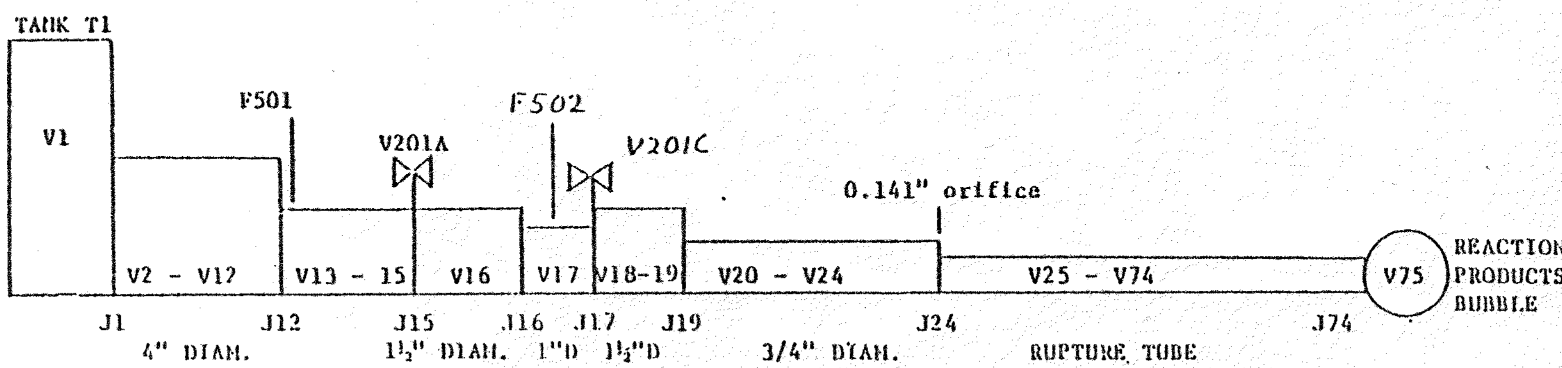


Figure 7 RELAP SCHEMATIC FOR TANK T1 SIDE OF RUPTURE TUBE = TEST A7

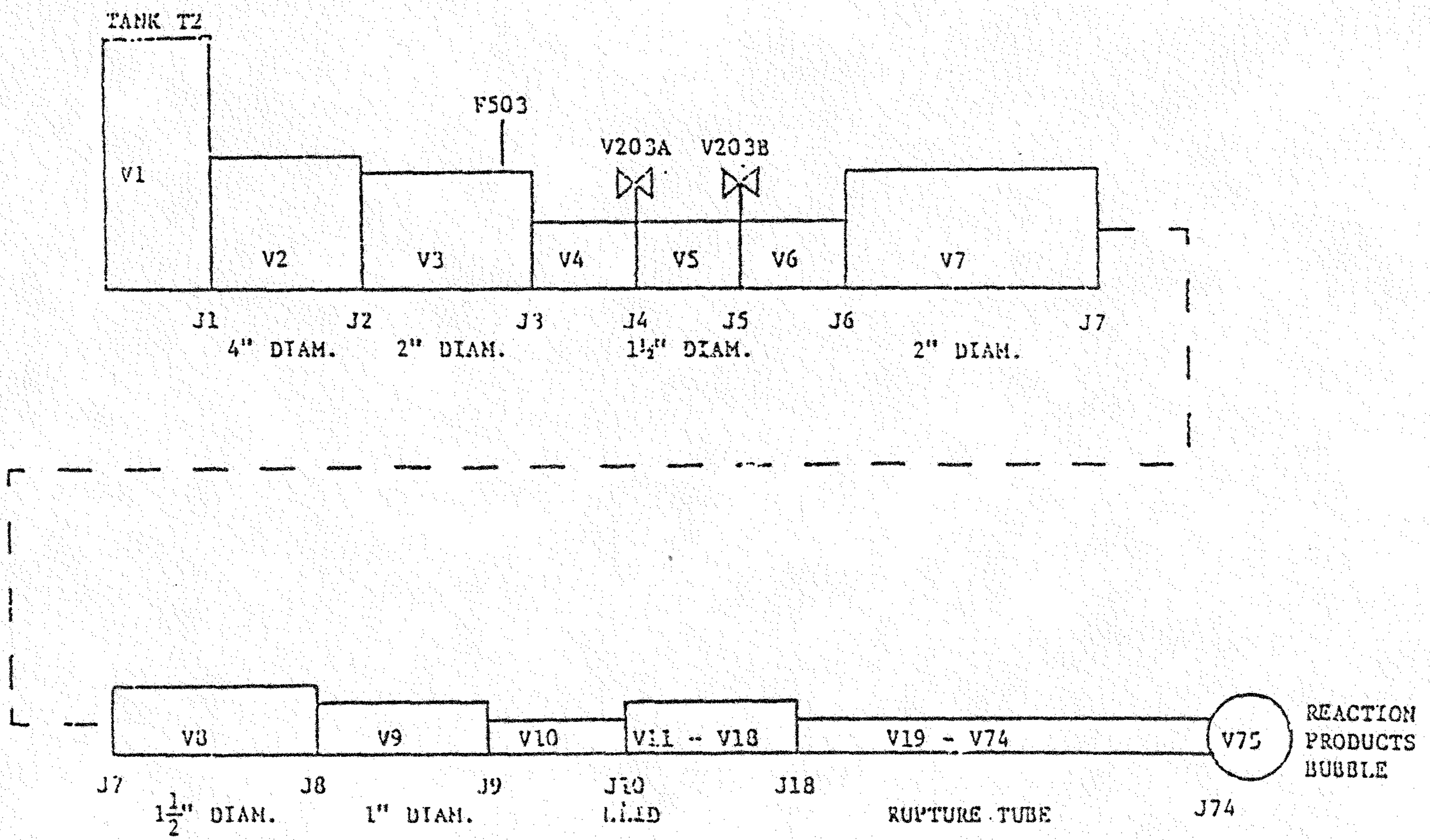
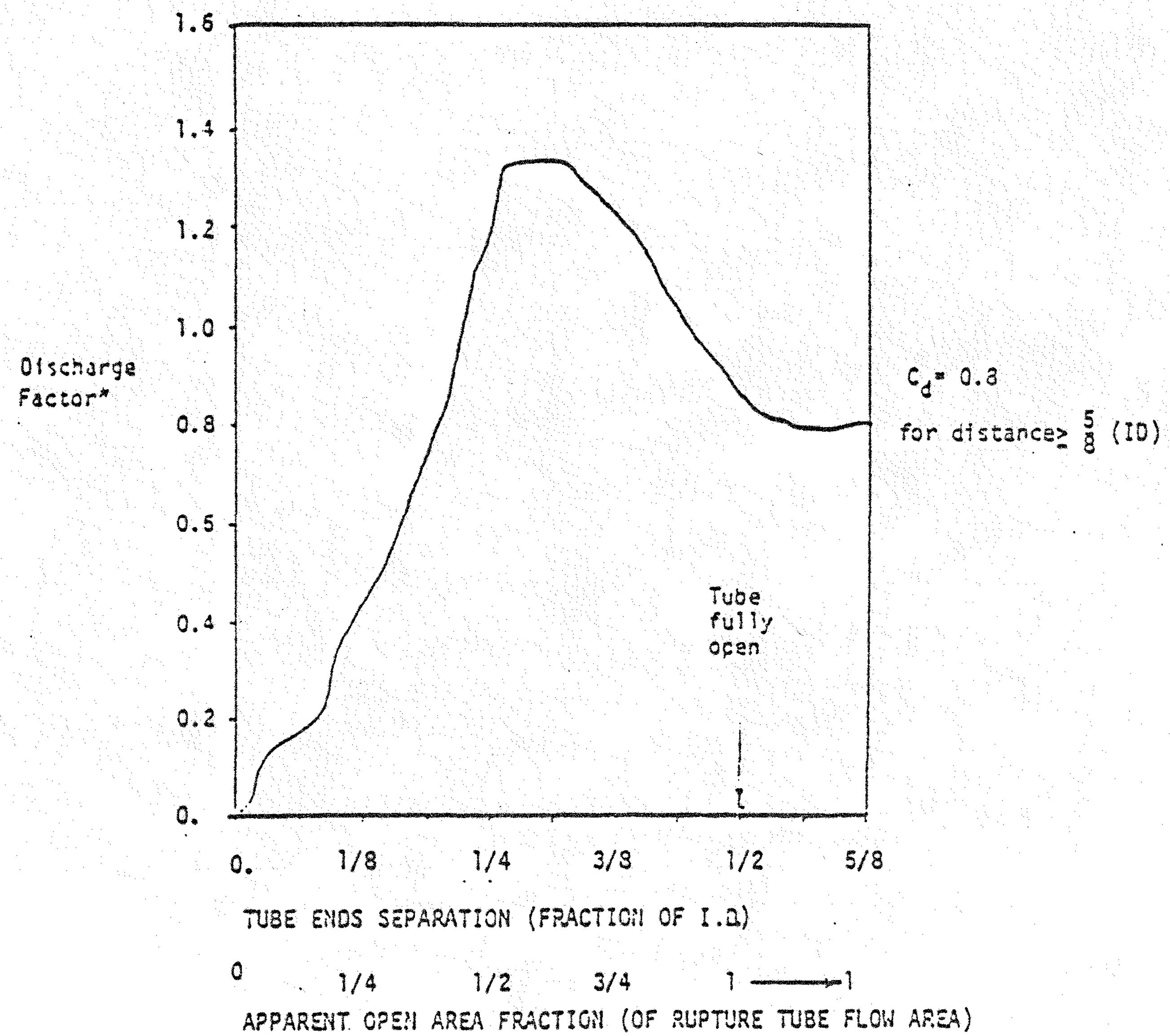


Figure 8 RELAP SCHEMATIC FOR TANK T2
SIDE OF RUPTURE TUBE - TEST A-7



*"Discharge Coefficient" of Reference 8, Vol 1, Appendix I

Figure 9 EMPIRICALLY-DERIVED DISCHARGE FACTOR FOR SWR-5 LEAKSITE

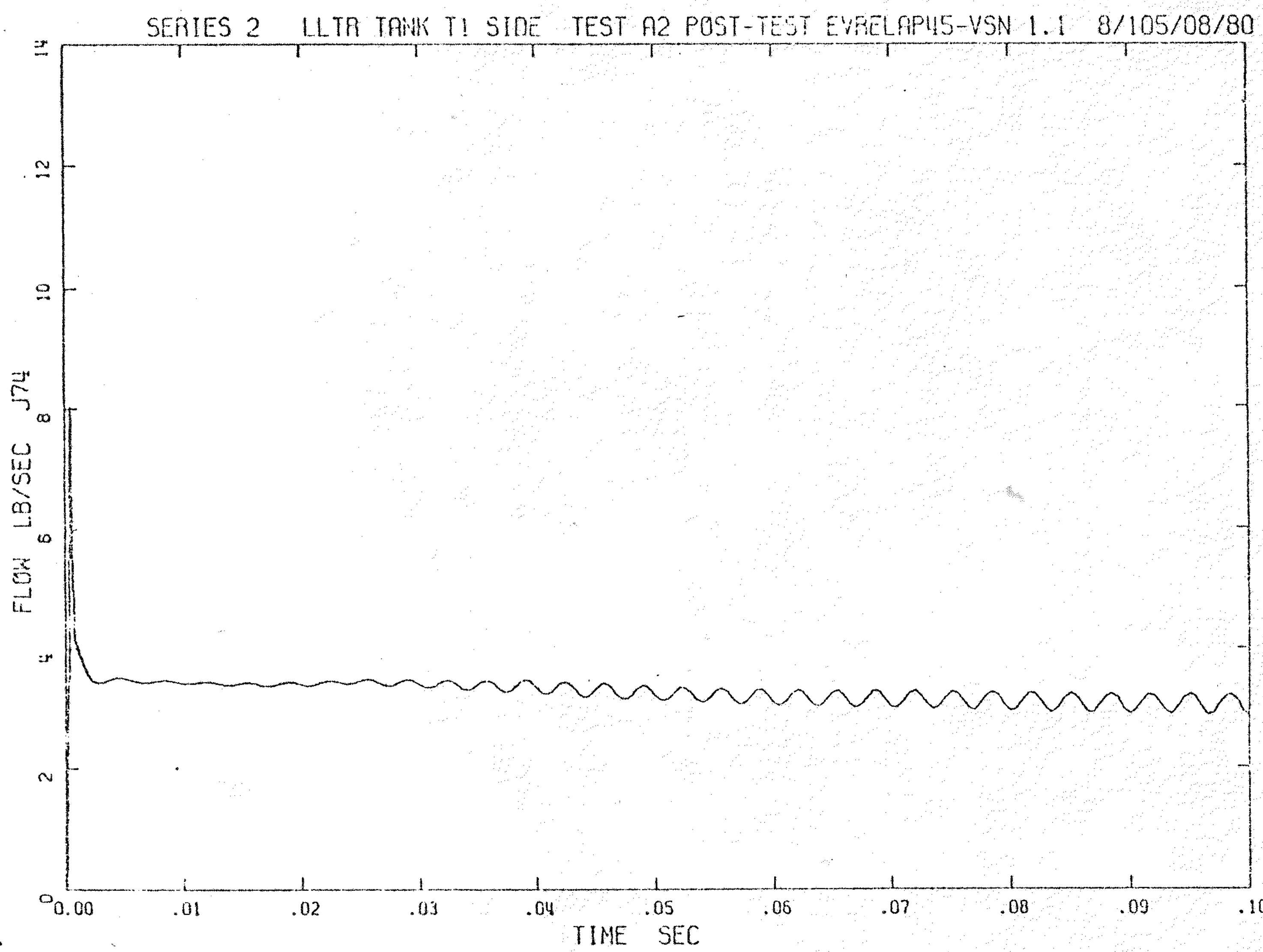


FIGURE 10a RELAP SIDE T1 BREAK FLOW RATE

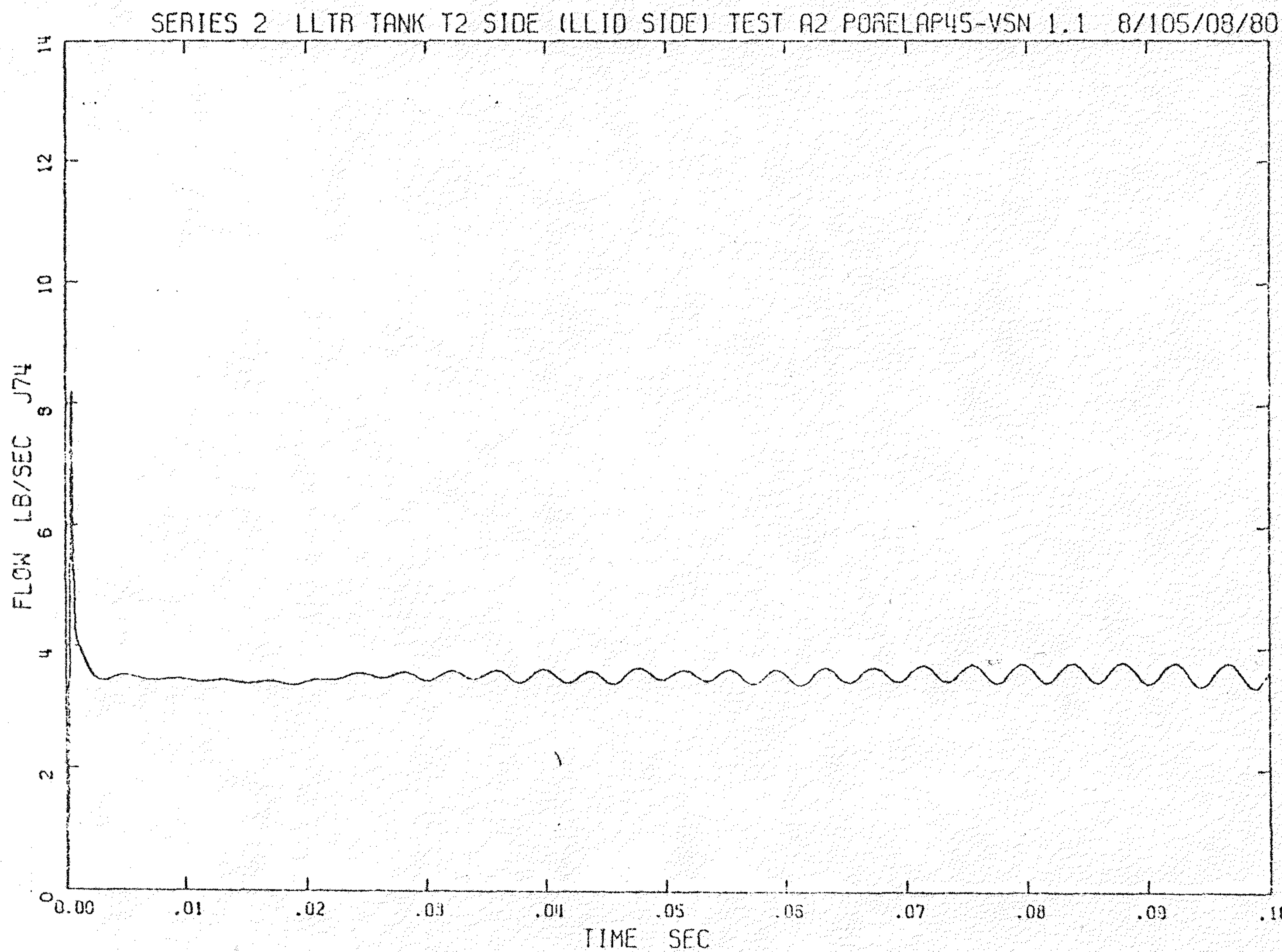
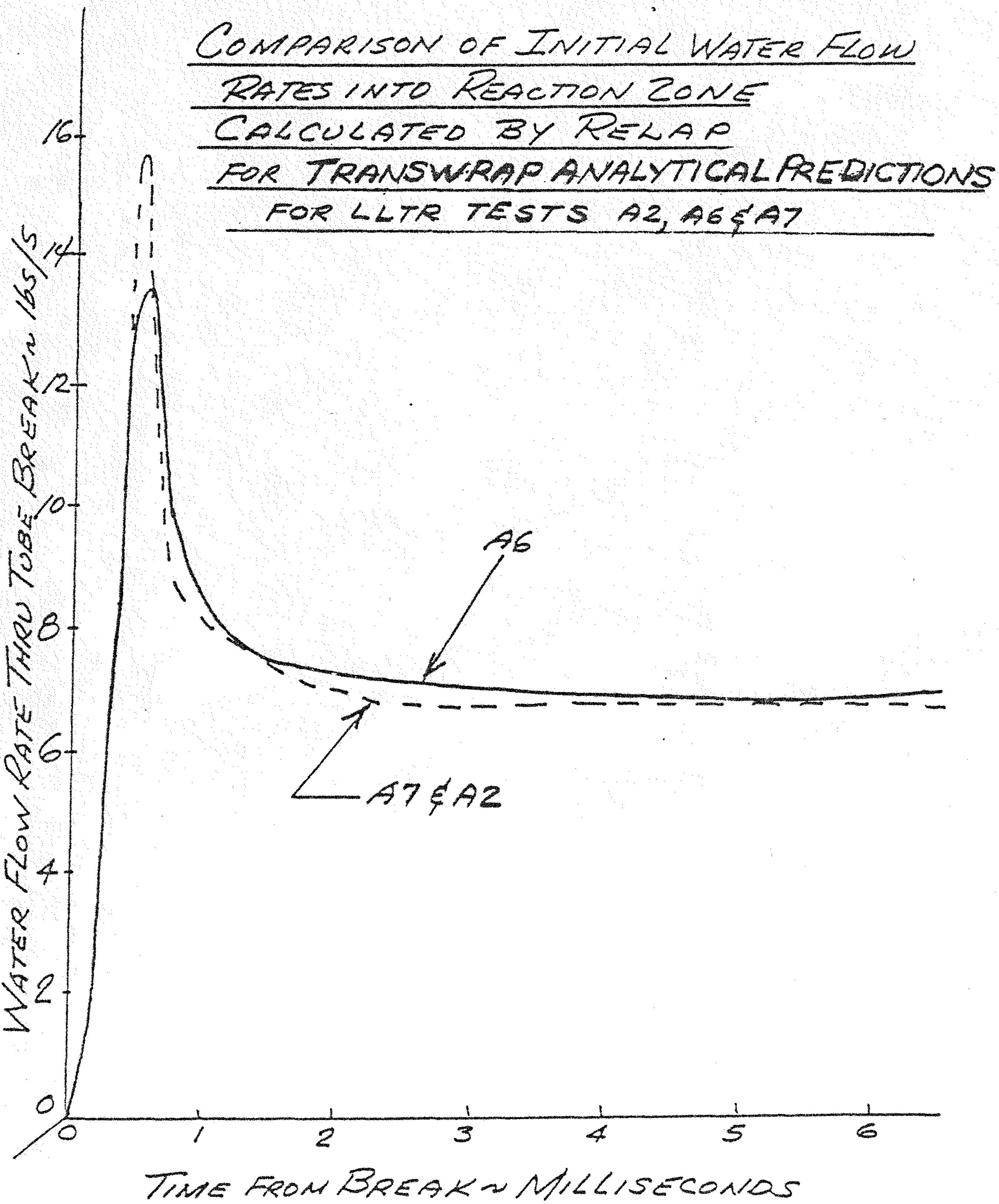


FIGURE 10b RELAP SIDE T2 BREAK FLOW RATE

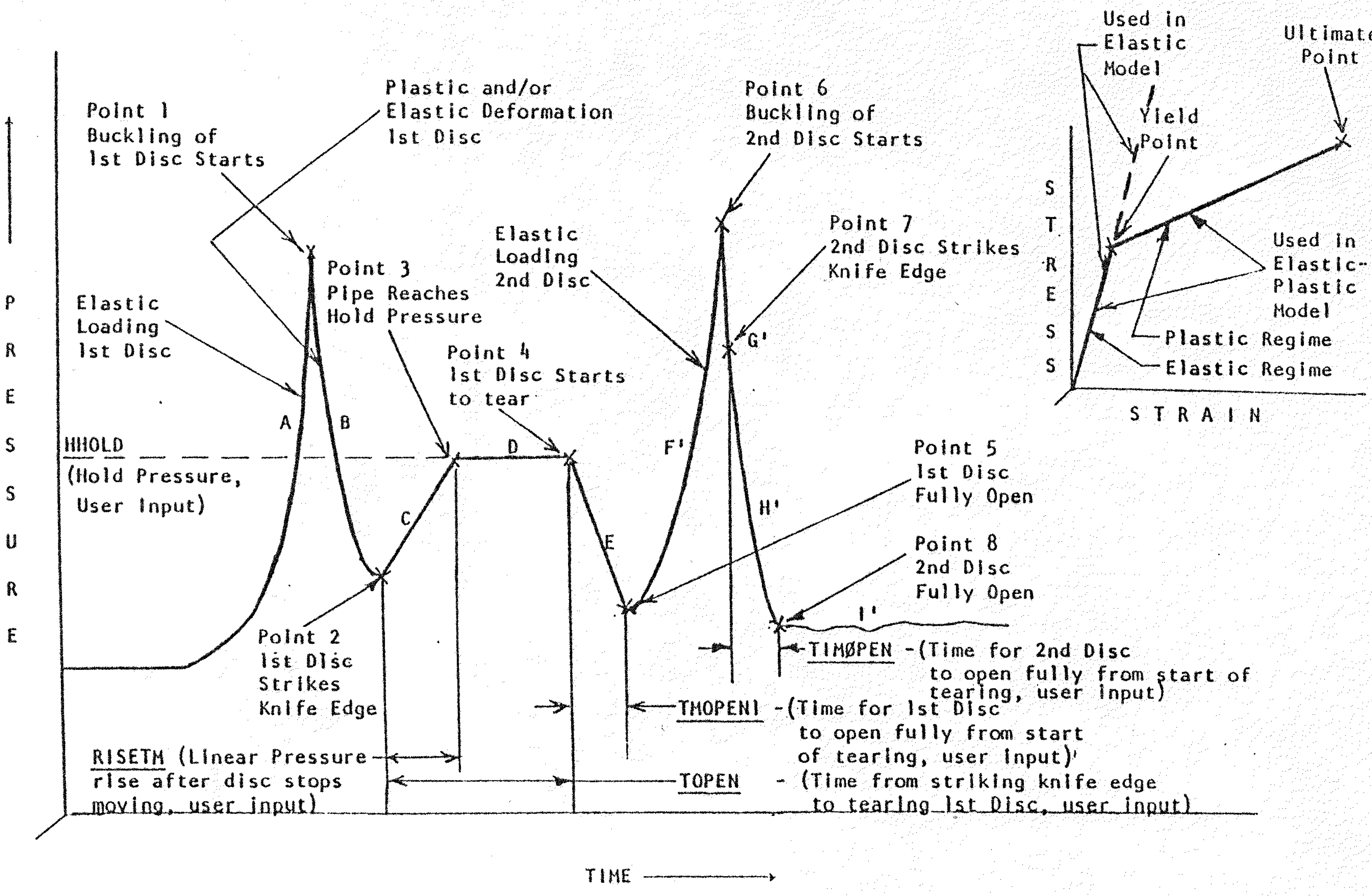


COMPARISON OF INITIAL WATER FLOW
RATES INTO REACTION ZONE
CALCULATED BY RELAP
FOR TRANSWRAP ANALYTICAL PREDICTIONS
FOR LLTR TESTS A2, A6 & A7
WATER FLOW RATE THRU TUBE BREAK ~ lbs/s
0
2
4
6
8
10
12
14
16
A6
A7 & A2
0
1
2
3
4
5
6
TIME FROM BREAK ~ MILLISECONDS

FIGURE 11

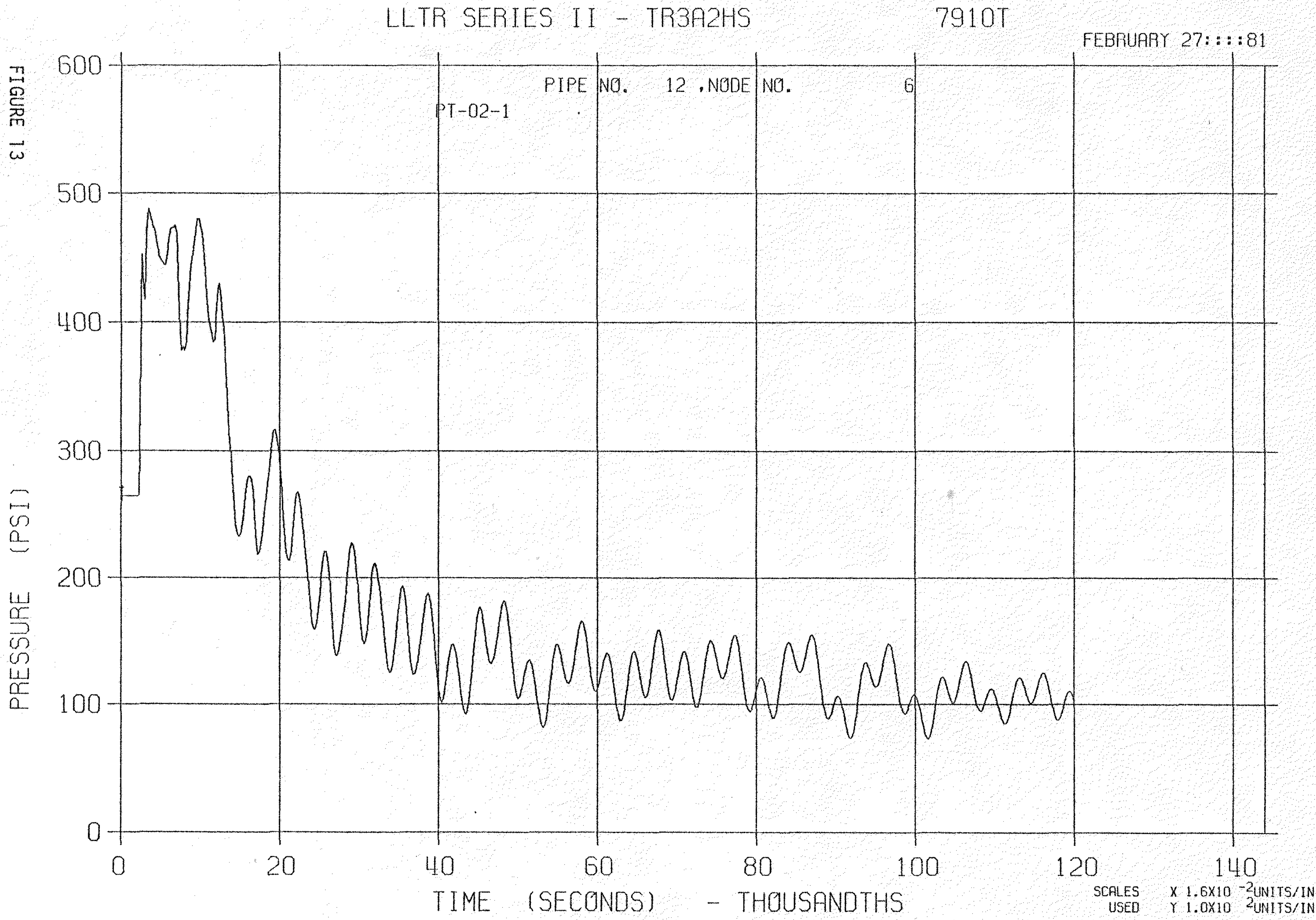
Figure 12

RUPTURE DISC DYNAMIC MODEL



* The behavior of the second disc differs somewhat from that of the first

FIGURE 13



PL 1

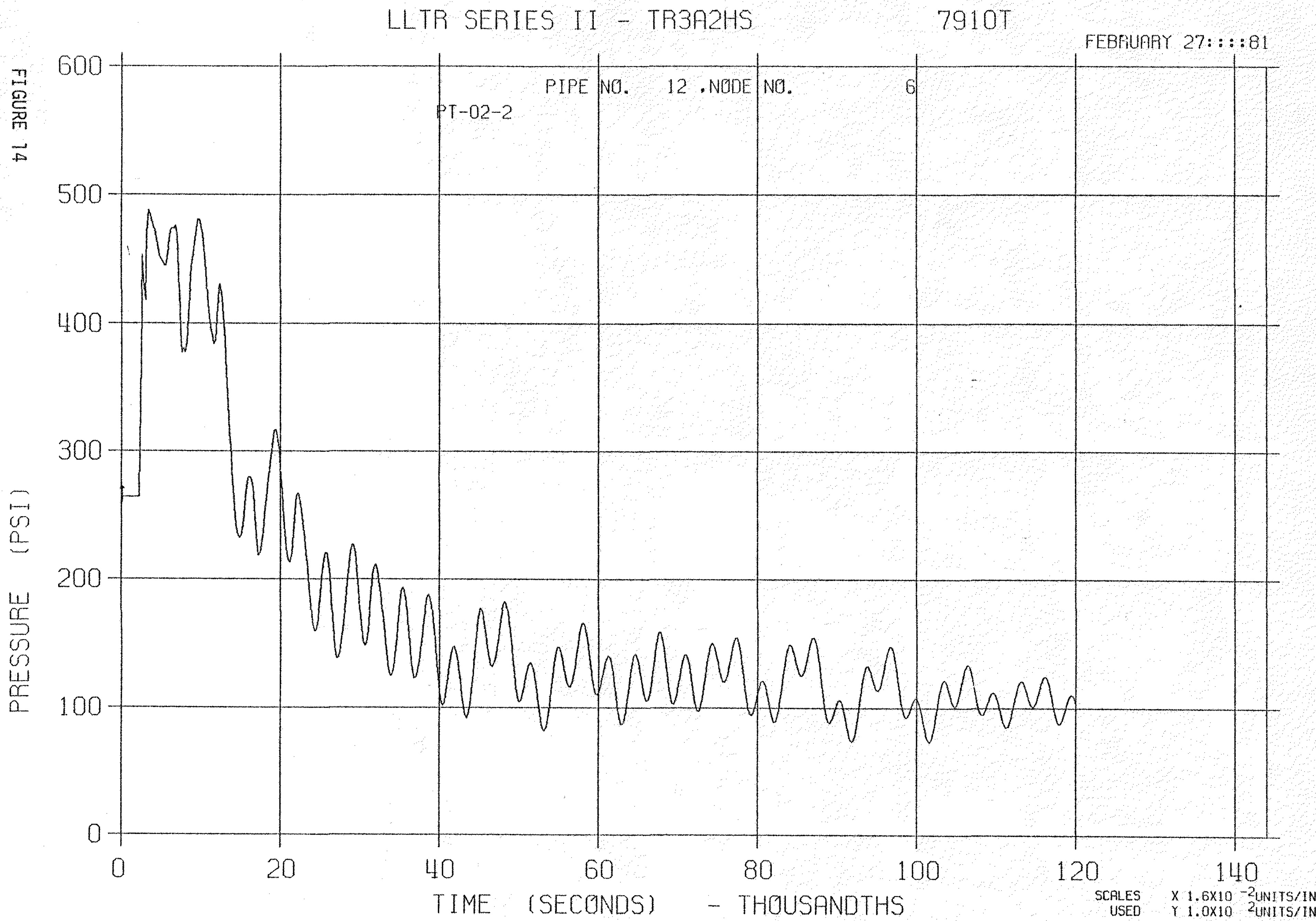
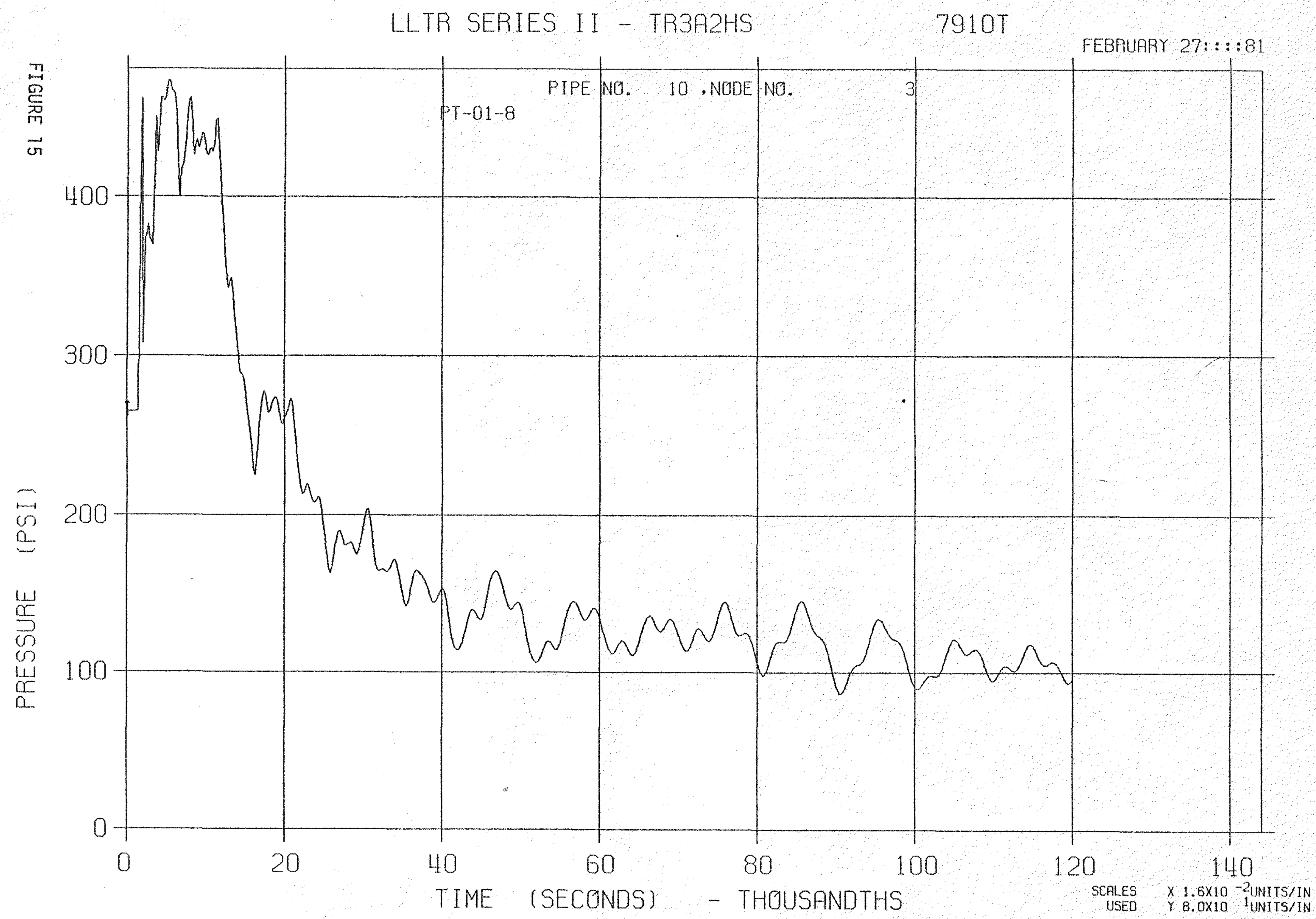


FIGURE 14

PL 2

FIGURE 15



PL 3

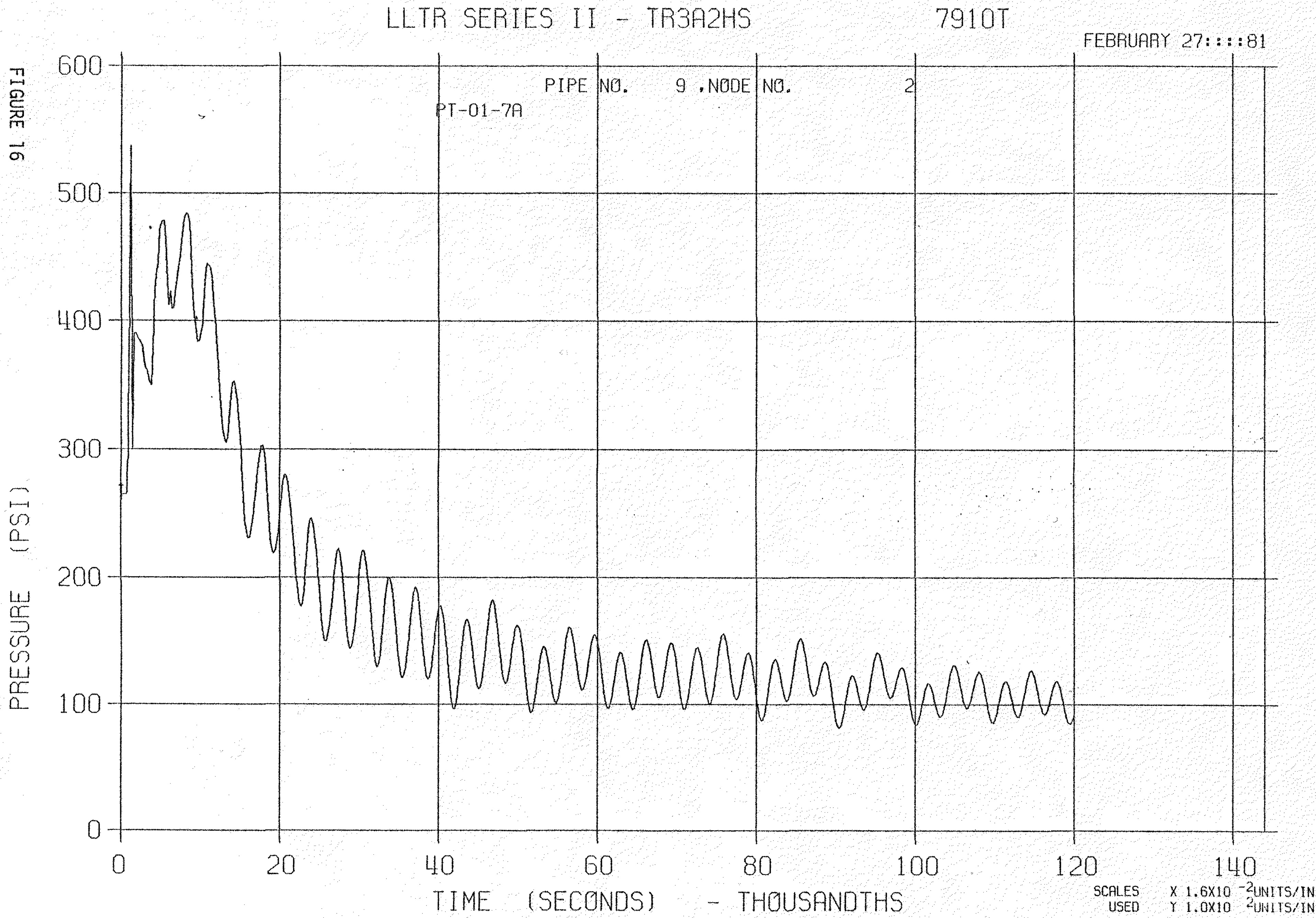
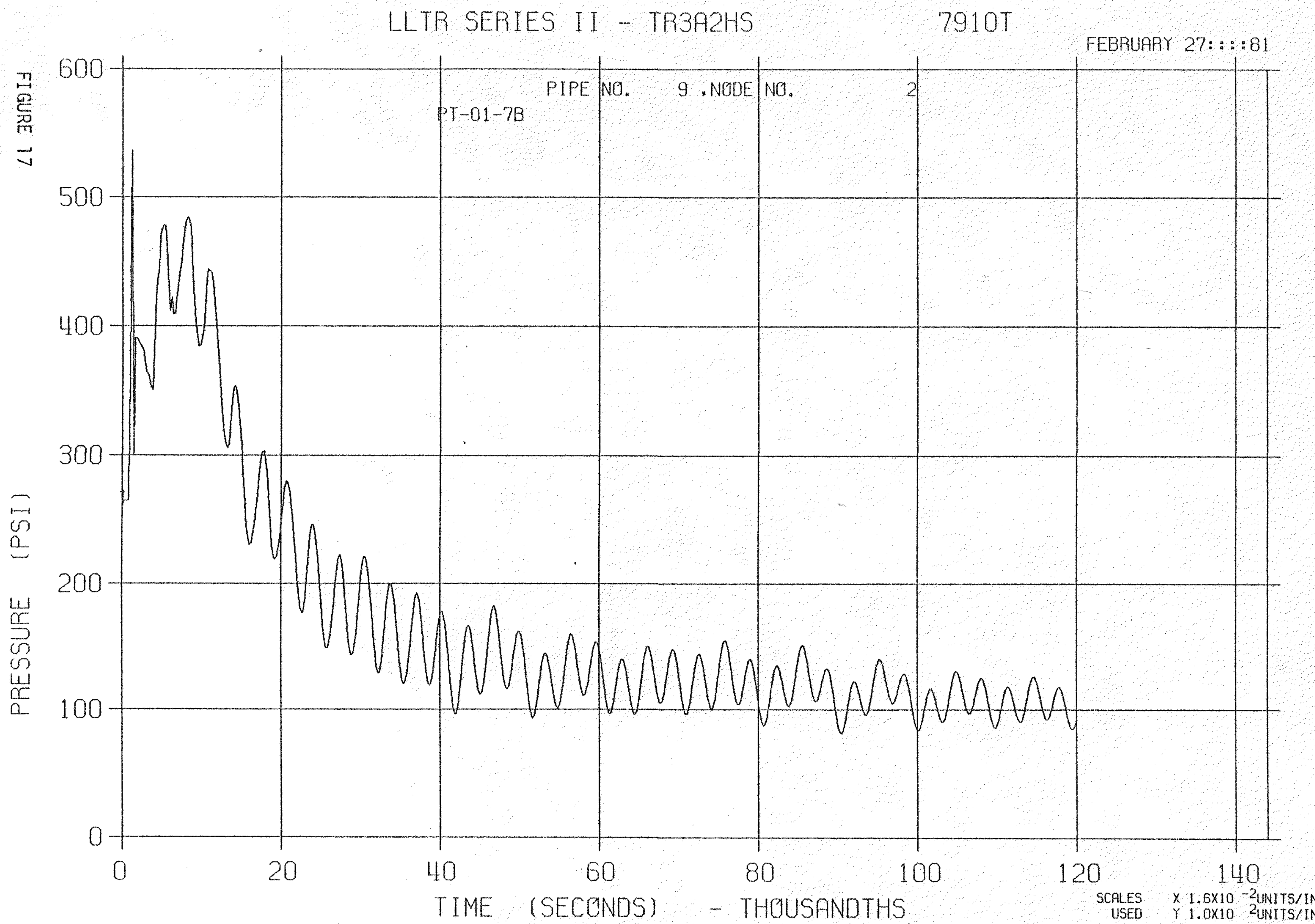


FIGURE 16

PL 4

FIGURE 17


LLTR SERIES II - TR3A2HS
7910T
FEBRUARY 27::::81
PIPE NO. 9 ,NODE NO. 2
PT-01-7B
PRESSURE (PSI)
0
100
200
300
400
500
600
0
20
40
60
80
100
120
140
TIME (SECONDS) - THOUSANDTHS
SCALES USED X 1.6X10 -2UNITS/IN
Y 1.0X10 2UNITS/IN

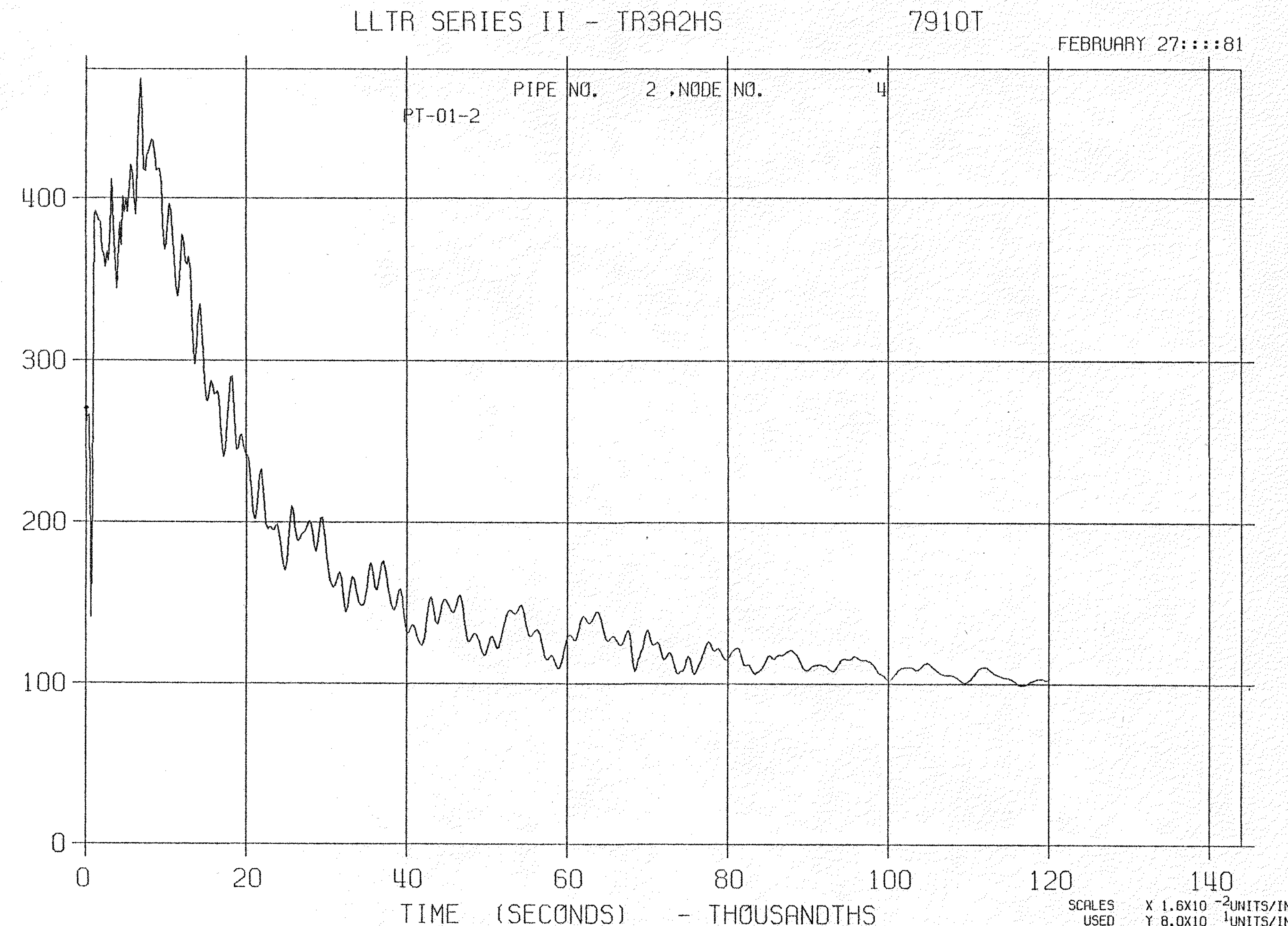

LLTR SERIES II - TR3A2HS
7910T
FEBRUARY 27::::81
PIPE NO. 2 ,NODE NO. 4
PT-01-2
PRESSURE (PSI)
0
100
200
300
400
0
20
40
60
80
100
120
140
TIME (SECONDS) - THOUSANDTHS
SCALES USED
X 1.6X10 -2UNITS/IN
Y 8.0X10 1UNITS/IN

FIGURE 18

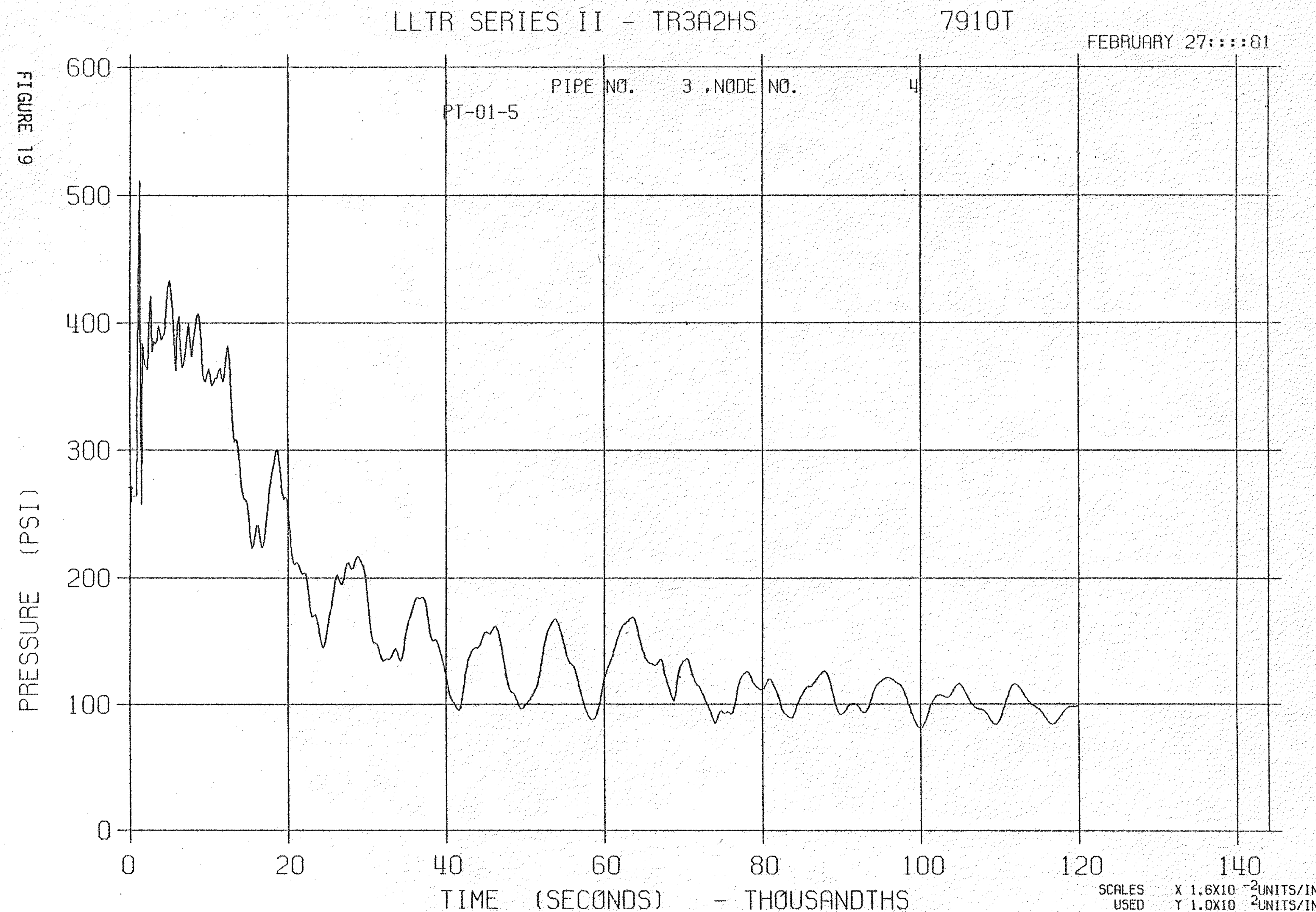
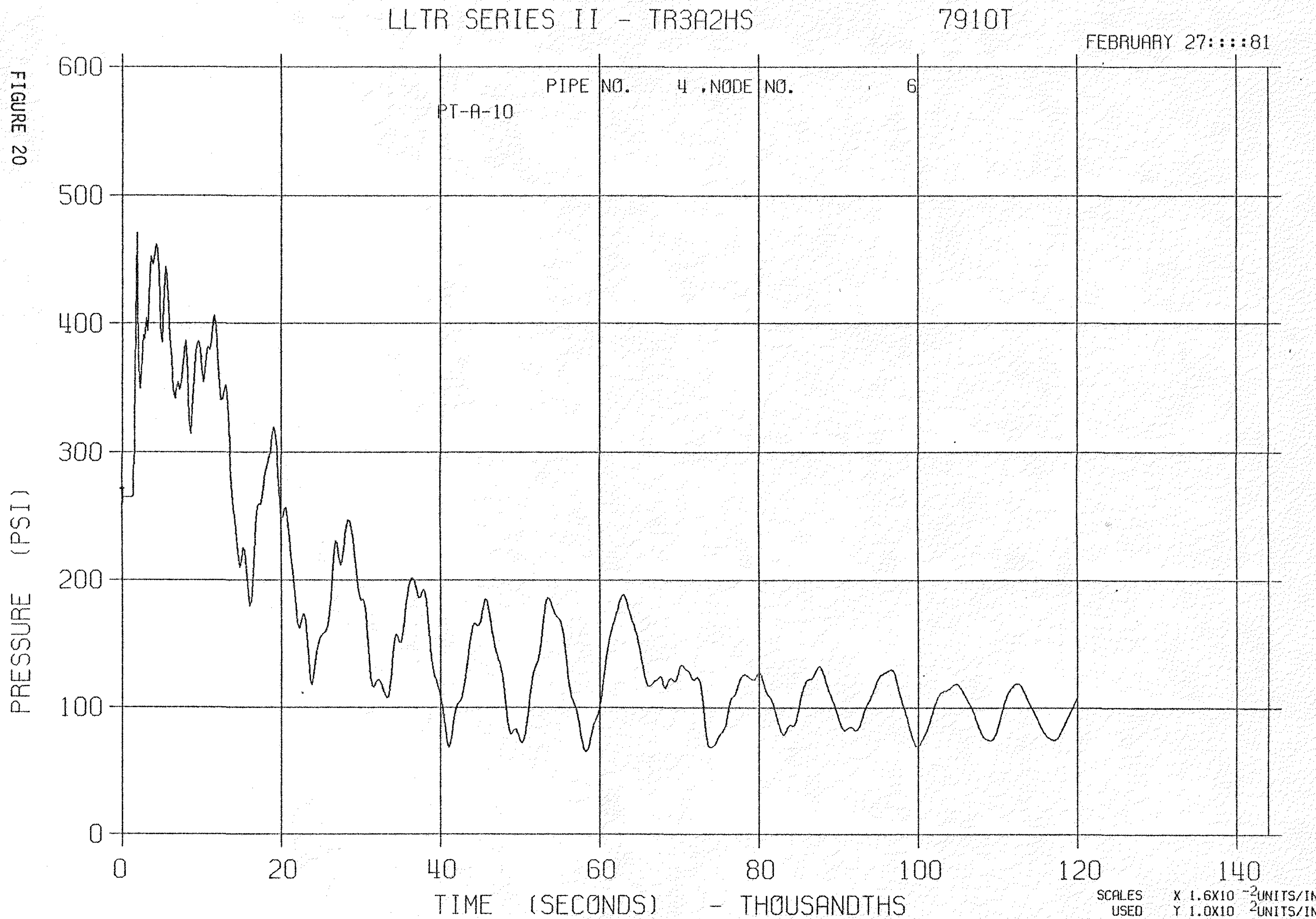


FIGURE 19

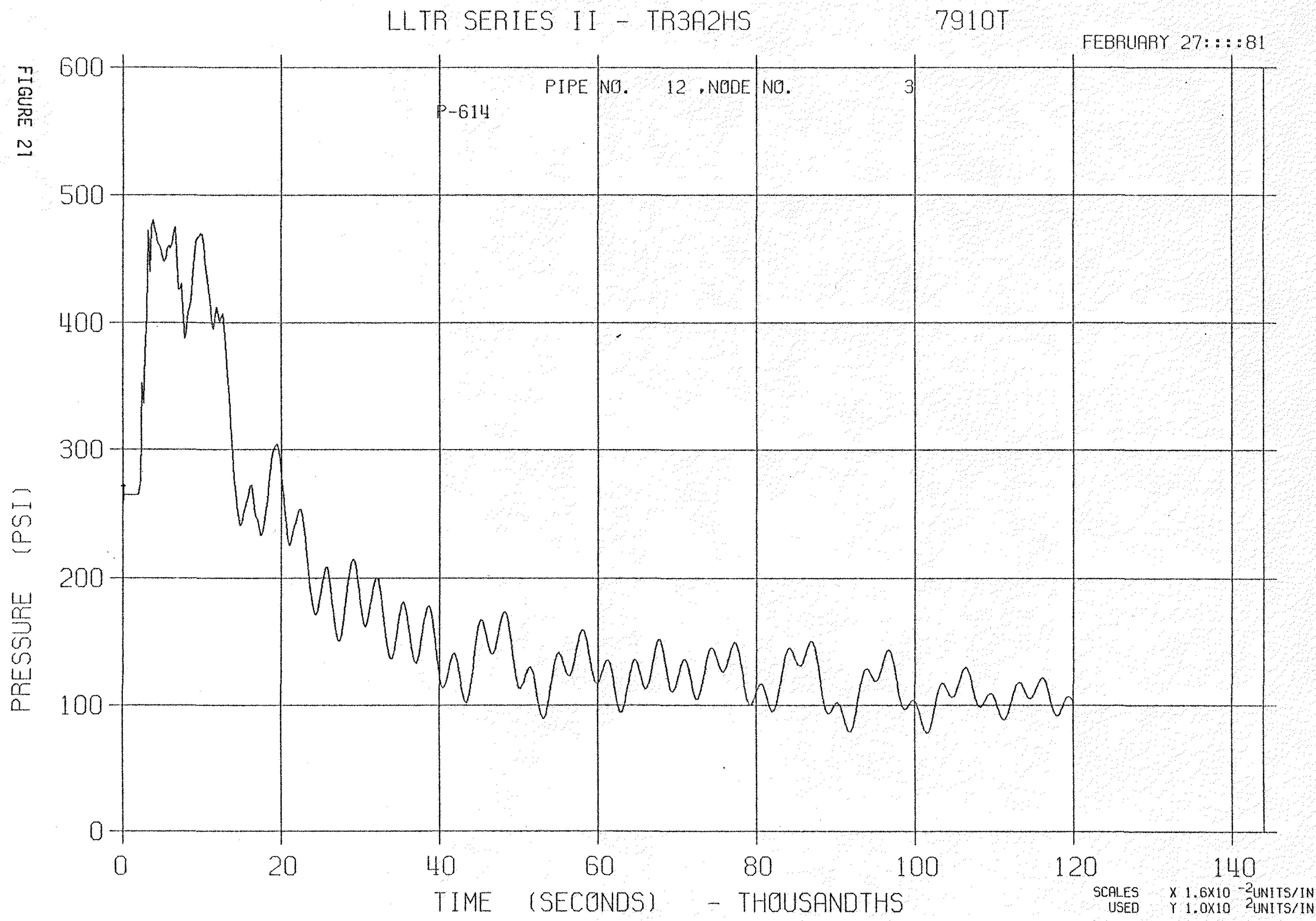
PL 7

FIGURE 20



PL 8

FIGURE 21



LLTR SERIES II - TR3A2HS
7910T
FEBRUARY 27::::81
PIPE NO. 12 ,NODE NO. 3
P-614
PRESSURE (PSI)
600
500
400
300
200
100
0
0
20
40
60
80
100
120
140
TIME (SECONDS) - THOUSANDTHS
SCALES USED
X 1.6X10 -2UNITS/IN
Y 1.0X10 2UNITS/IN

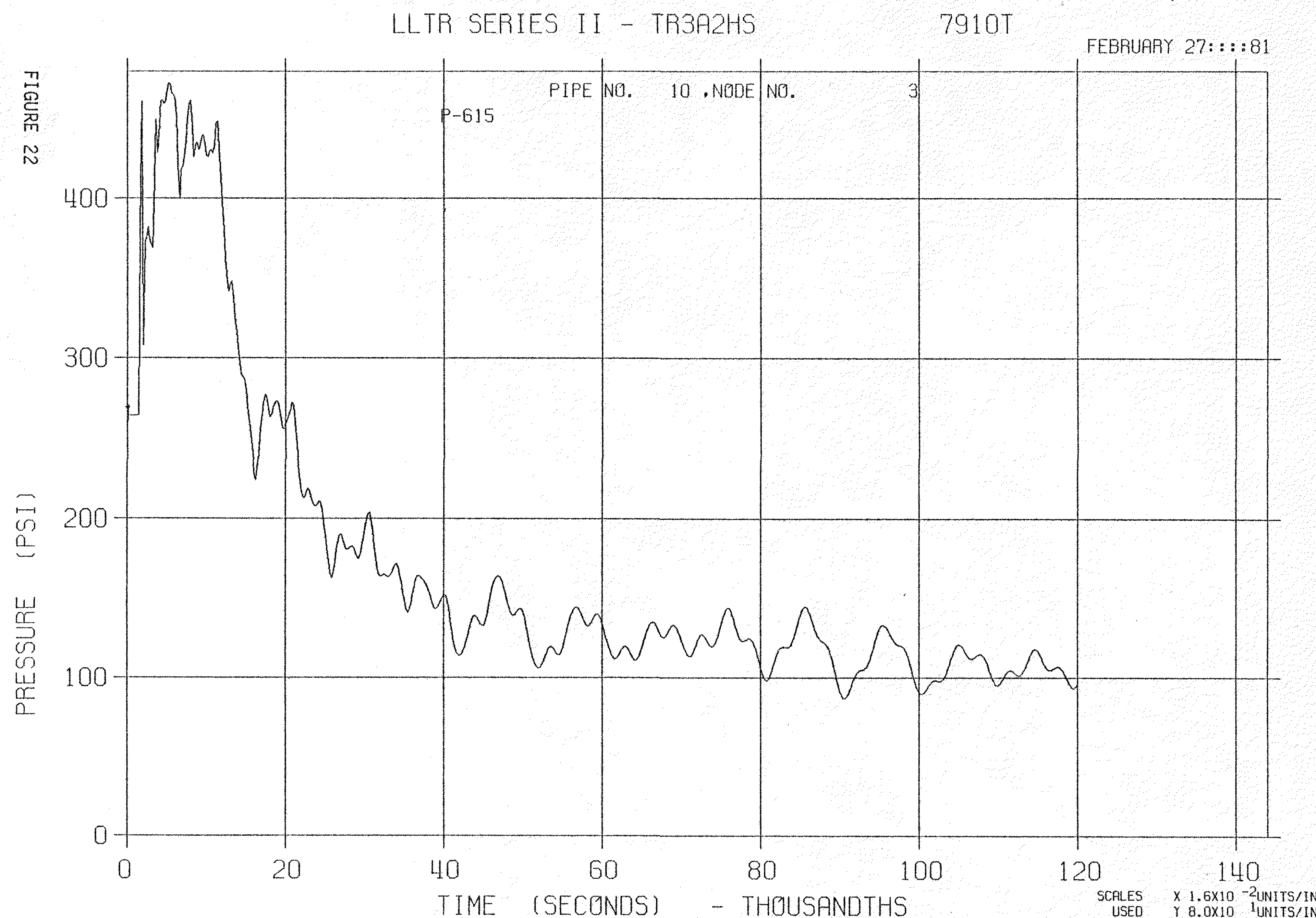
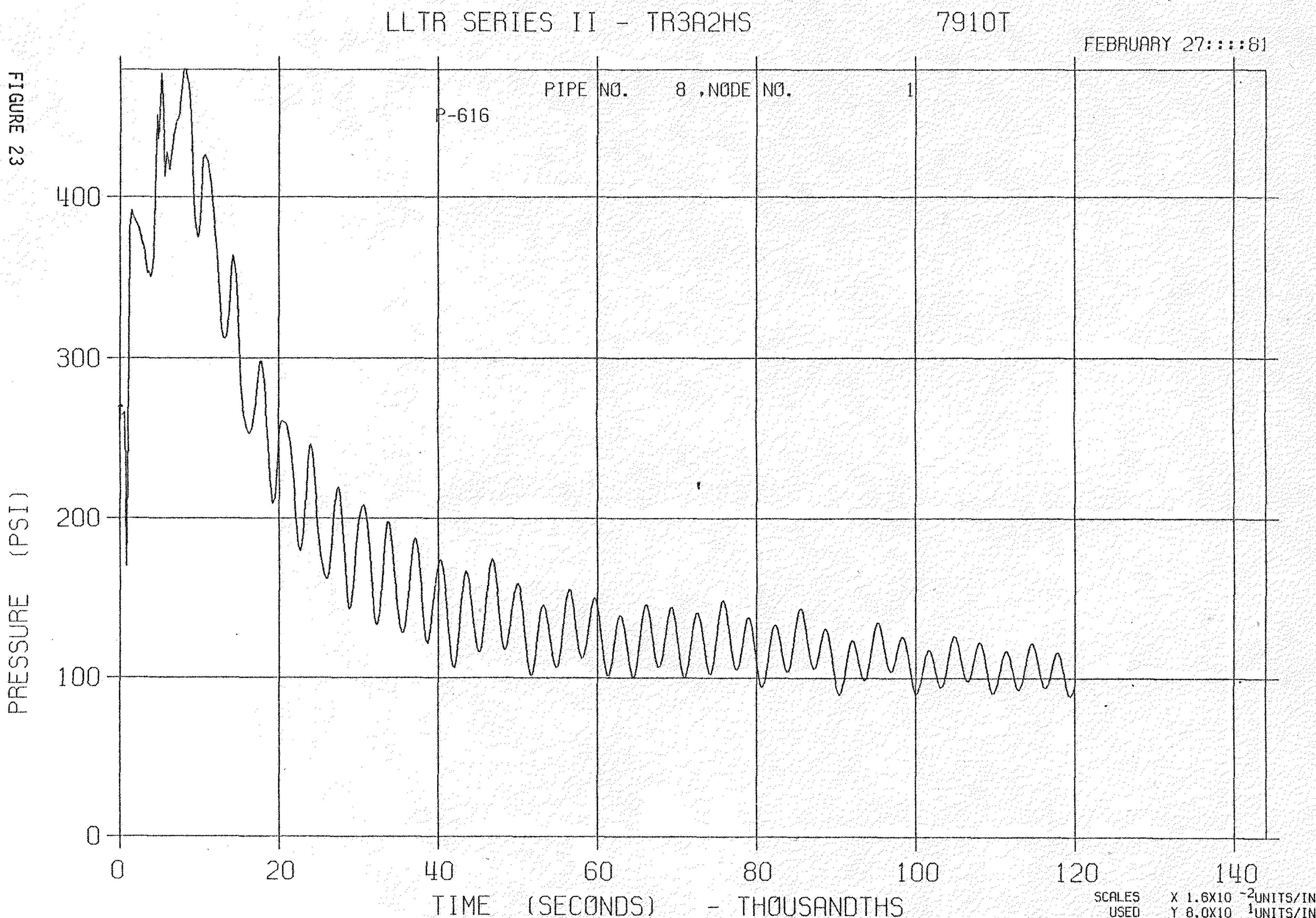
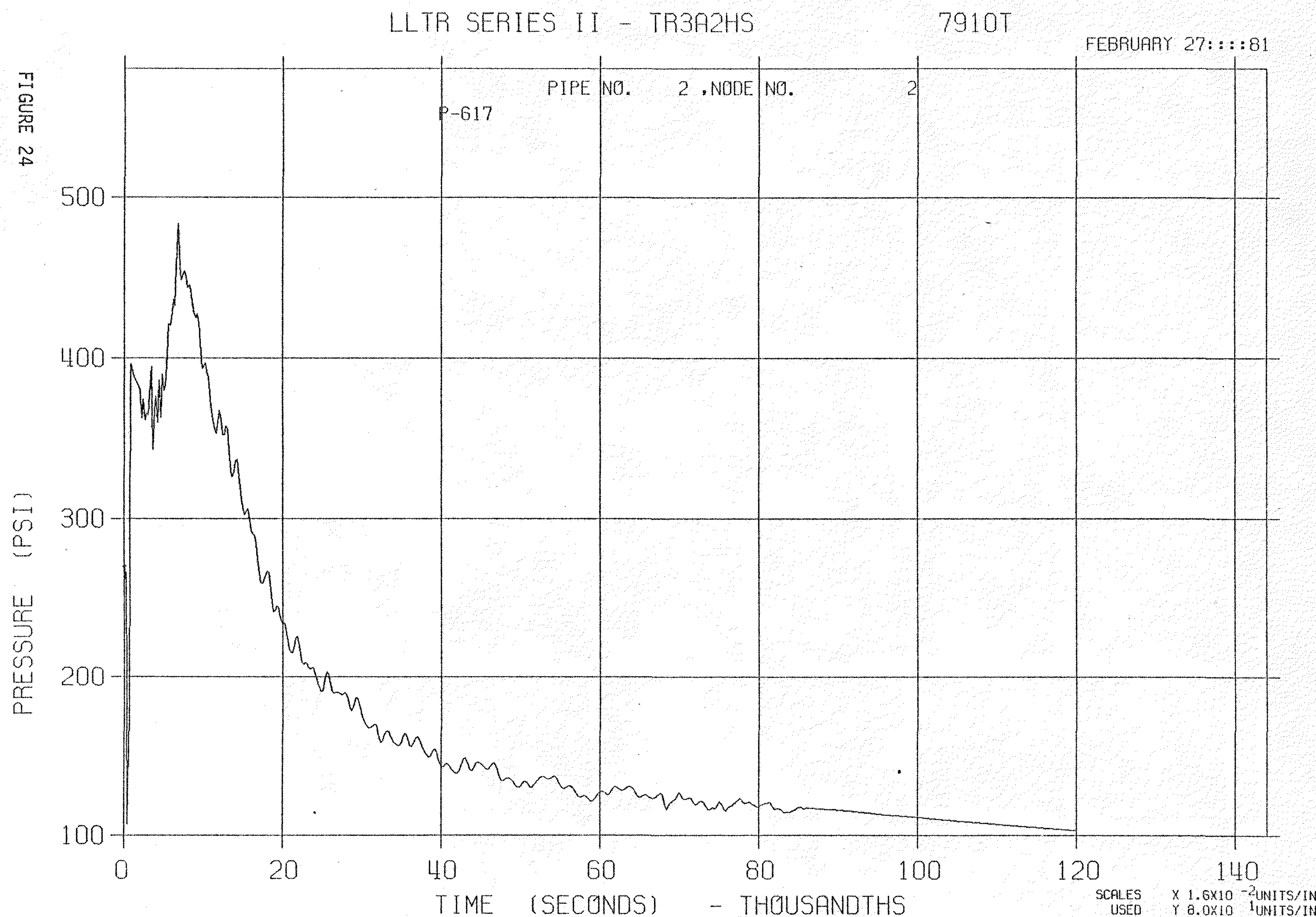

LLTR SERIES II - TR3A2HS
7910T
FEBRUARY 27::::81
PIPE NO. 10 ,NODE NO. 3
P-615
PRESSURE (PSI)
0
100
200
300
400
0
20
40
60
80
100
120
140
TIME (SECONDS) - THOUSANDTHS
SCALES USED
X 1.6X10 -2UNITS/IN
Y 8.0X10 1UNITS/IN

FIGURE 22



LLTR SERIES II - TR3A2HS
7910T
FEBRUARY 27::::81
PIPE NO. 8 ,NODE NO. 1
P-616
PRESSURE (PSI)
0
100
200
300
400
0
20
40
60
80
100
120
140
TIME (SECONDS) - THOUSANDTHS
SCALES USED
X 1.6X10 -2UNITS/IN
Y 8.0X10 1UNITS/IN

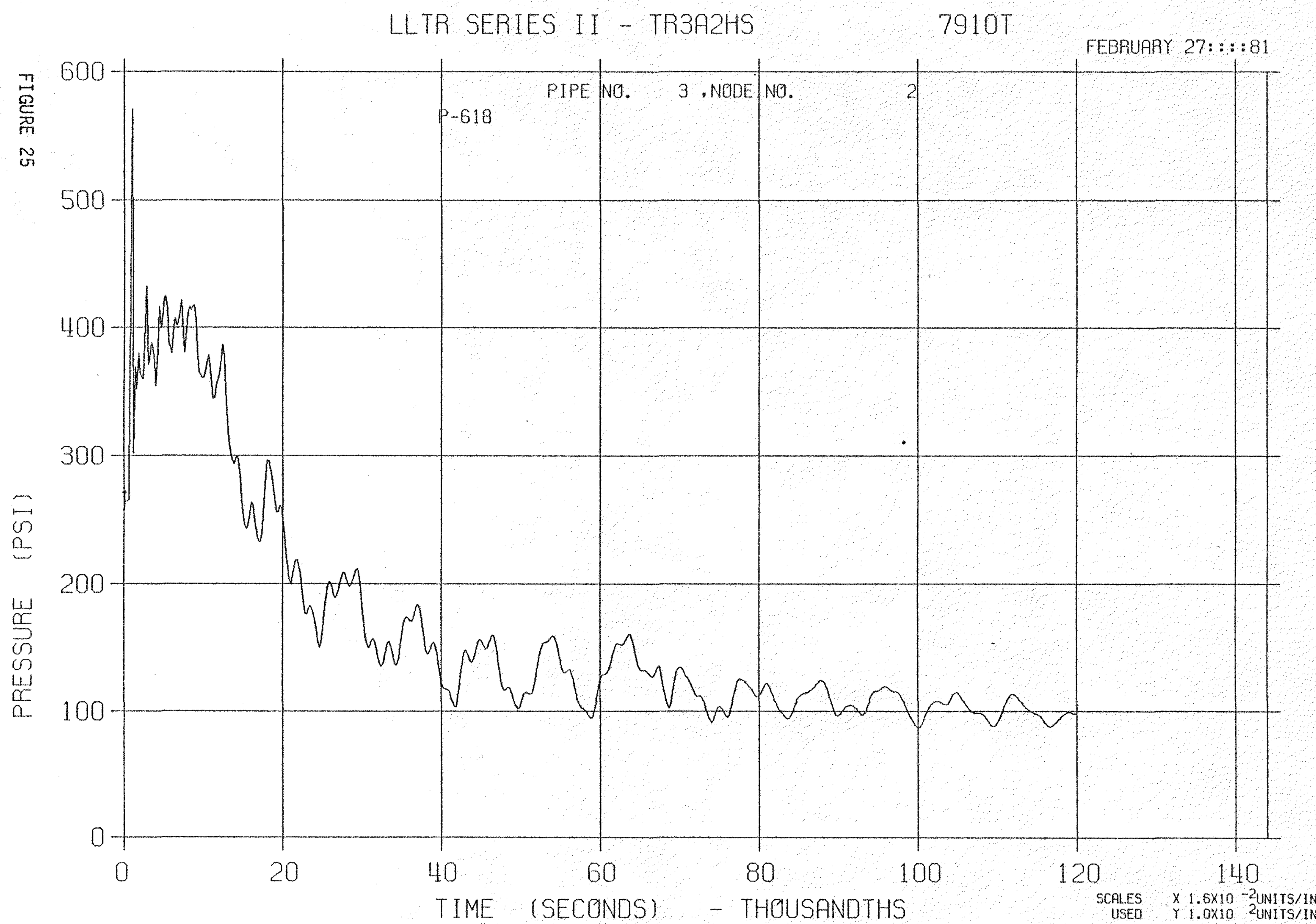
FIGURE 23



LLTR SERIES II - TR3A2HS
7910T
FEBRUARY 27::::81
PIPE NO. 2 ,NODE NO. 2
P-617
PRESSURE (PSI)
500
400
300
200
100
0
20
40
60
80
100
120
140
TIME (SECONDS) - THOUSANDTHS
SCALES USED
X 1.6X10 -2 UNITS/IN
Y 8.0X10 1 UNITS/IN

FIGURE 24

FIGURE 25



PL 25

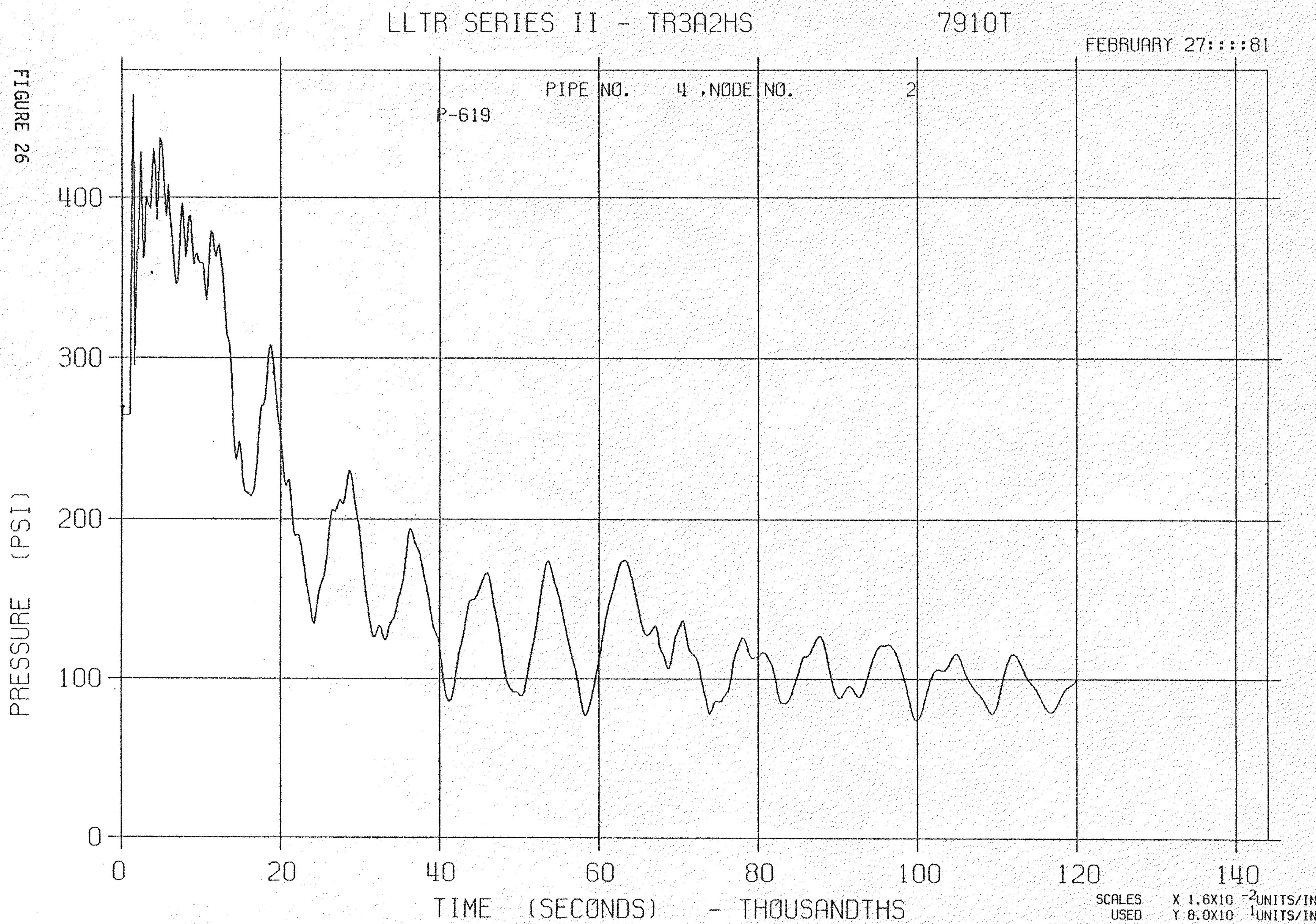
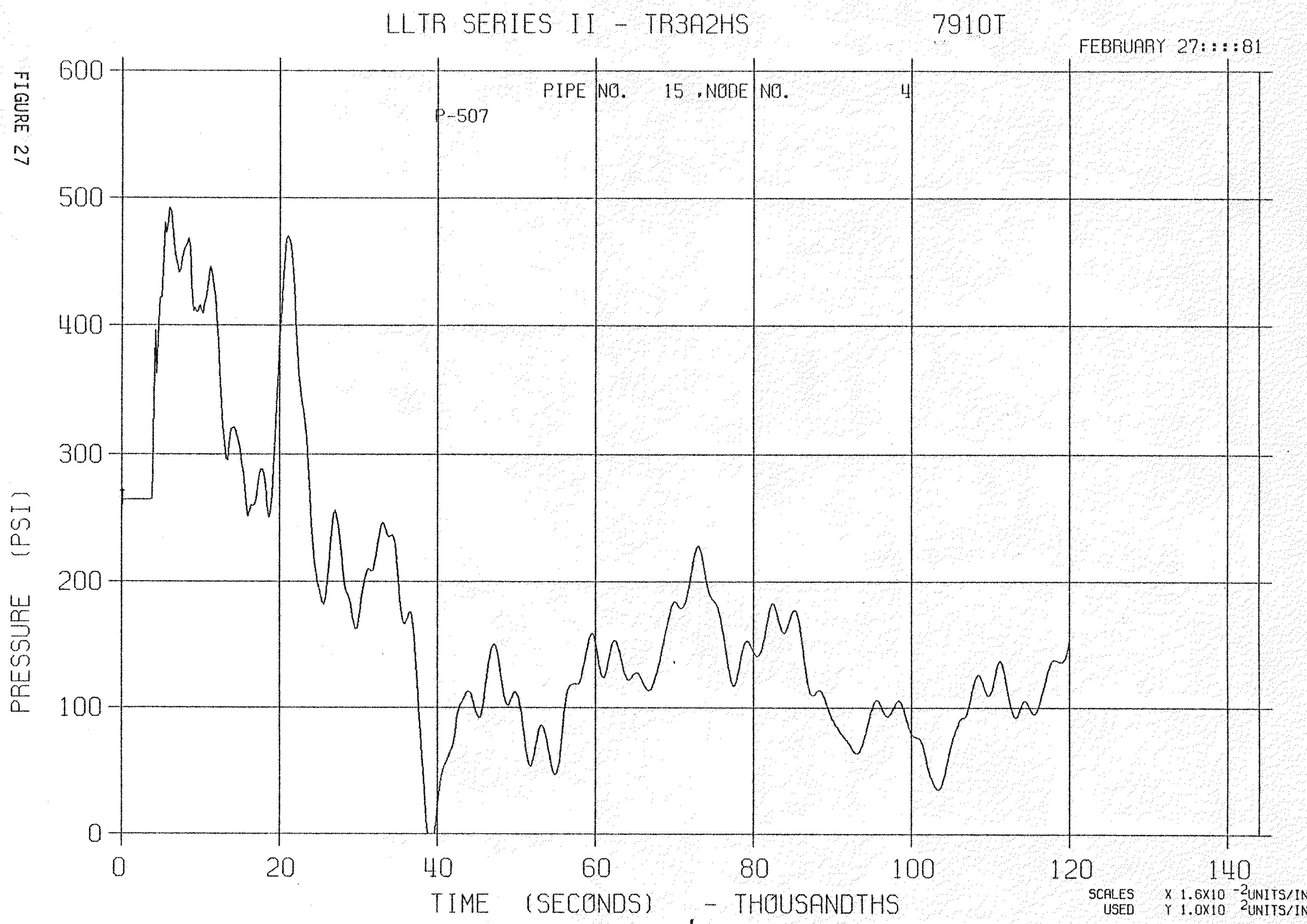


FIGURE 26

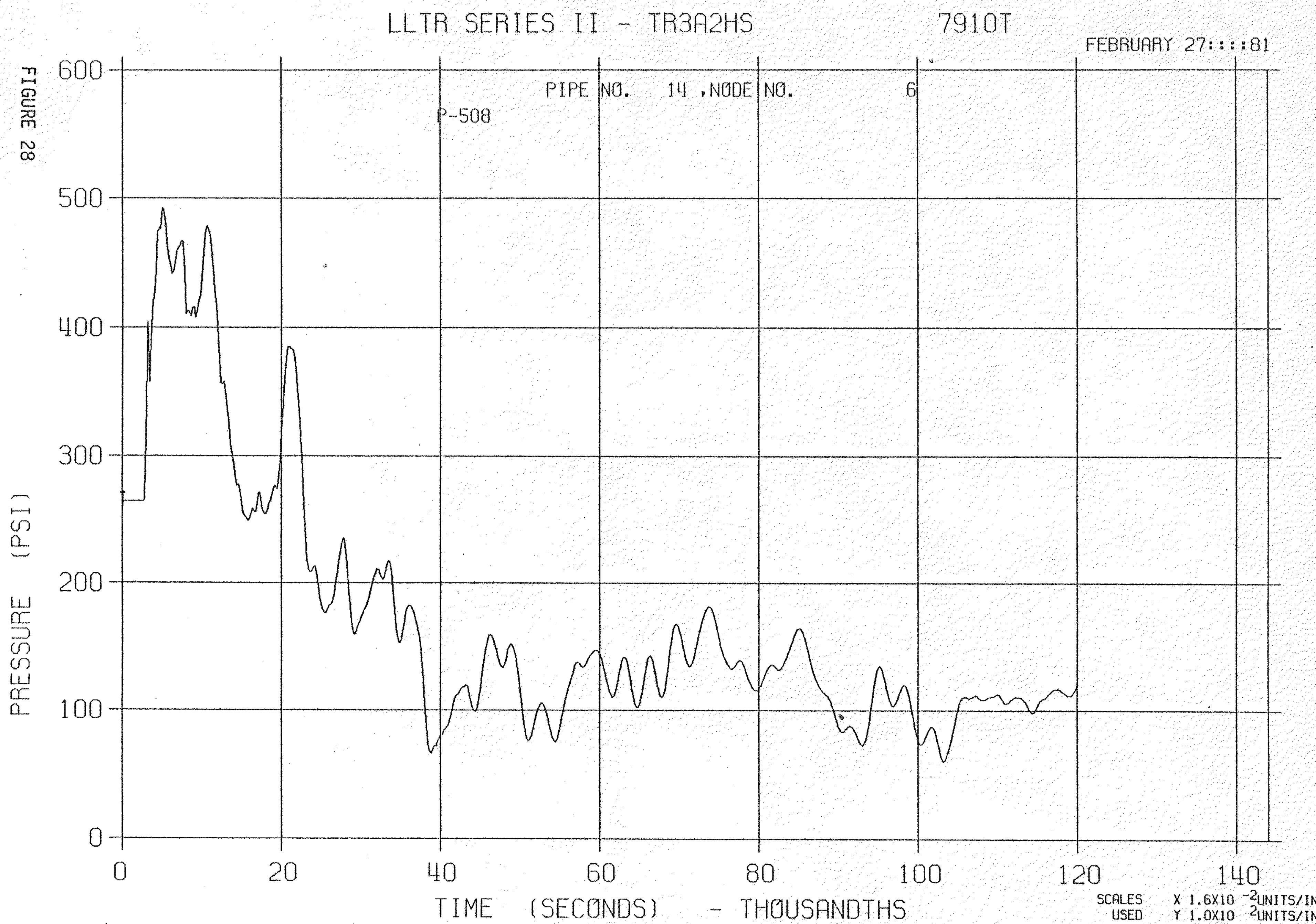
PL 26

FIGURE 27



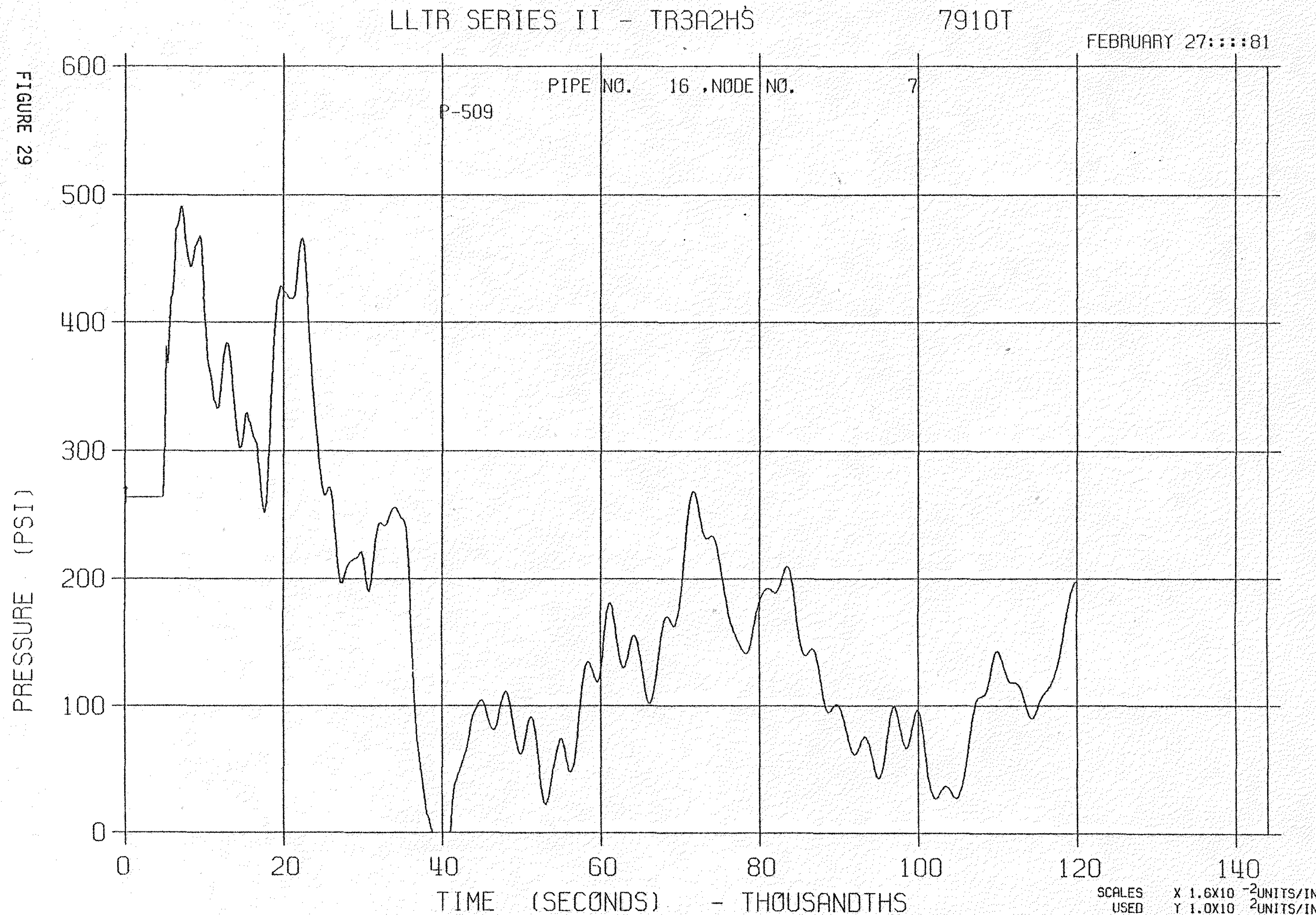
PL 9

FIGURE 28


LLTR SERIES II - TR3A2HS
7910T
FEBRUARY 27::::81
PIPE NO. 14 ,NODE NO. 6
P-508
600
500
400
300
200
100
0
PRESSURE (PSI)
0
20
40
60
80
100
120
140
TIME (SECONDS) - THOUSANDTHS
SCALES USED
X 1.6X10 -2UNITS/IN
Y 1.0X10 2UNITS/IN

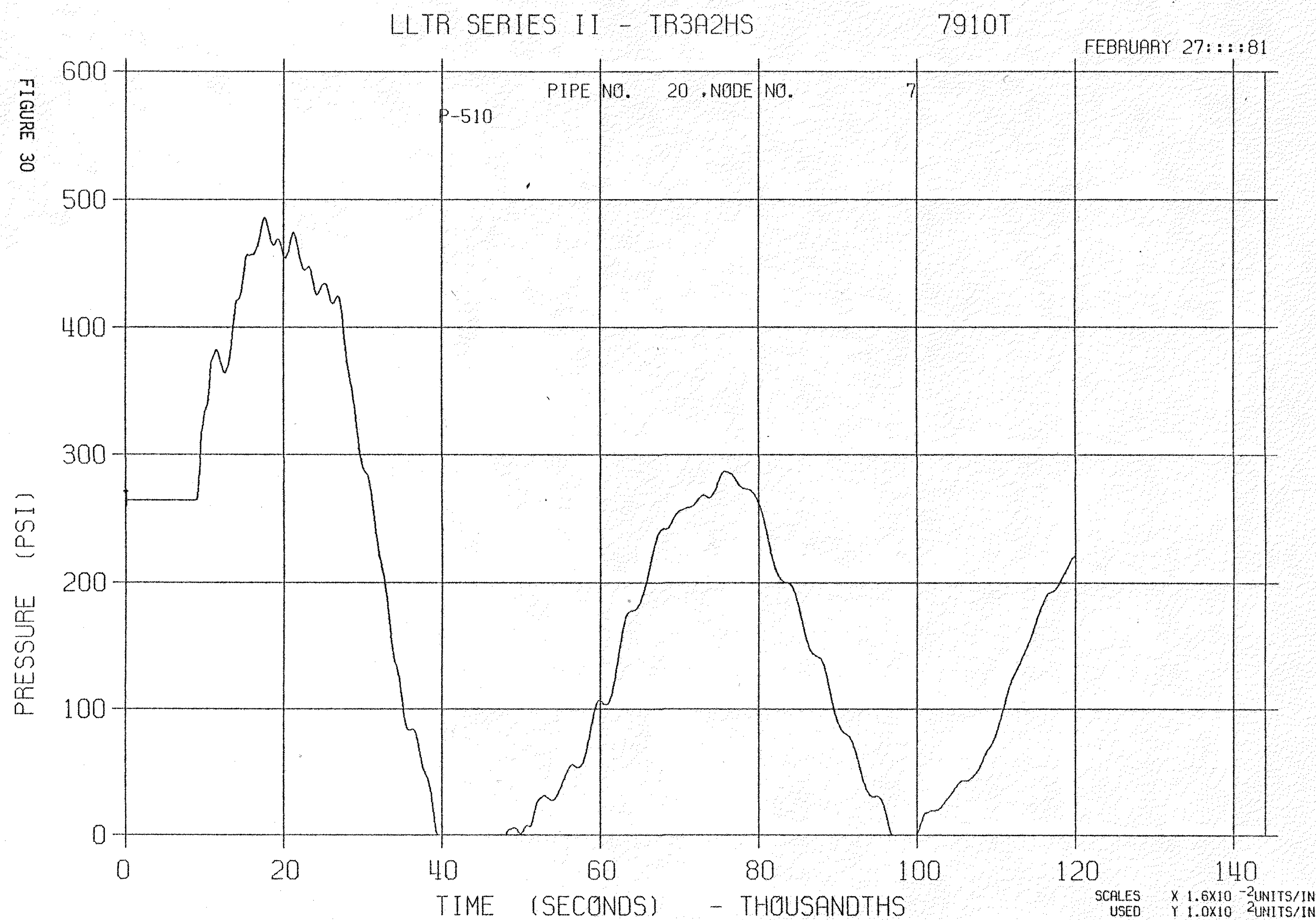
PL 10

FIGURE 29



LLTR SERIES II - TR3A2HS
7910T
FEBRUARY 27::::81
PIPE NO. 16 ,NODE NO. 7
P-509
PRESSURE (PSI)
600
500
400
300
200
100
0
0
20
40
60
80
100
120
140
TIME (SECONDS) - THOUSANDTHS
SCALES USED
X 1.6X10 -2UNITS/IN
Y 1.0X10 2UNITS/IN

FIGURE 30



PL 12

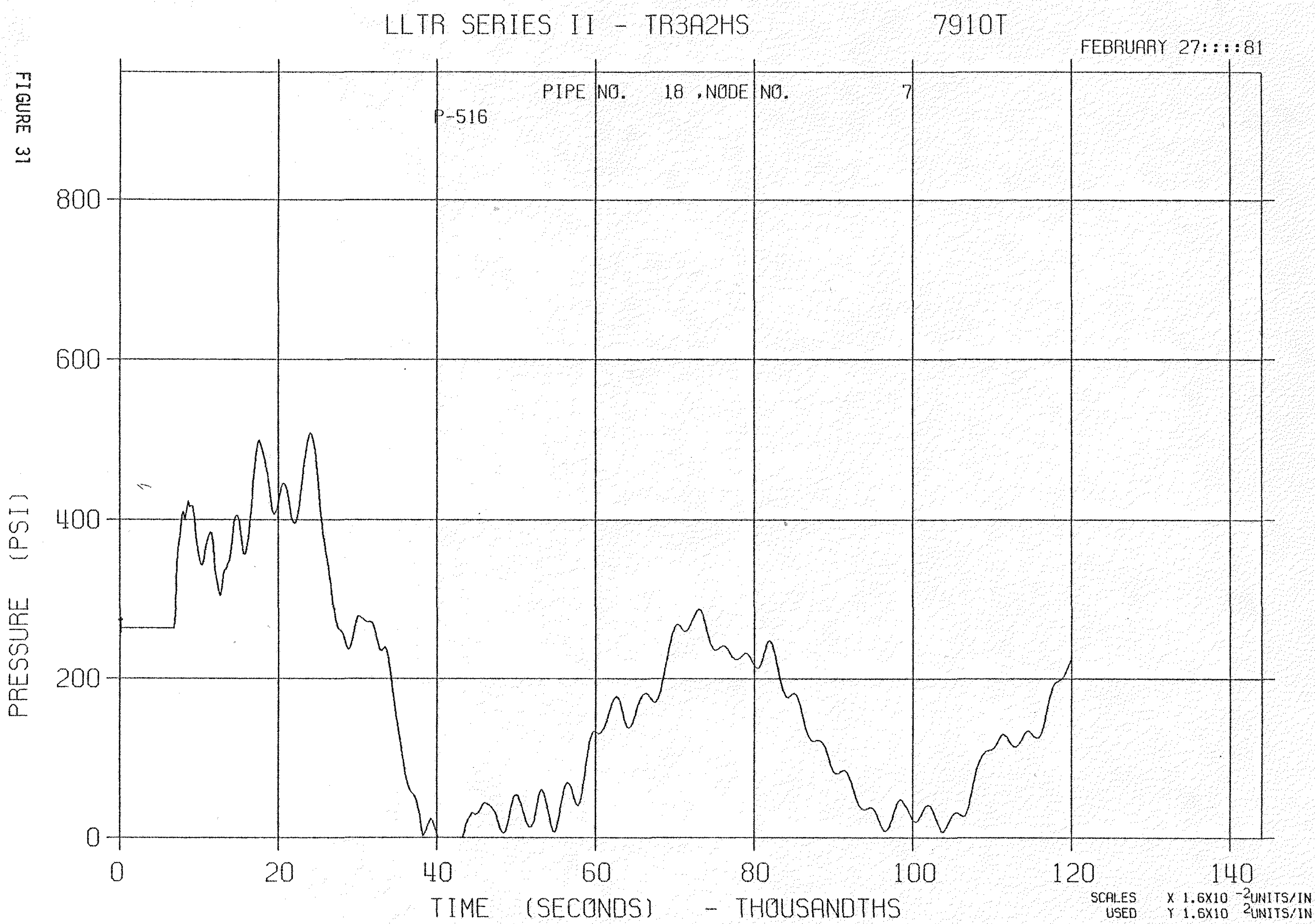
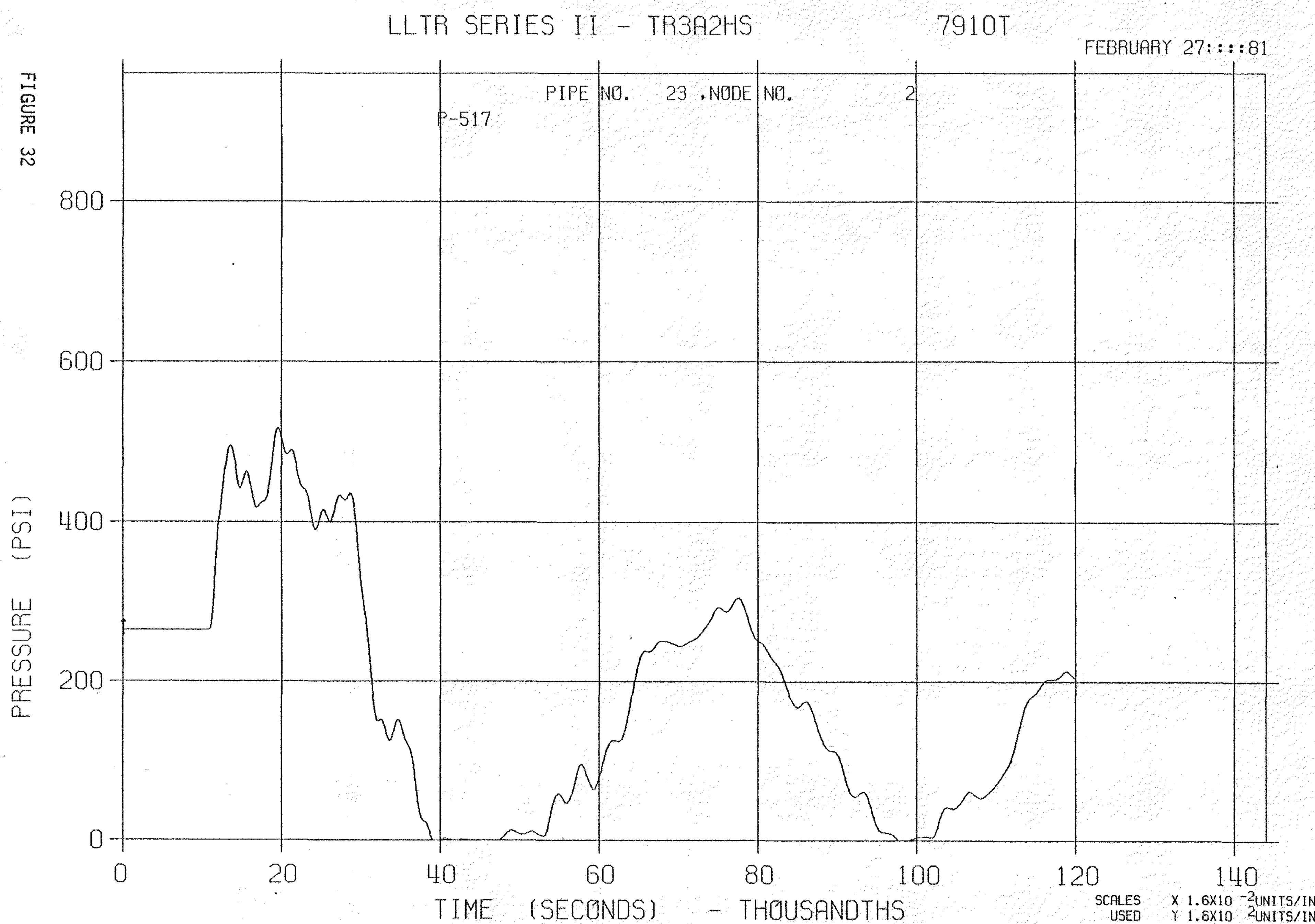


FIGURE 31

PL 13

FIGURE 32



PL 14

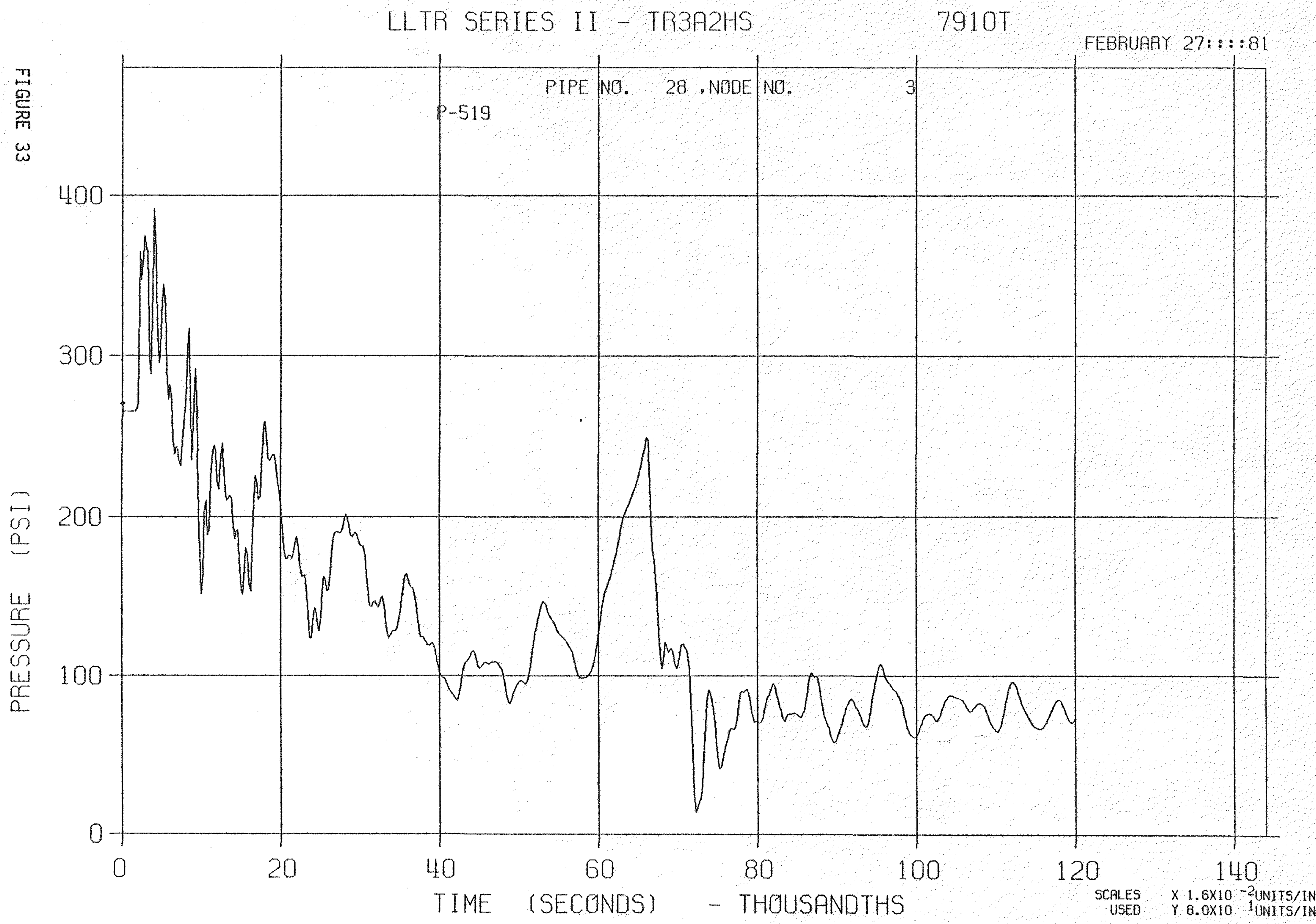
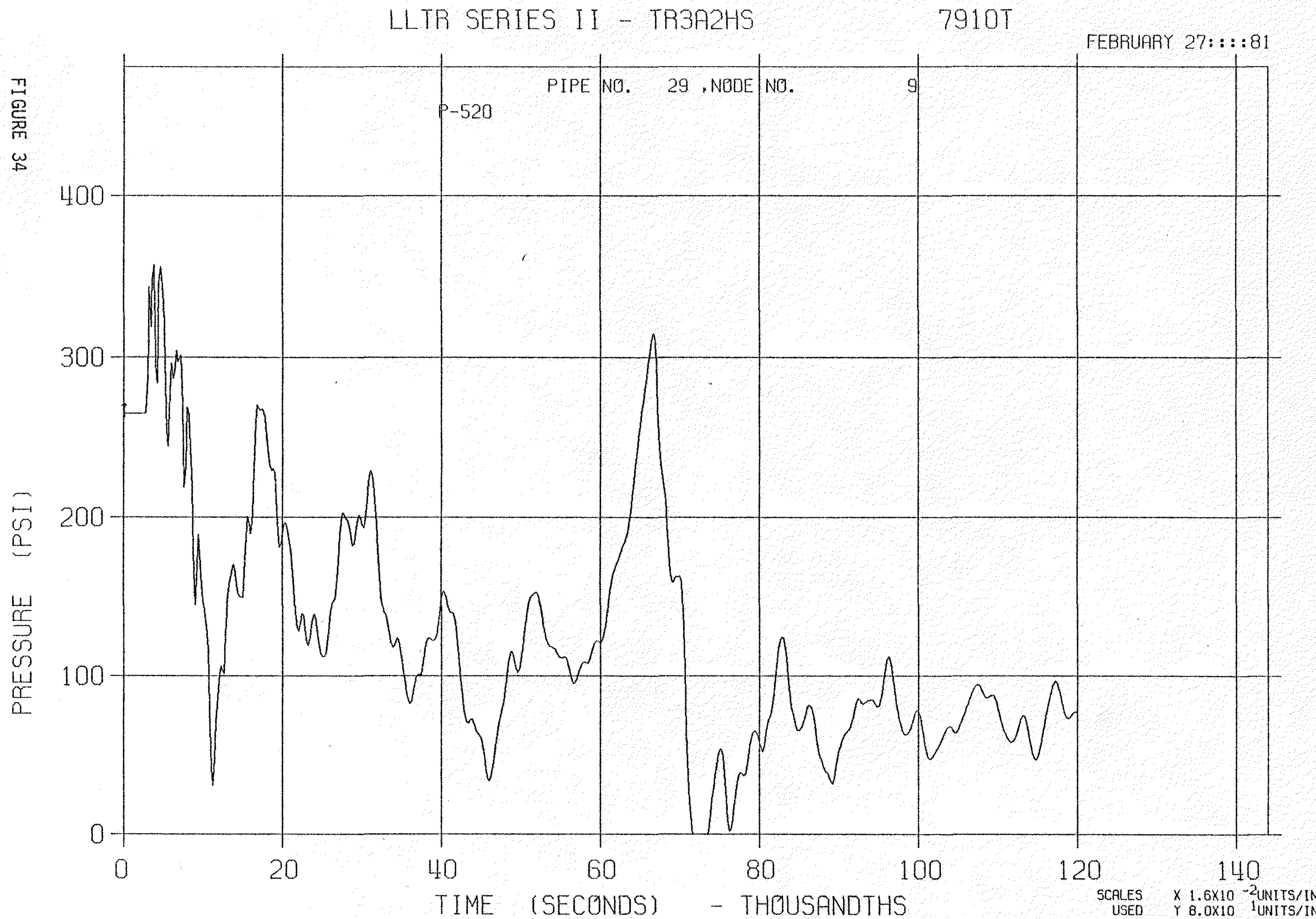


FIGURE 33

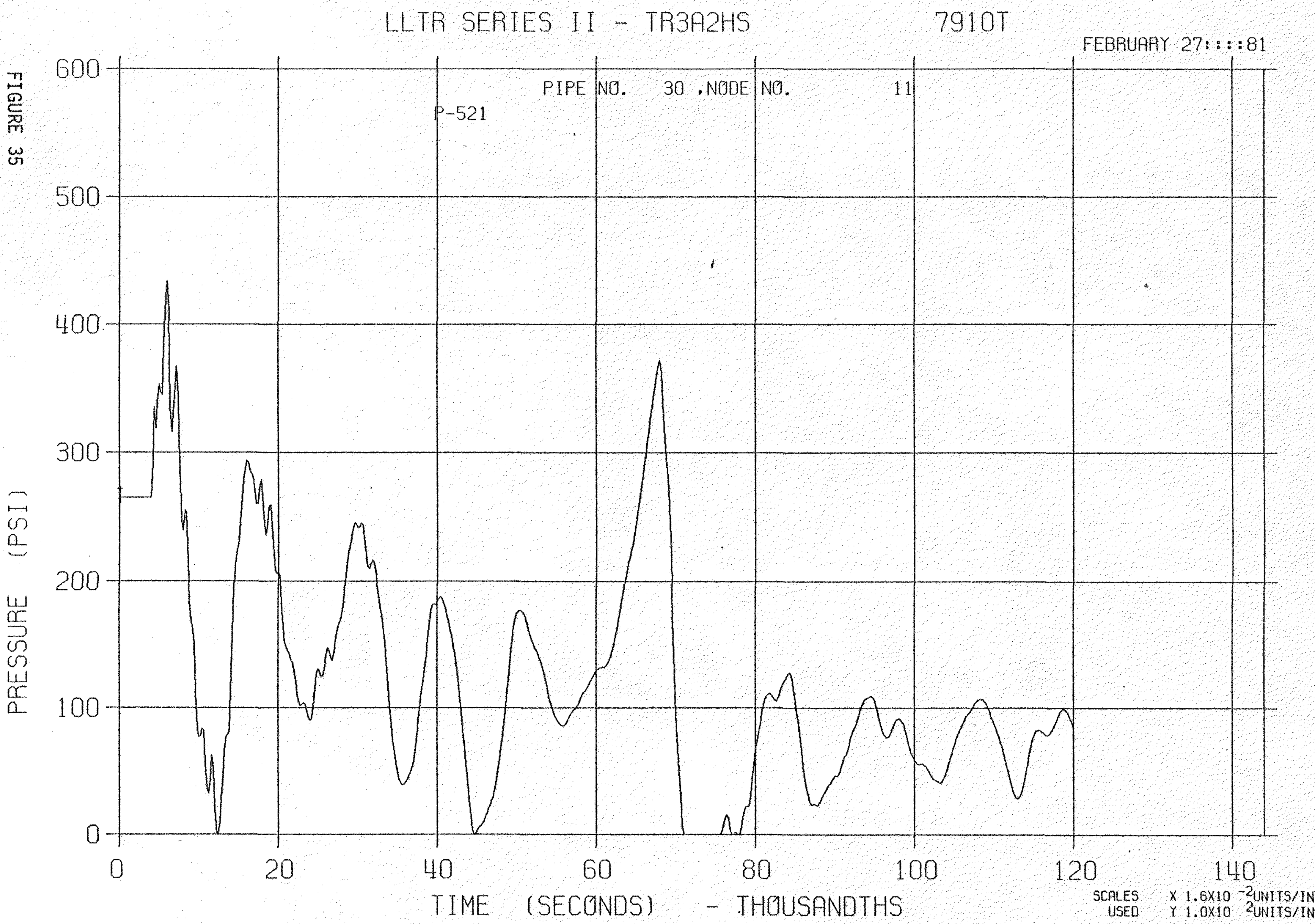
PL 15

FIGURE 34

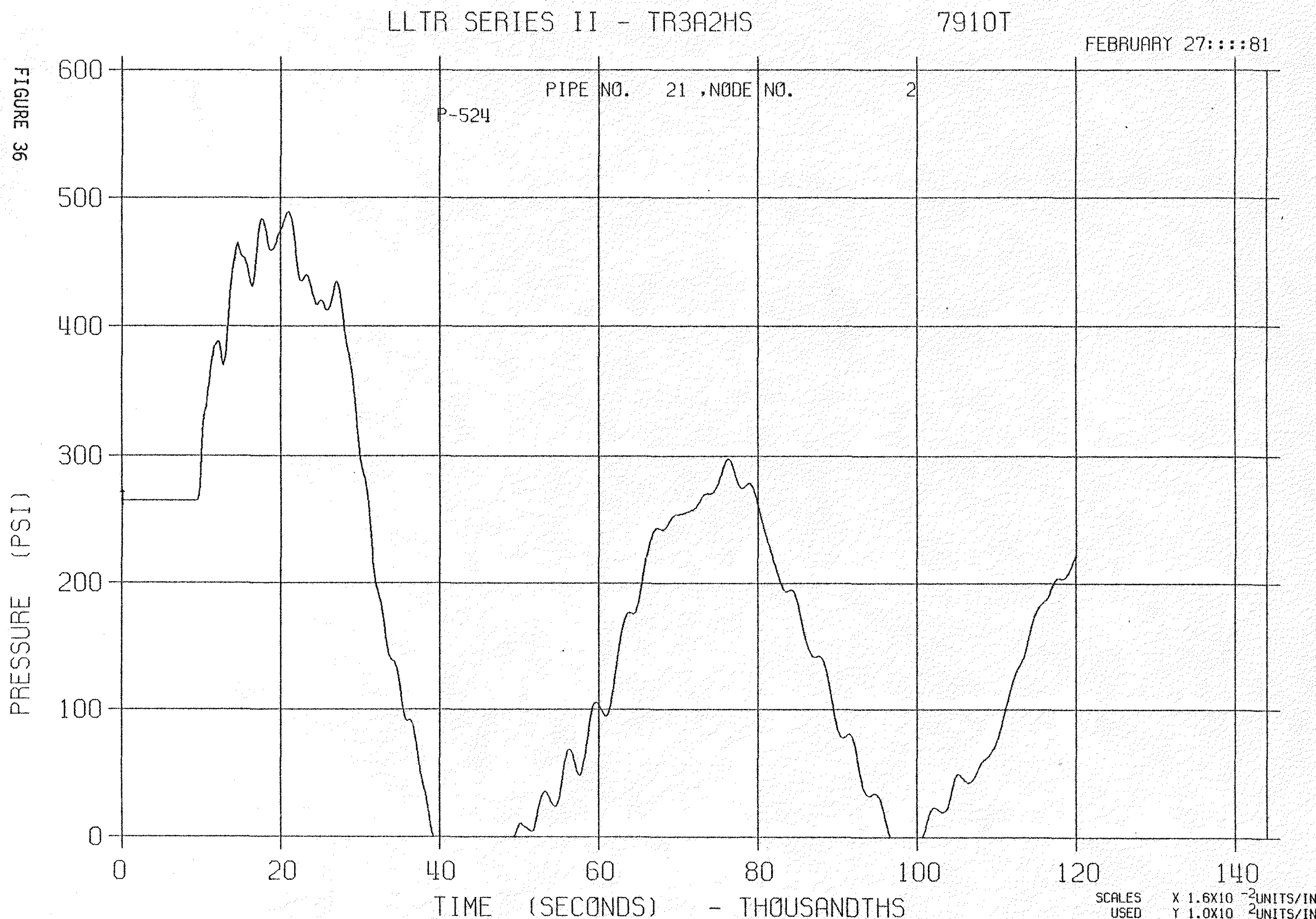


PL 16

FIGURE 35



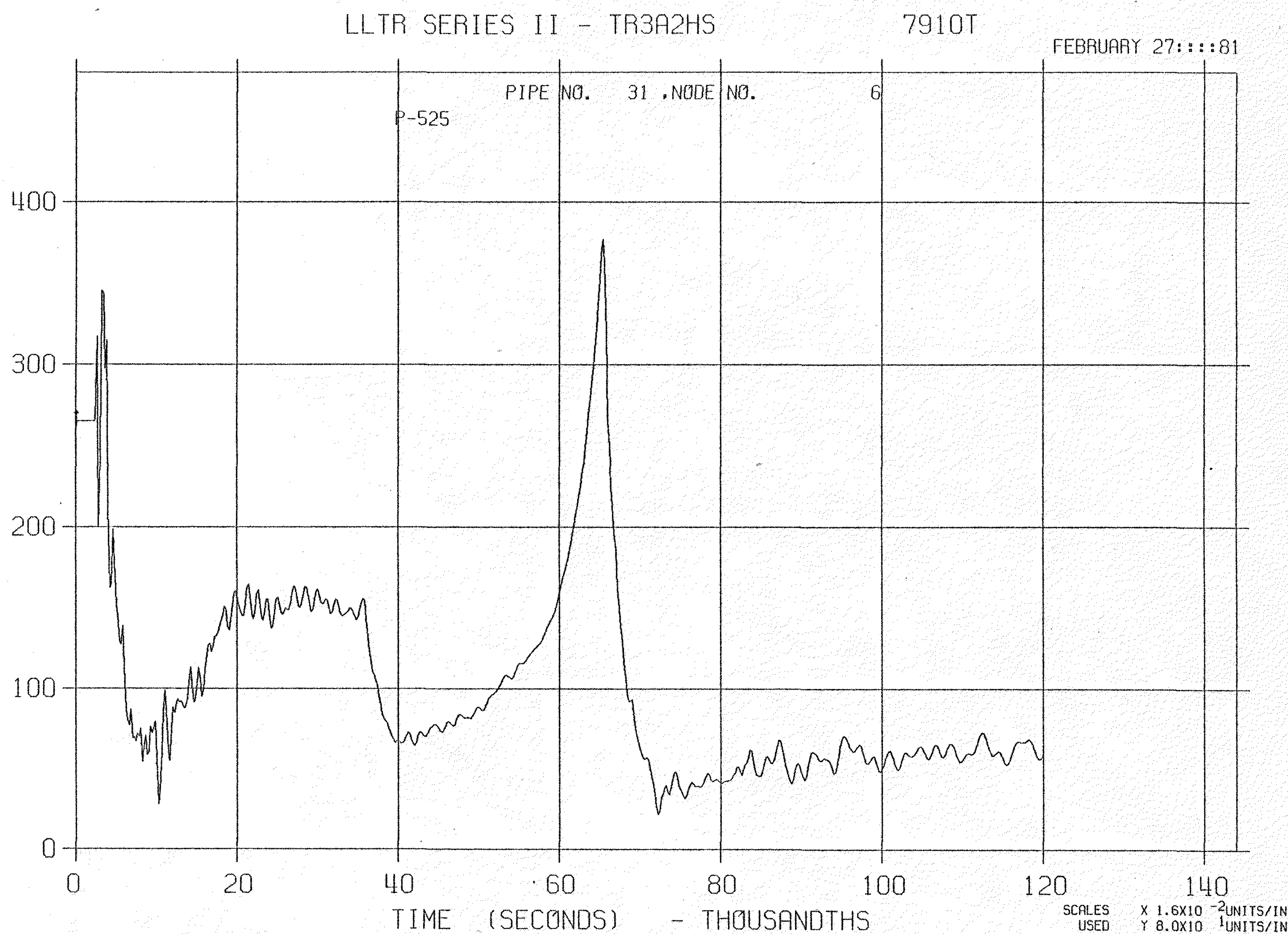
PL 17



LLTR SERIES II - TR3A2HS
7910T
FEBRUARY 27::::81
PIPE NO. 21 ,NODE NO. 2
P-524
FIGURE 36
PRESSURE (PSI)
600
500
400
300
200
100
0
0
20
40
60
80
100
120
140
TIME (SECONDS) - THOUSANDTHS
SCALES USED
X 1.6X10 -2UNITS/IN
Y 1.0X10 2UNITS/IN

PL 18

FIGURE 37



LLTR SERIES II - TR3A2HS
7910T
FEBRUARY 27::::81
PIPE NO. 31 ,NODE NO. 6
P-525
400
300
200
100
0
PRESSURE (PSI)
0
20
40
60
80
100
120
140
TIME (SECONDS) - THOUSANDTHS
SCALES USED
X 1.6X10 -2UNITS/IN
Y 8.0X10 1UNITS/IN

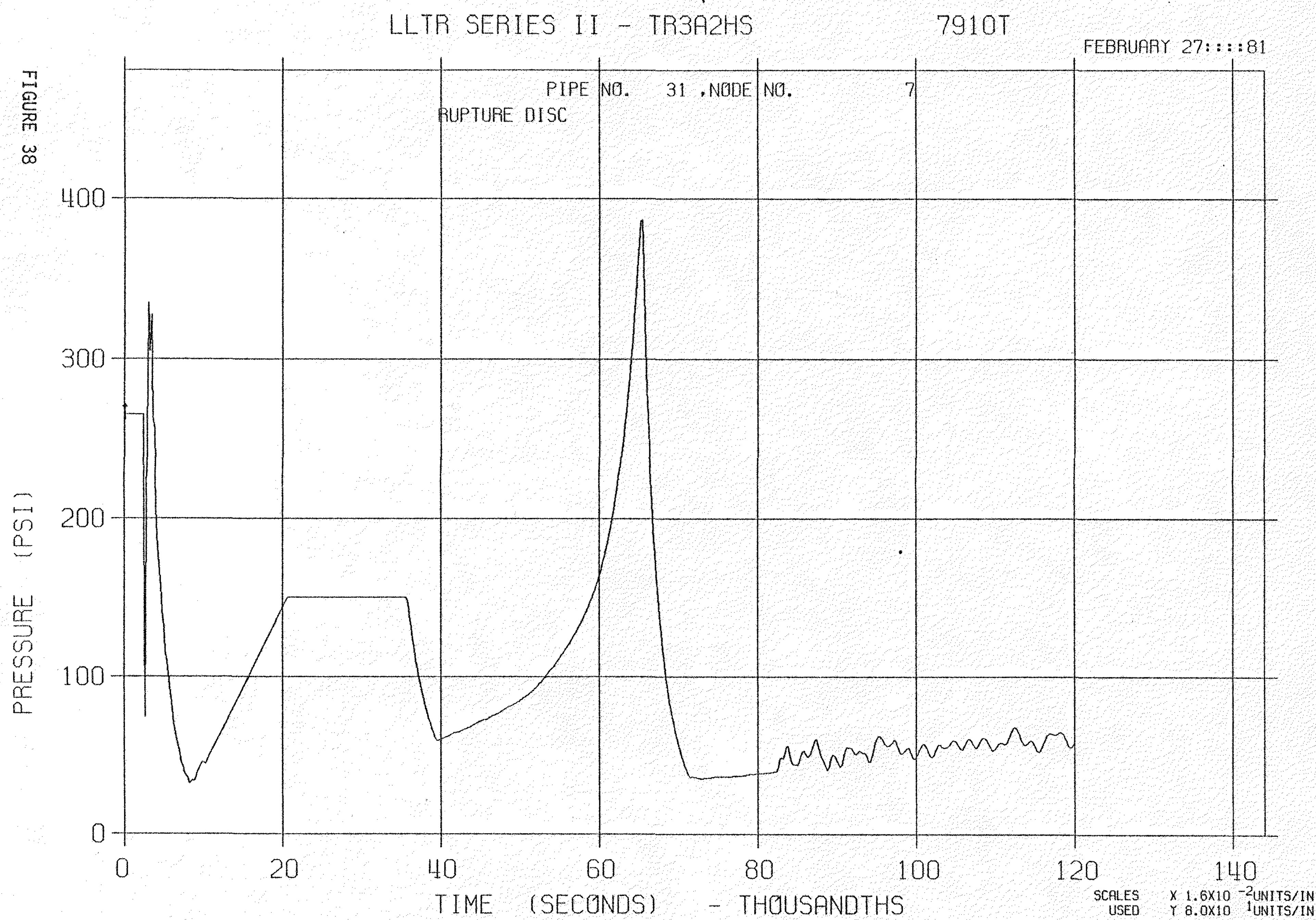
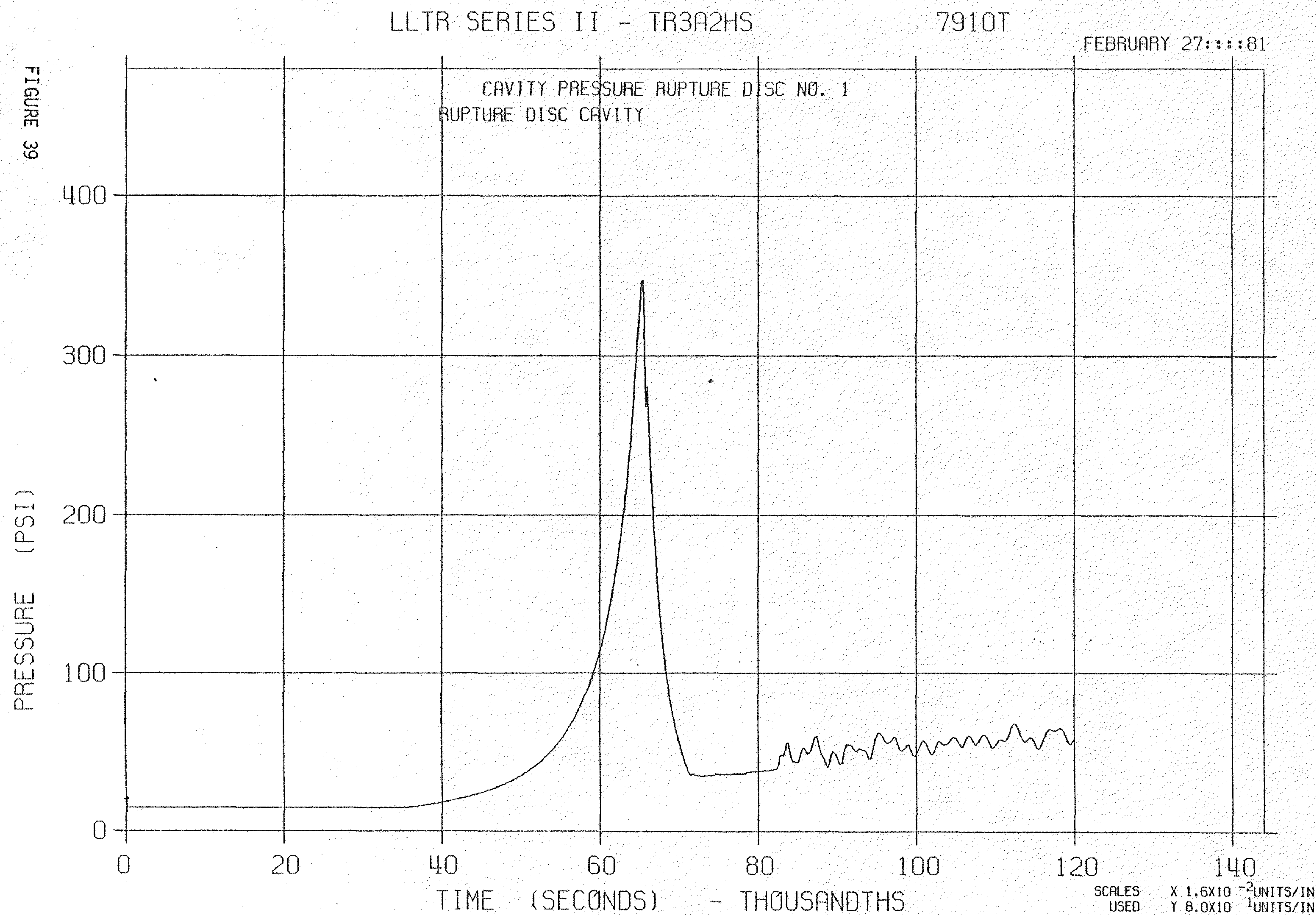
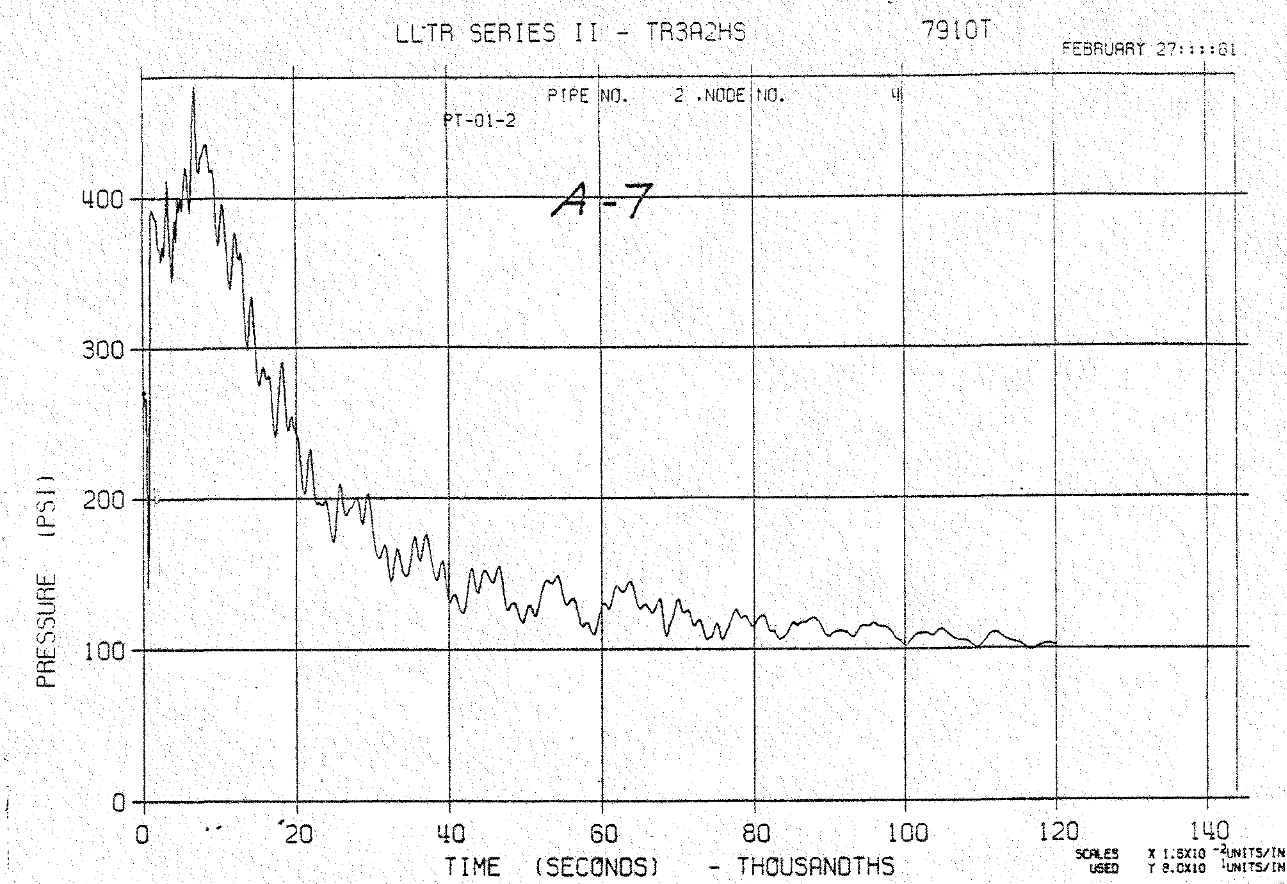

LLTR SERIES II - TR3A2HS
7910T
FEBRUARY 27::::81
PIPE NO. 31 ,NODE NO. 7
RUPTURE DISC
PRESSURE (PSI)
0
100
200
300
400
0
20
40
60
80
100
120
140
TIME (SECONDS) - THOUSANDTHS
SCALES USED
X 1.6X10 -2UNITS/IN
Y 8.0X10 1UNITS/IN

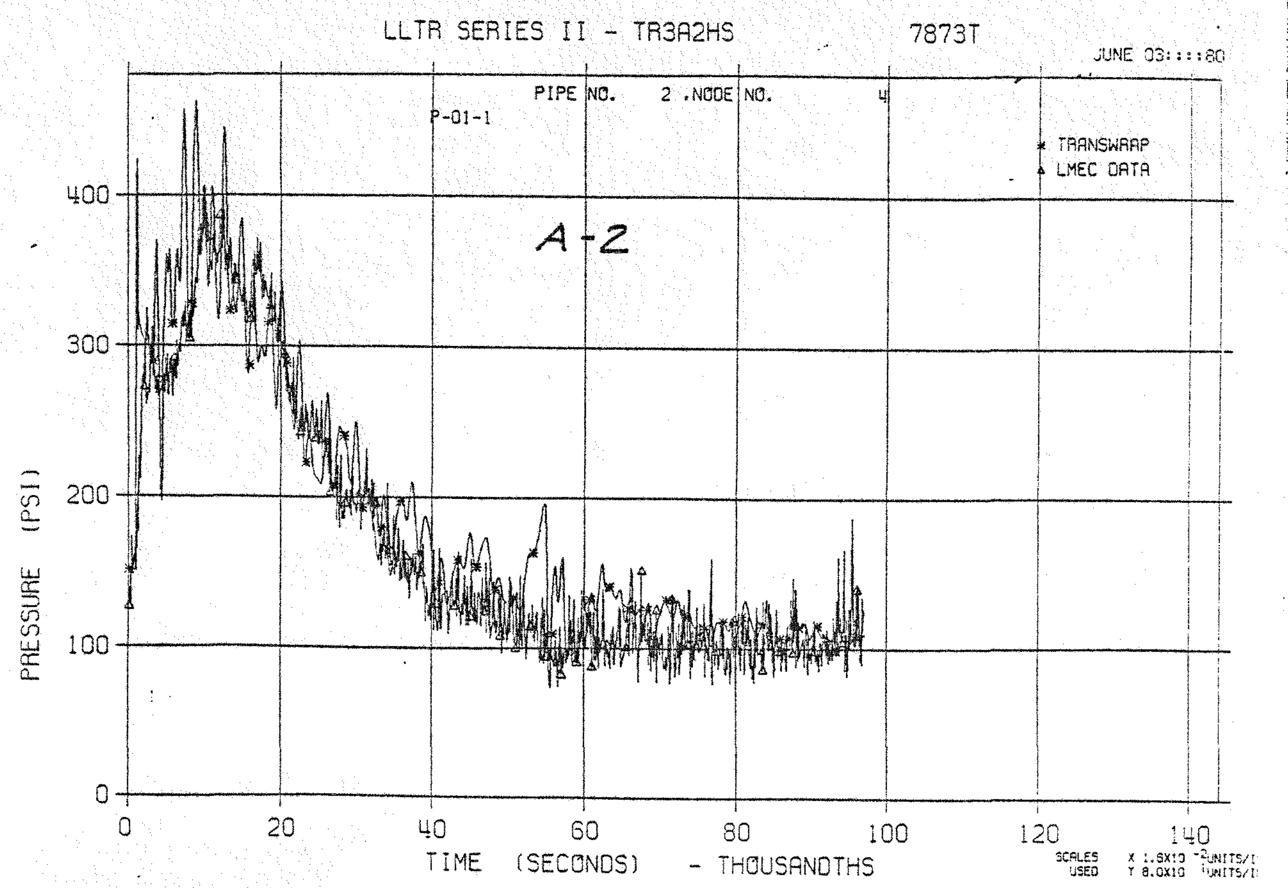
FIGURE 38

FIGURE 39



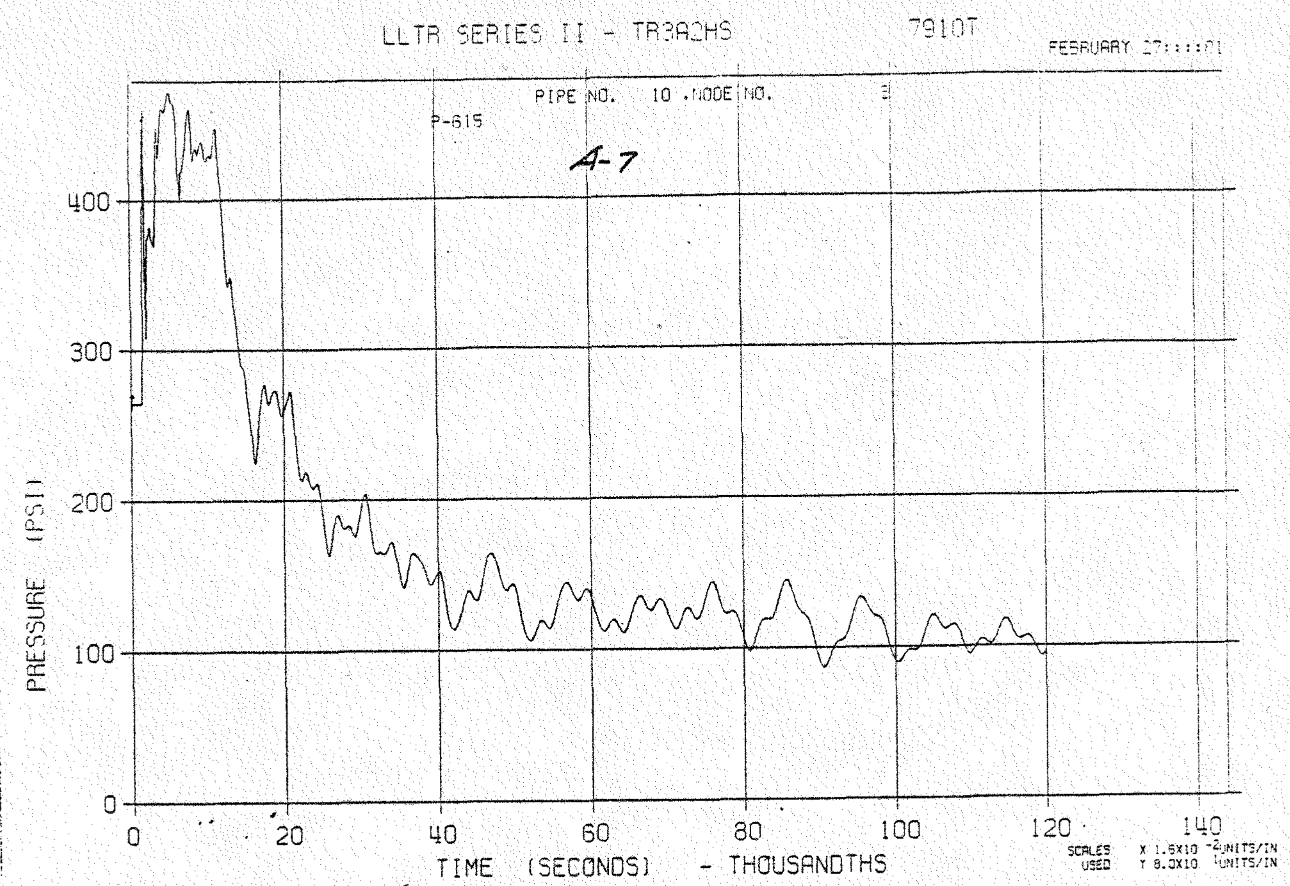
PL 27





PL 1

FIGURE 40


LLTR SERIES II - TR3A2HS
7910T
FEBRUARY 27
PIPE NO. 10 .NODE NO. 3
P-615
A-7
PRESSURE (PSI)
TIME (SECONDS) - THOUSANDTHS
0
20
40
60
80
100
120
140
100
200
300
400

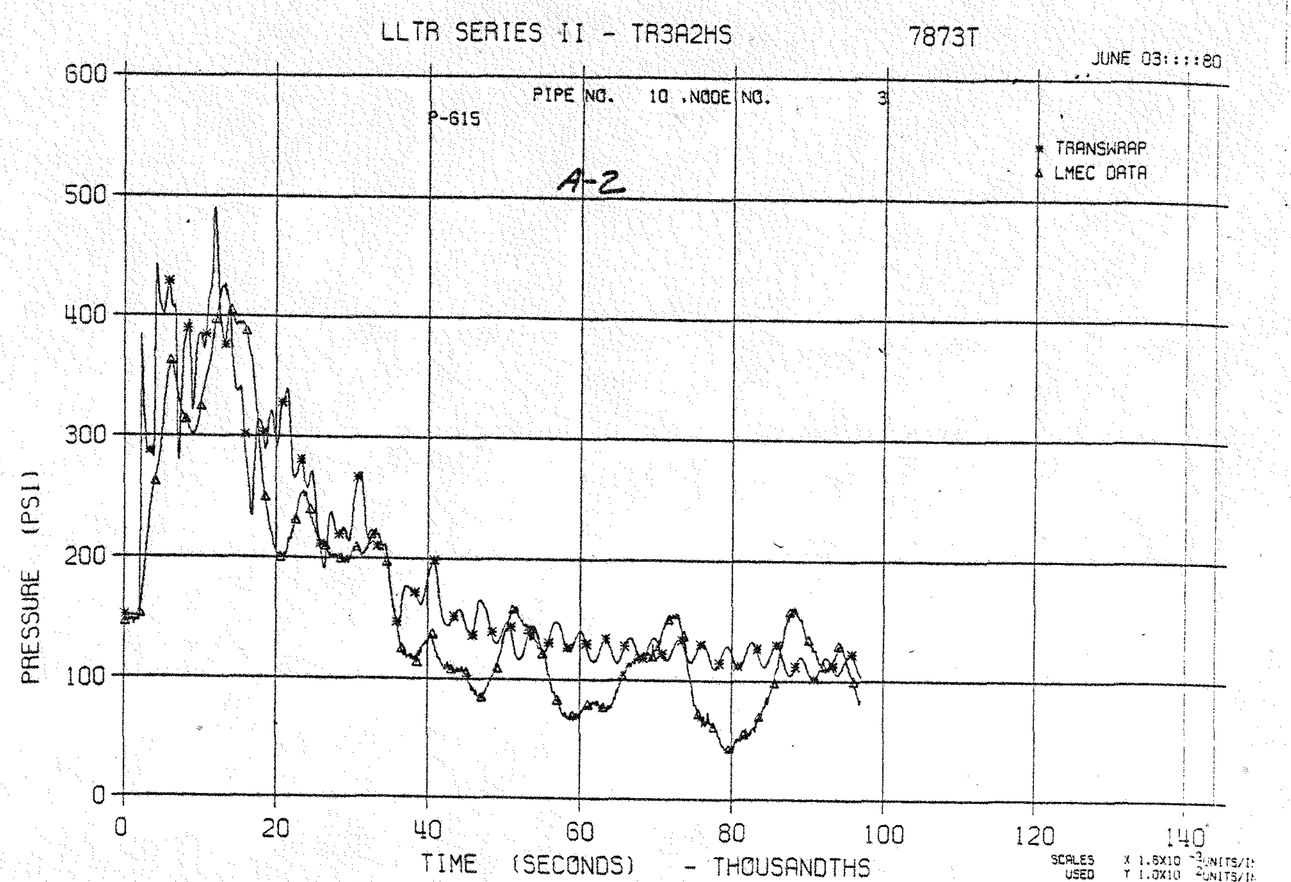
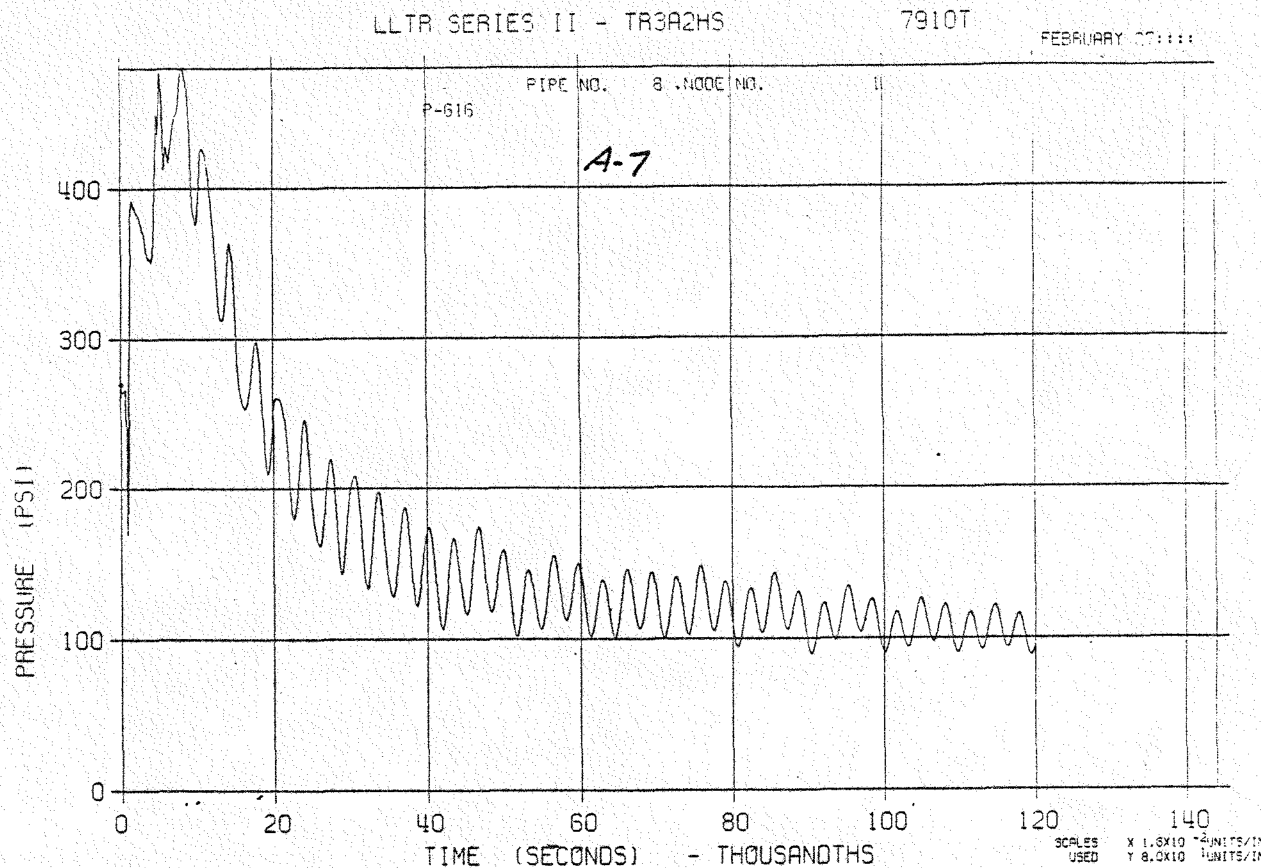
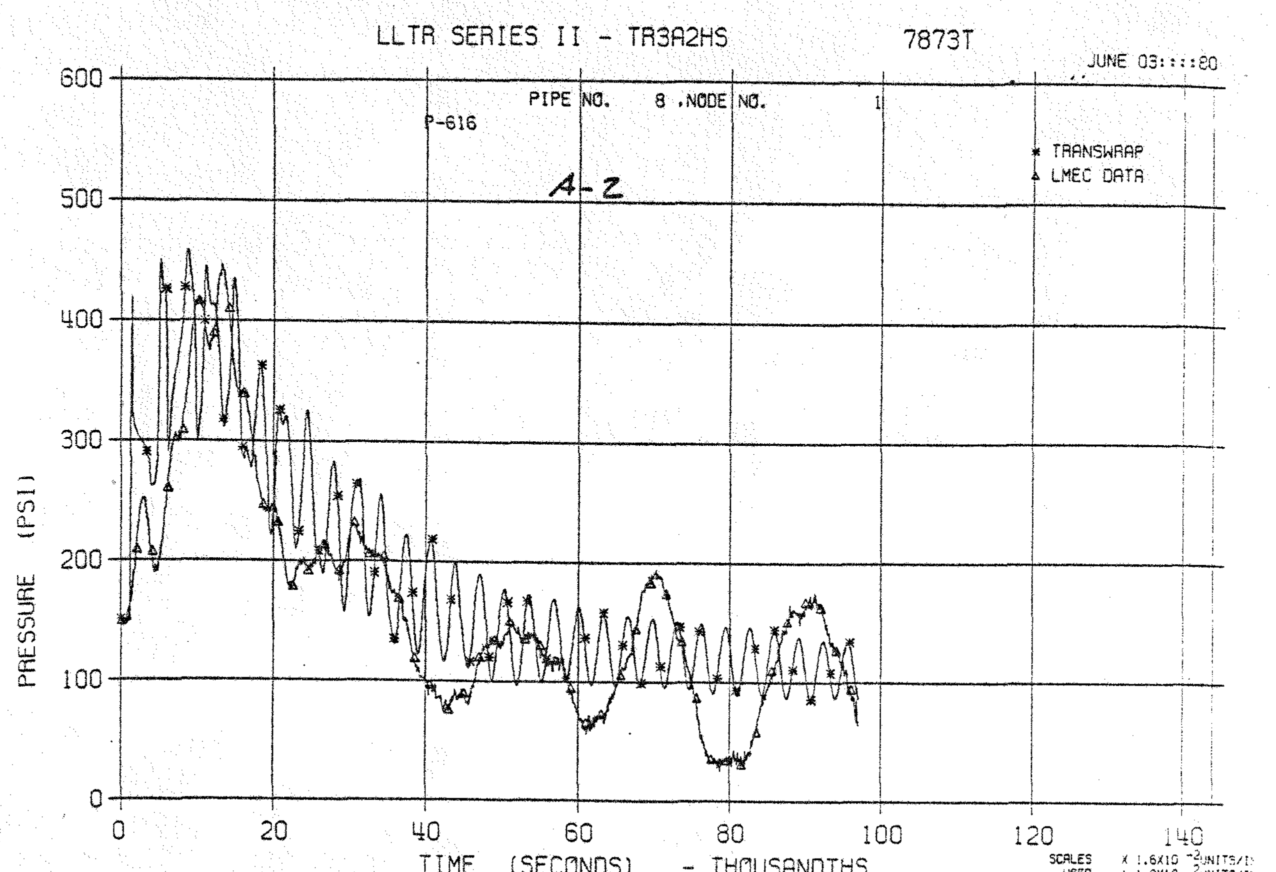

LLTR SERIES II - TR3A2HS
7873T
JUNE 03::::80
PIPE NO. 10 .NODE NO. 3
P-615
A-2
TRANSWRAP
LMEC DATA
PRESSURE (PSI)
TIME (SECONDS) - THOUSANDTHS
0
20
40
60
80
100
120
140
100
200
300
400
500
600

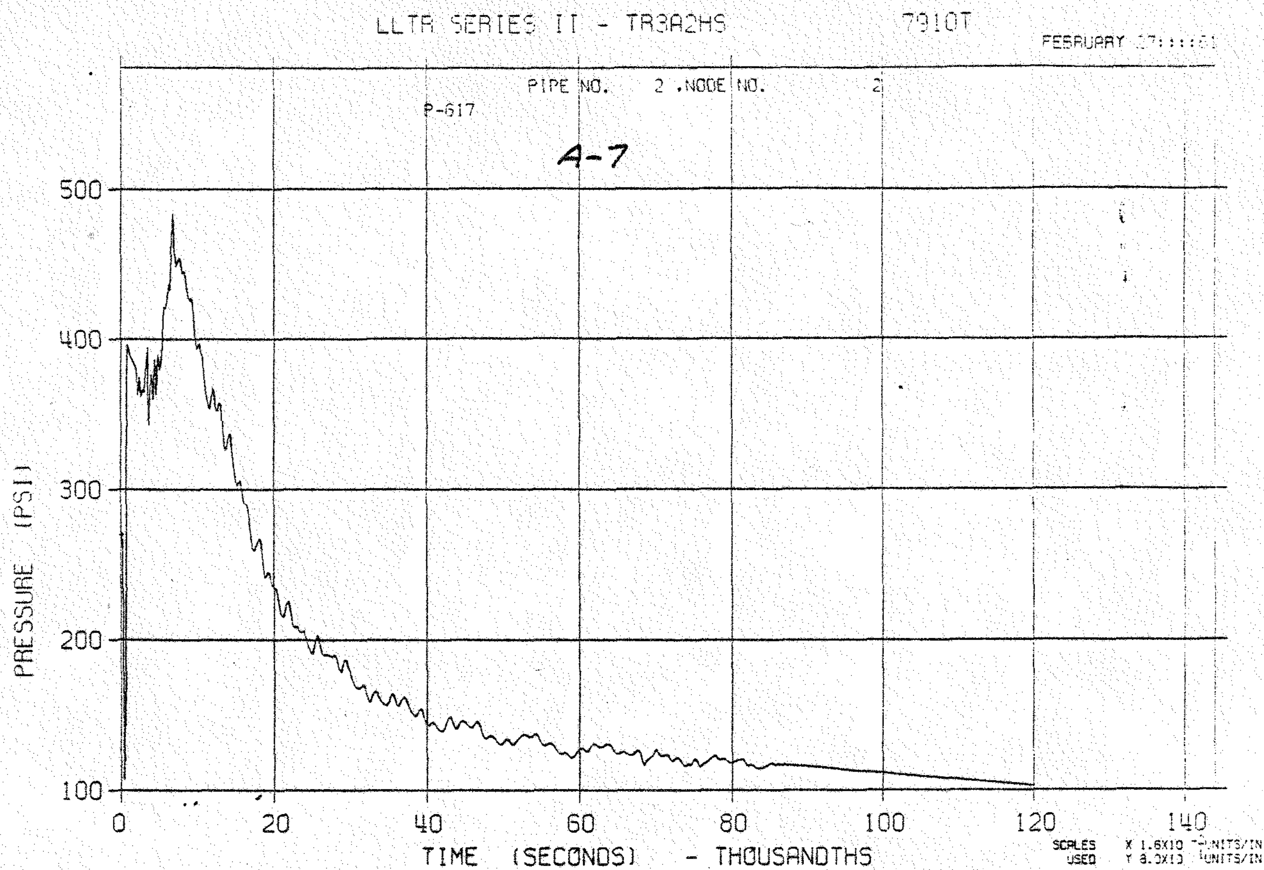
FIGURE 41

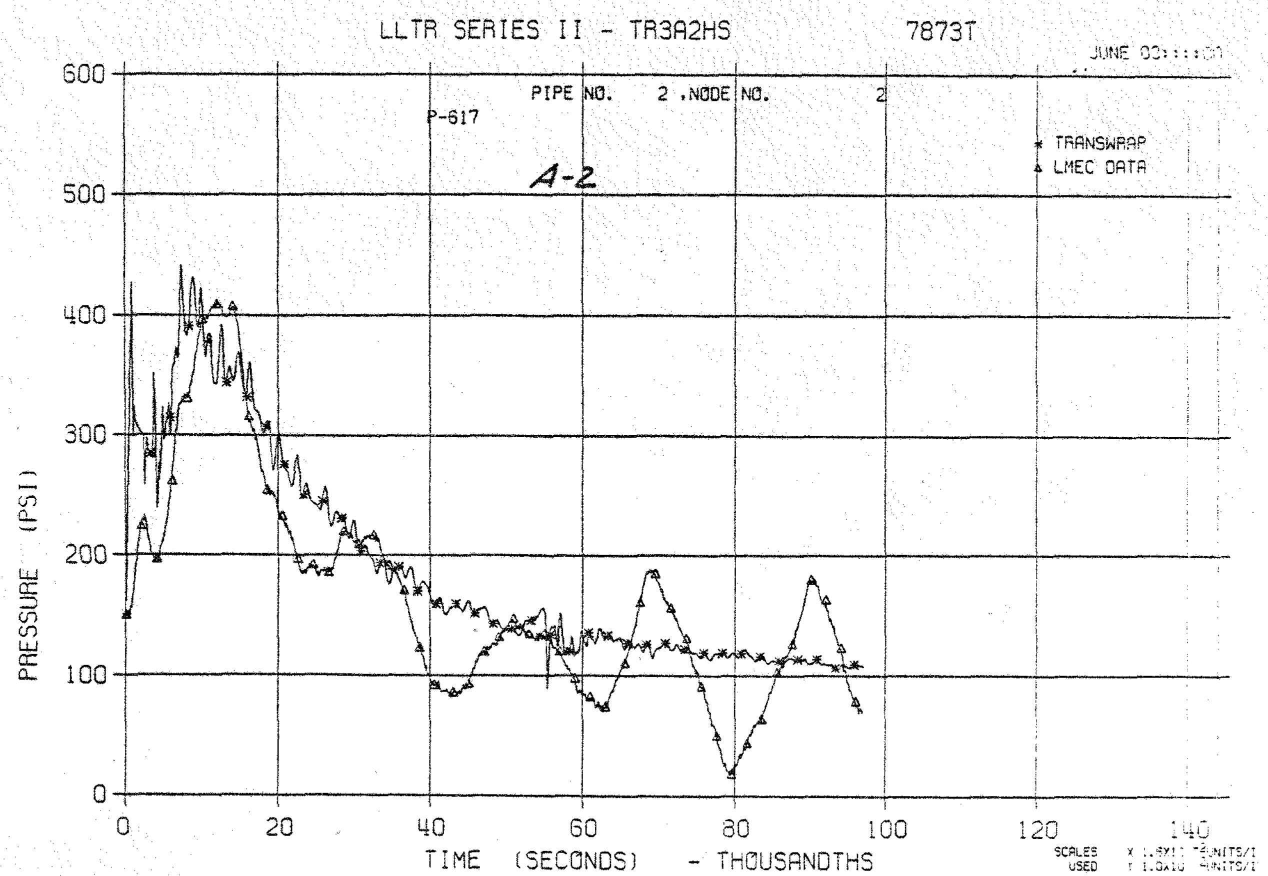




PL 20

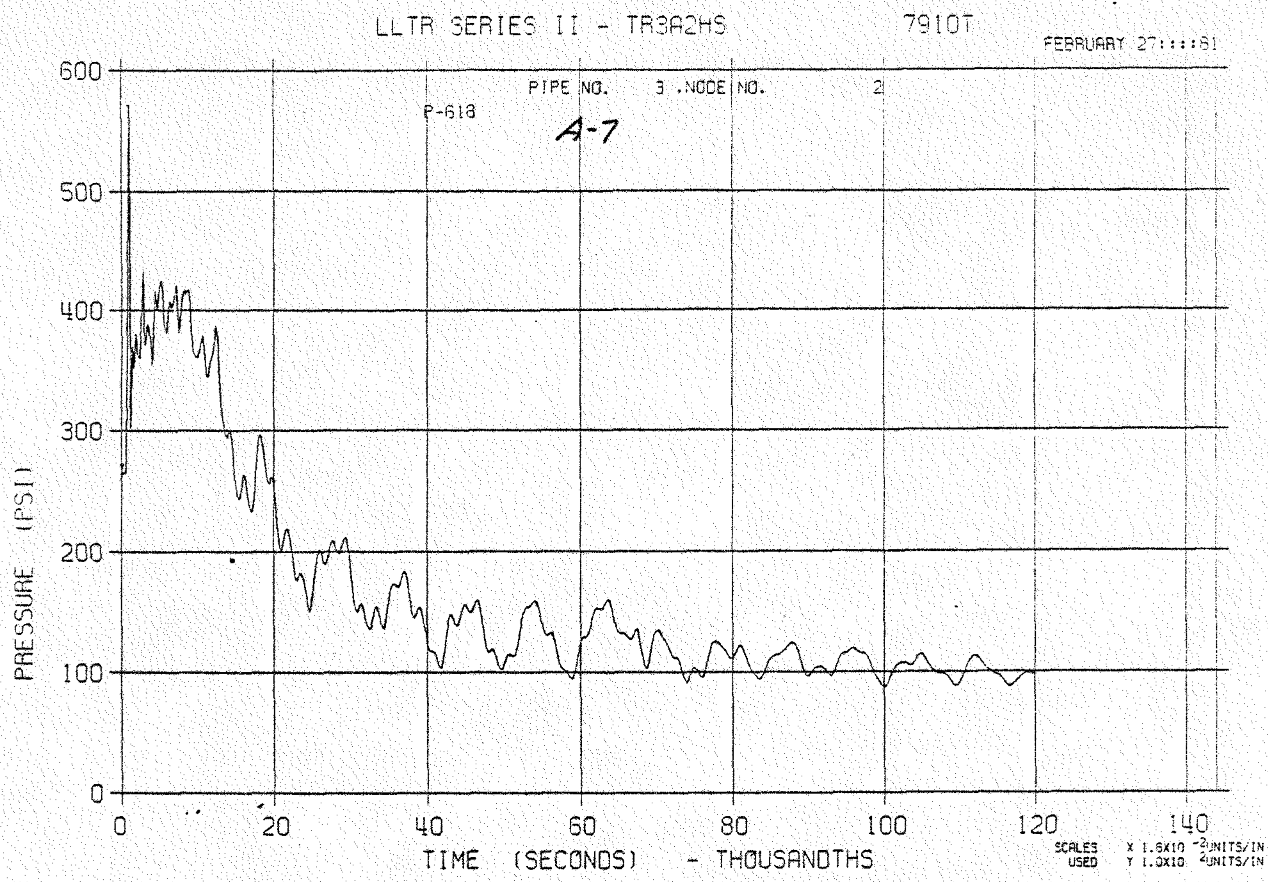
FIGURE 42

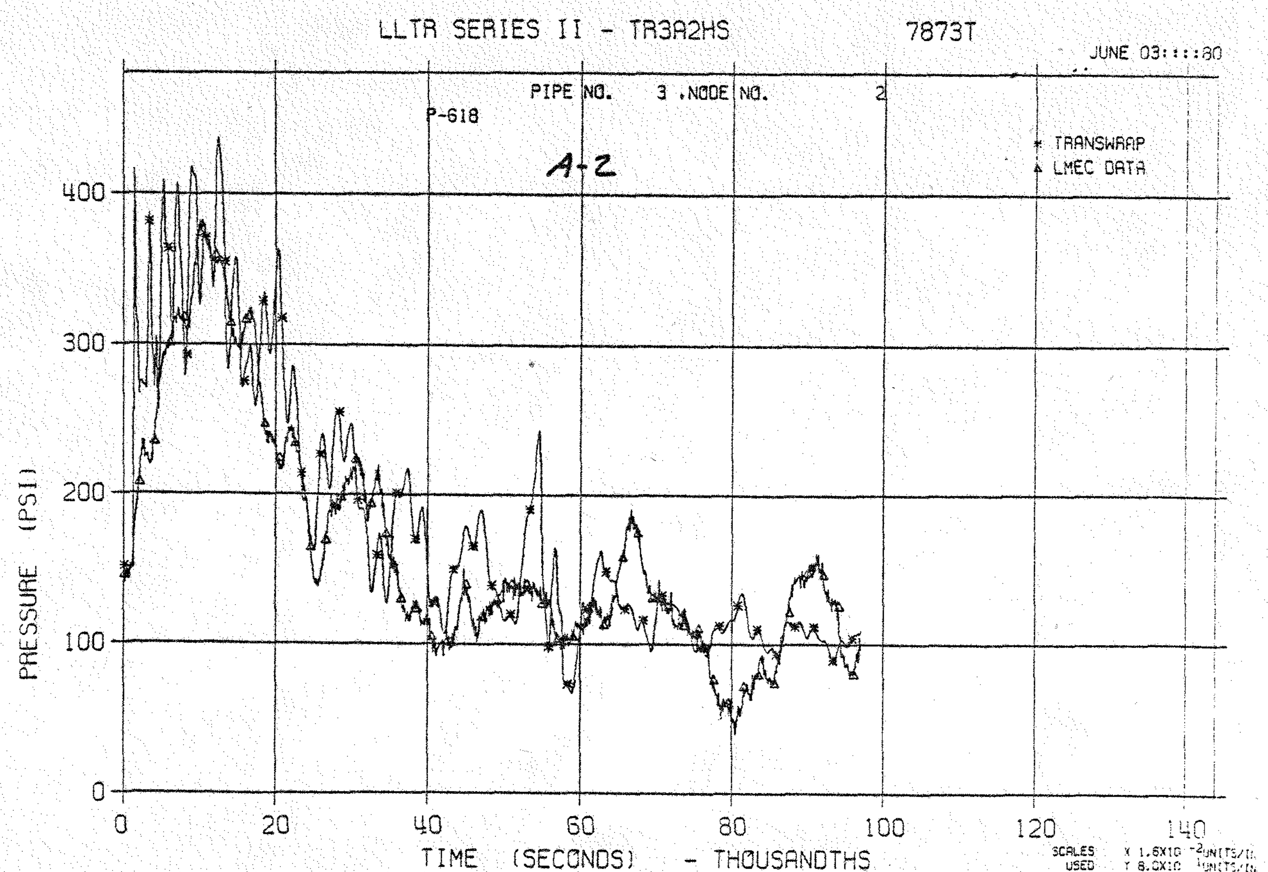




PL 21

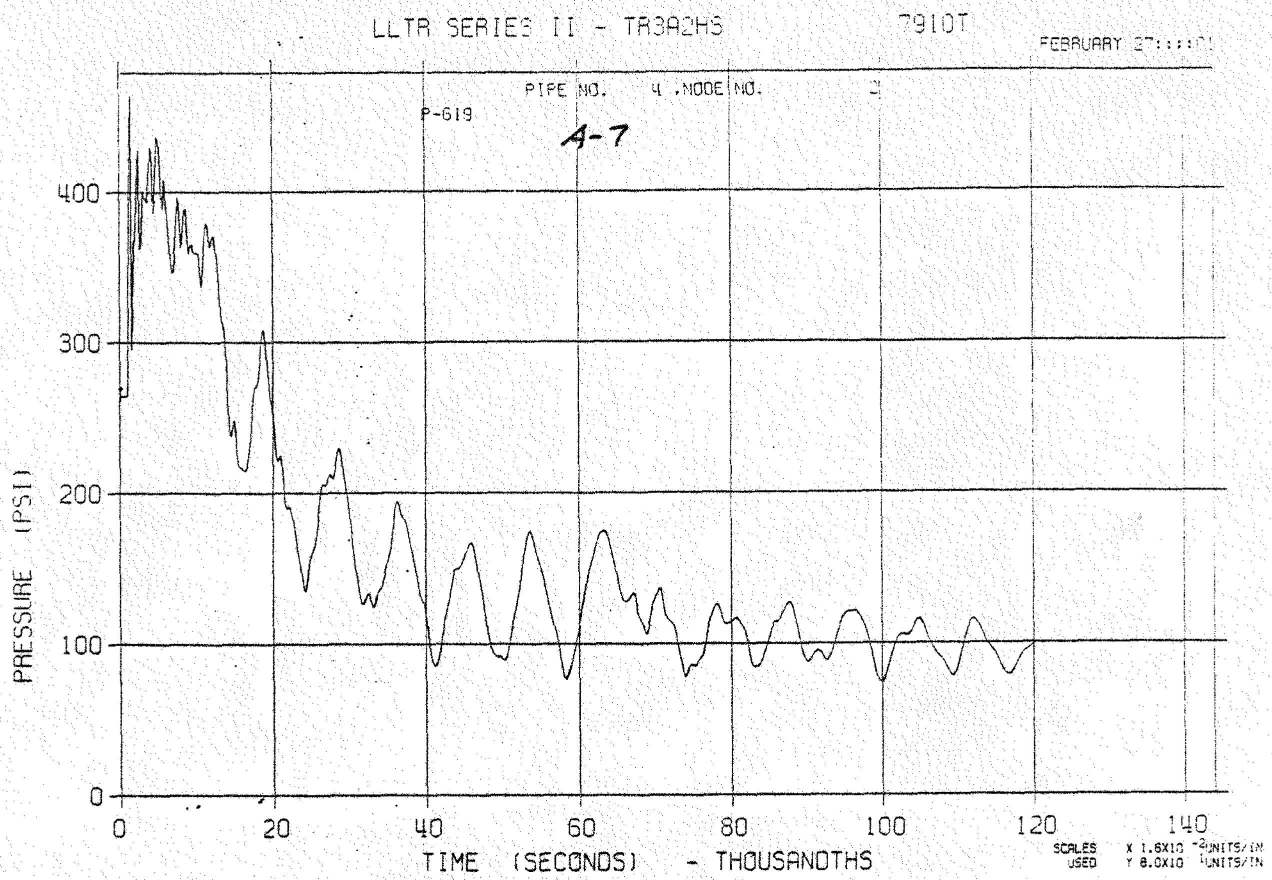
FIGURE 43





PL 22

FIGURE 44


LLTR SERIES II - TR3A2HS
7910T
FEBRUARY
PIPE NO. 4 ,NODE NO.
P-619
A-7
PRESSURE (PSI)
0
100
200
300
400
0
20
40
60
80
100
120
140
TIME (SECONDS) - THOUSANDTHS
SCALES USED

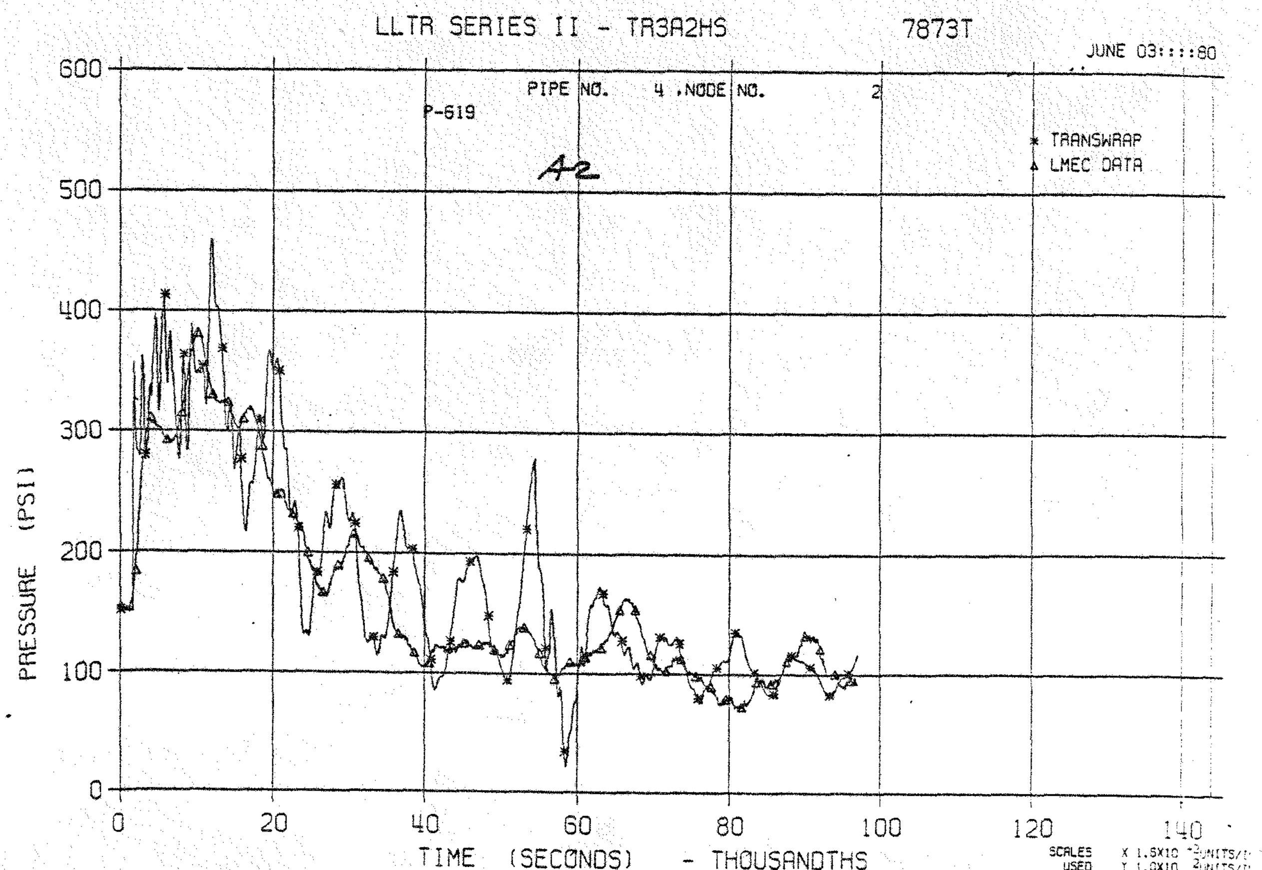
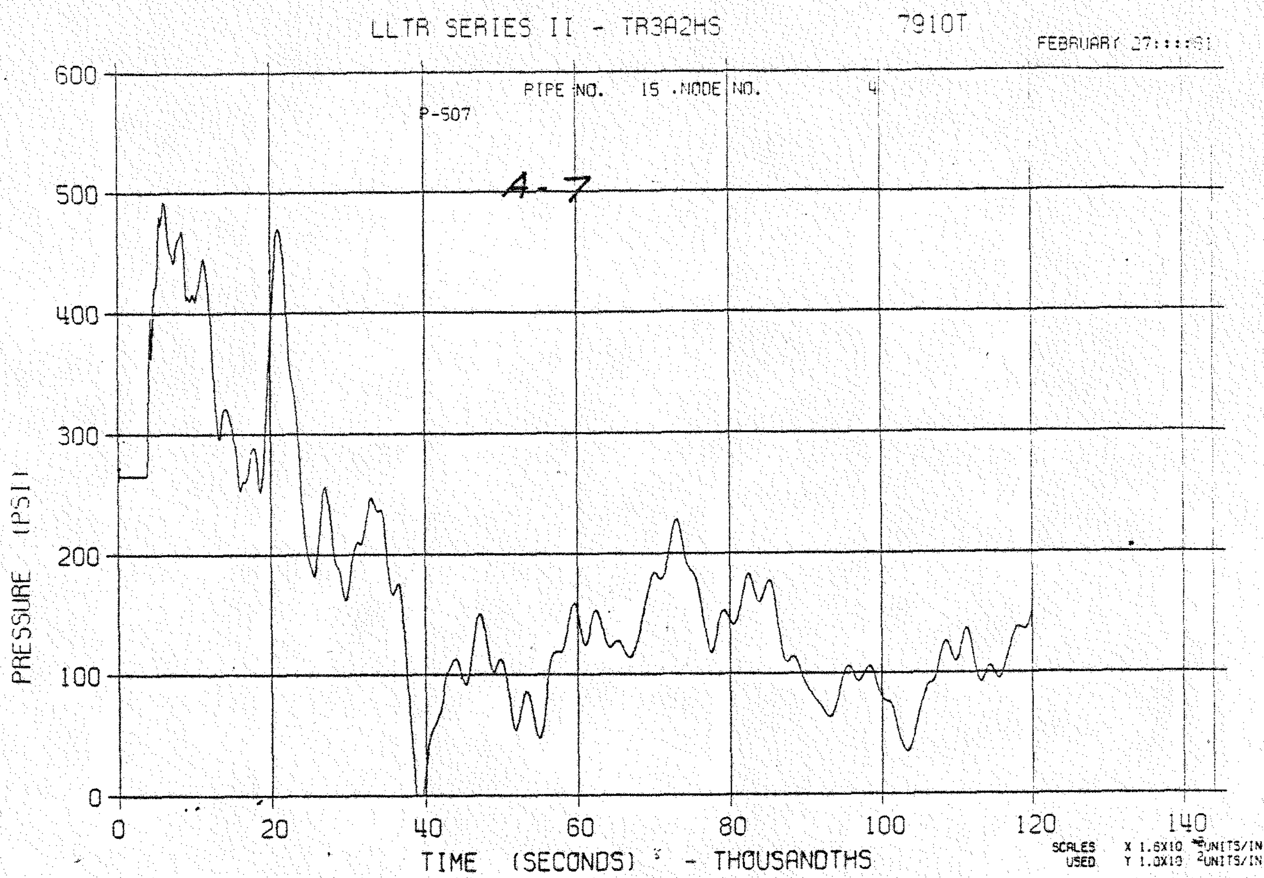

LLTR SERIES II - TR3A2HS
7873T
JUNE 03::::80
PIPE NO. 4 ,NODE NO. 2
P-619
A2
* TRANSWRAP
Δ LMEC DATA
PRESSURE (PSI)
0
100
200
300
400
500
600
0
20
40
60
80
100
120
140
TIME (SECONDS) - THOUSANDTHS
SCALES USED

FIGURE 45


LLTR SERIES II - TR3A2HS
7910T
FEBRUARY 27
PIPE NO. 15 .NODE NO. 4
P-507
A-7
PRESSURE (PSI)
0
100
200
300
400
500
600
0
20
40
60
80
100
120
140
TIME (SECONDS) - THOUSANDTHS
SCALES USED

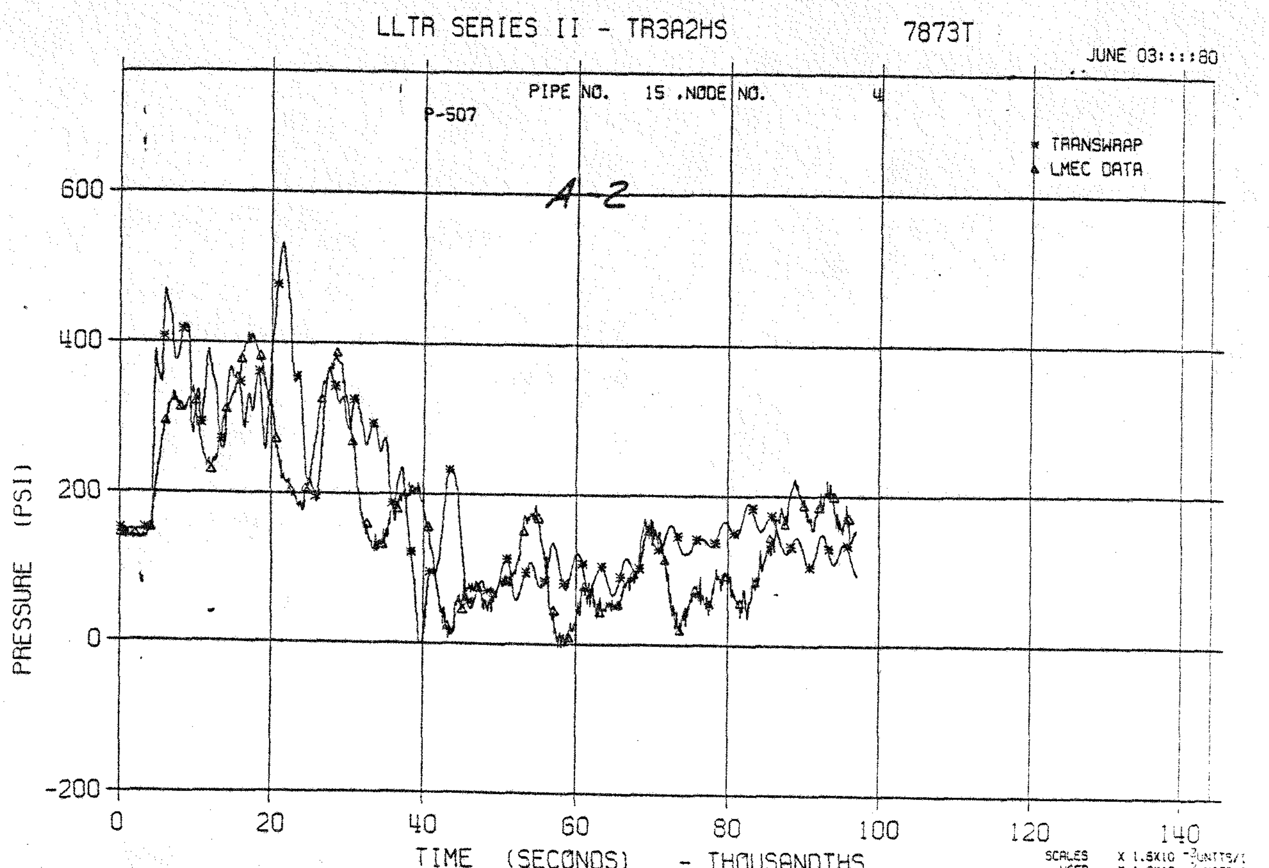
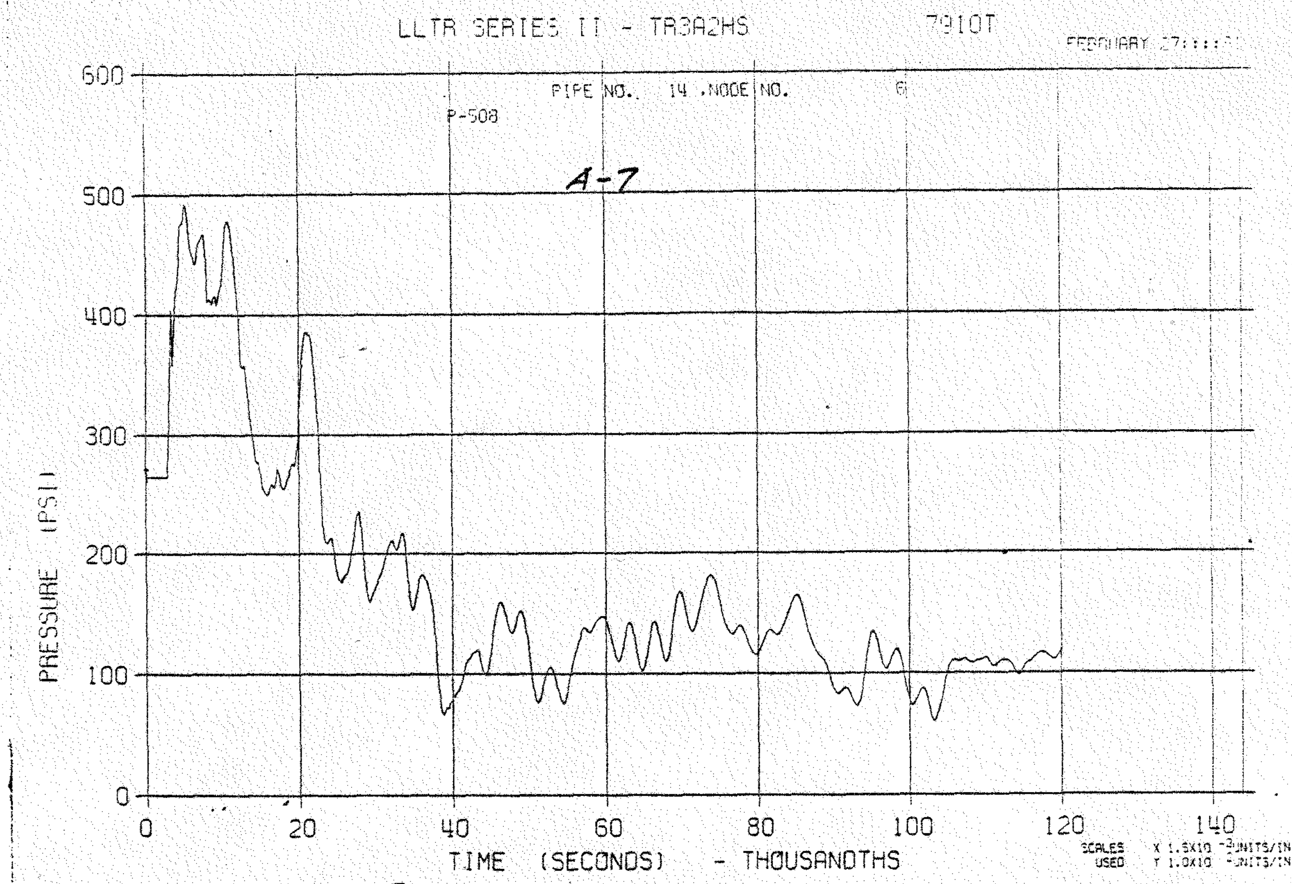

LLTR SERIES II - TR3A2HS
7873T
JUNE 03:::80
PIPE NO. 15 .NODE NO. 4
P-507
TRANSWRAP
LMEC DATA
A-2
PRESSURE (PSI)
-200
0
200
400
600
0
20
40
60
80
100
120
140
TIME (SECONDS) - THOUSANDTHS
SCALES USED

FIGURE 46



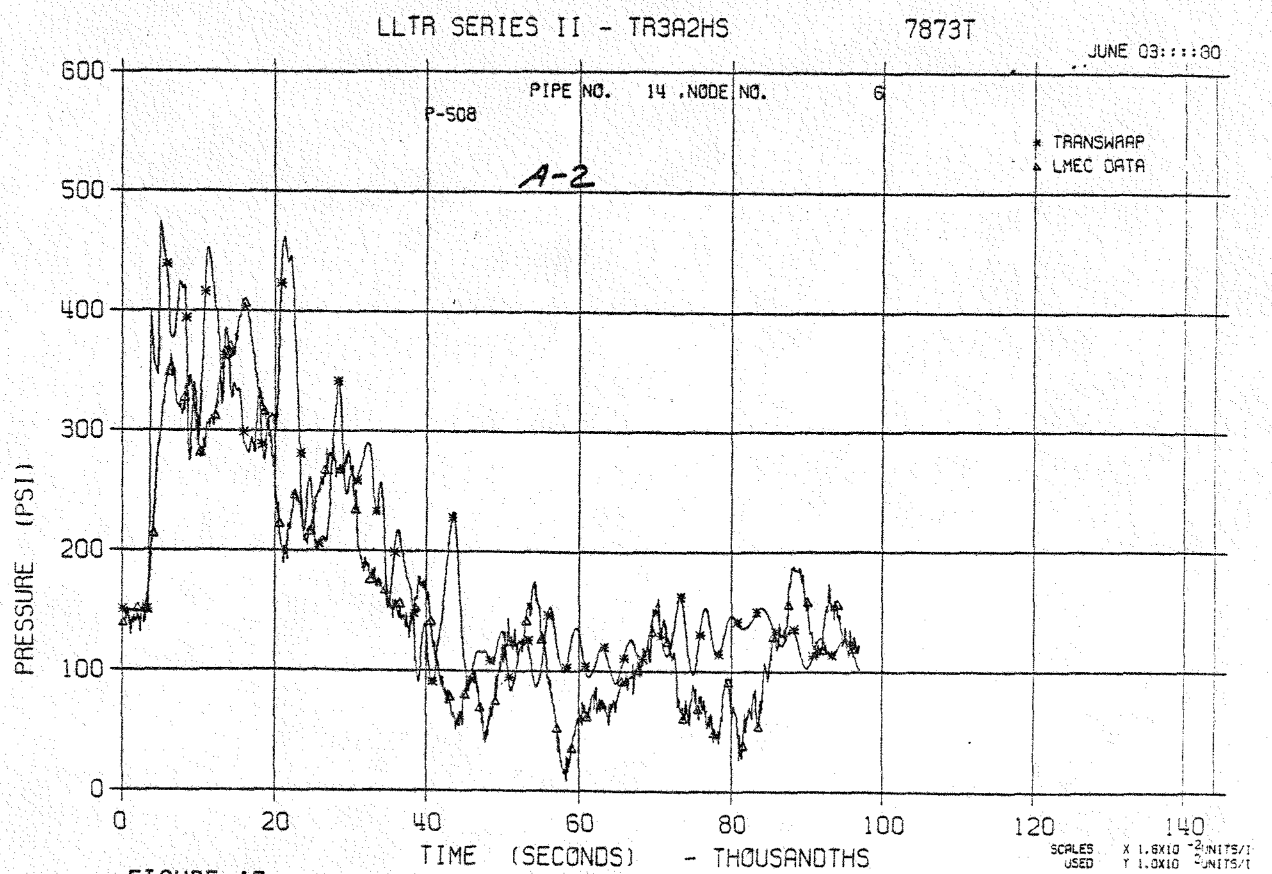
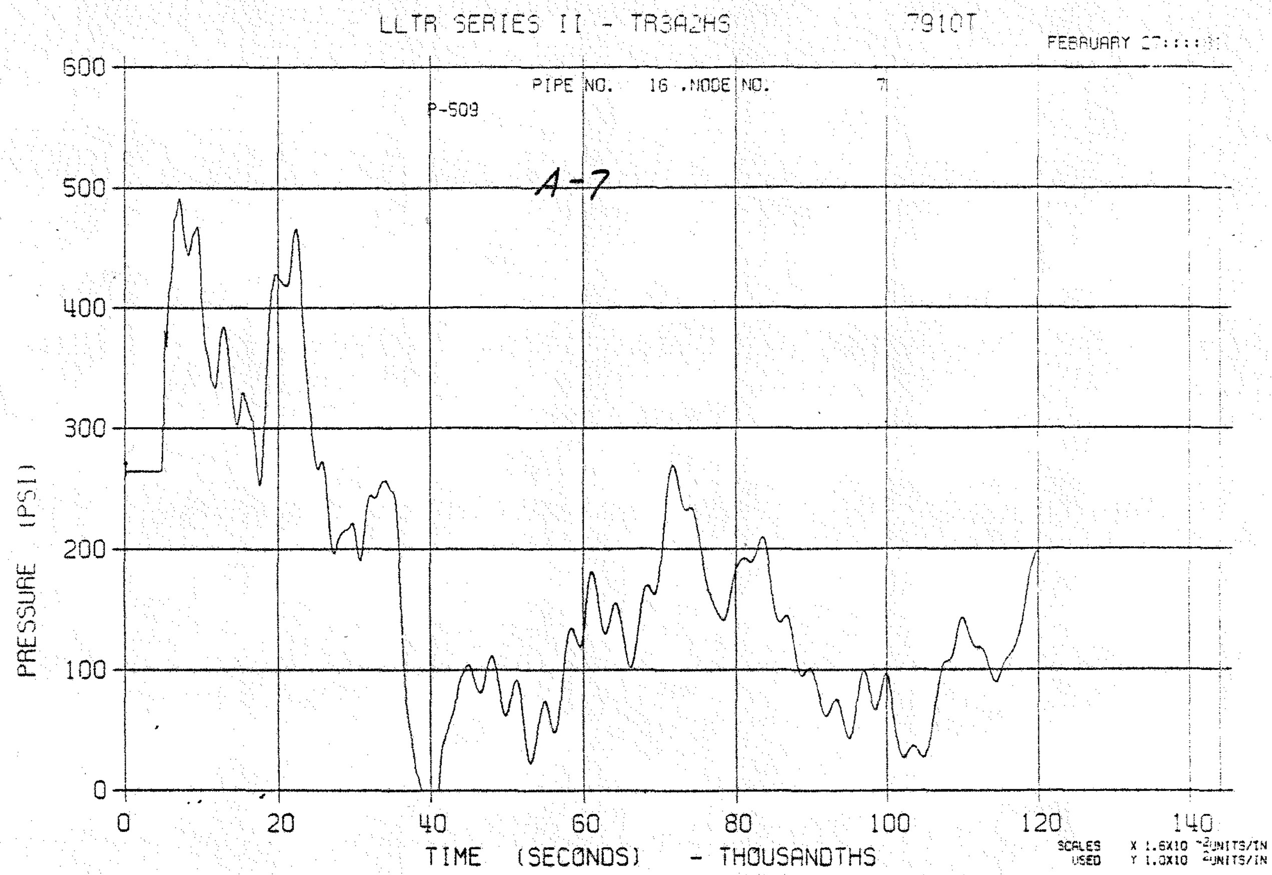


FIGURE 47

PL 8



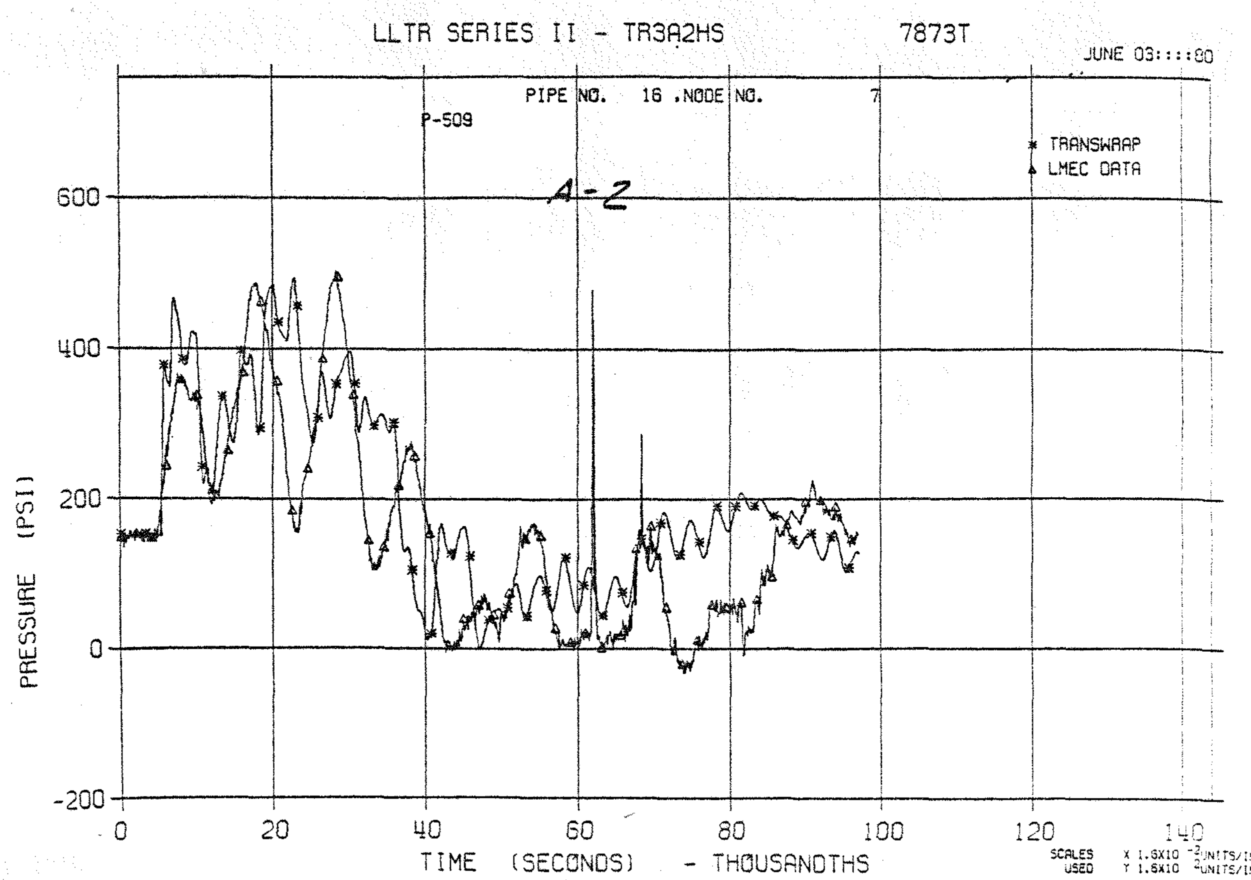
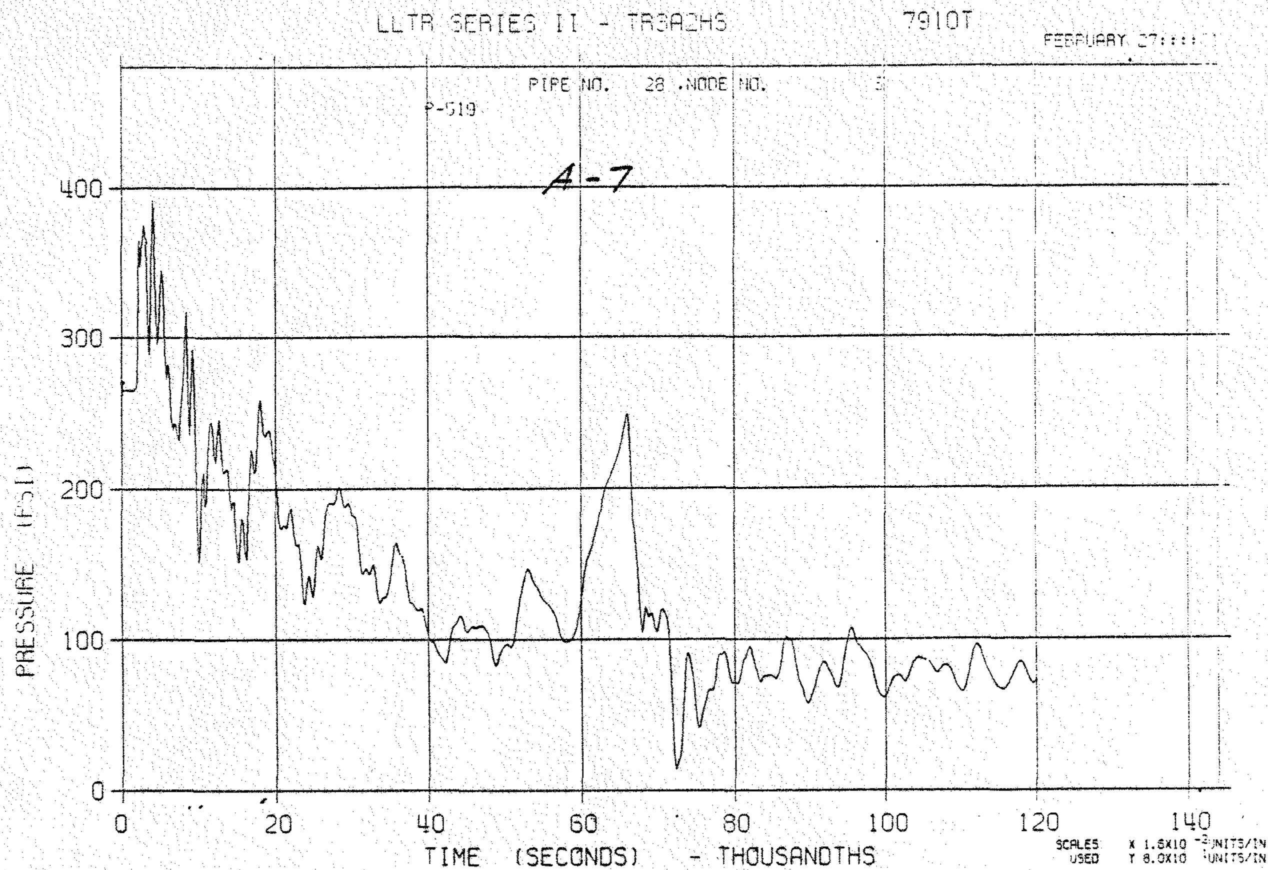
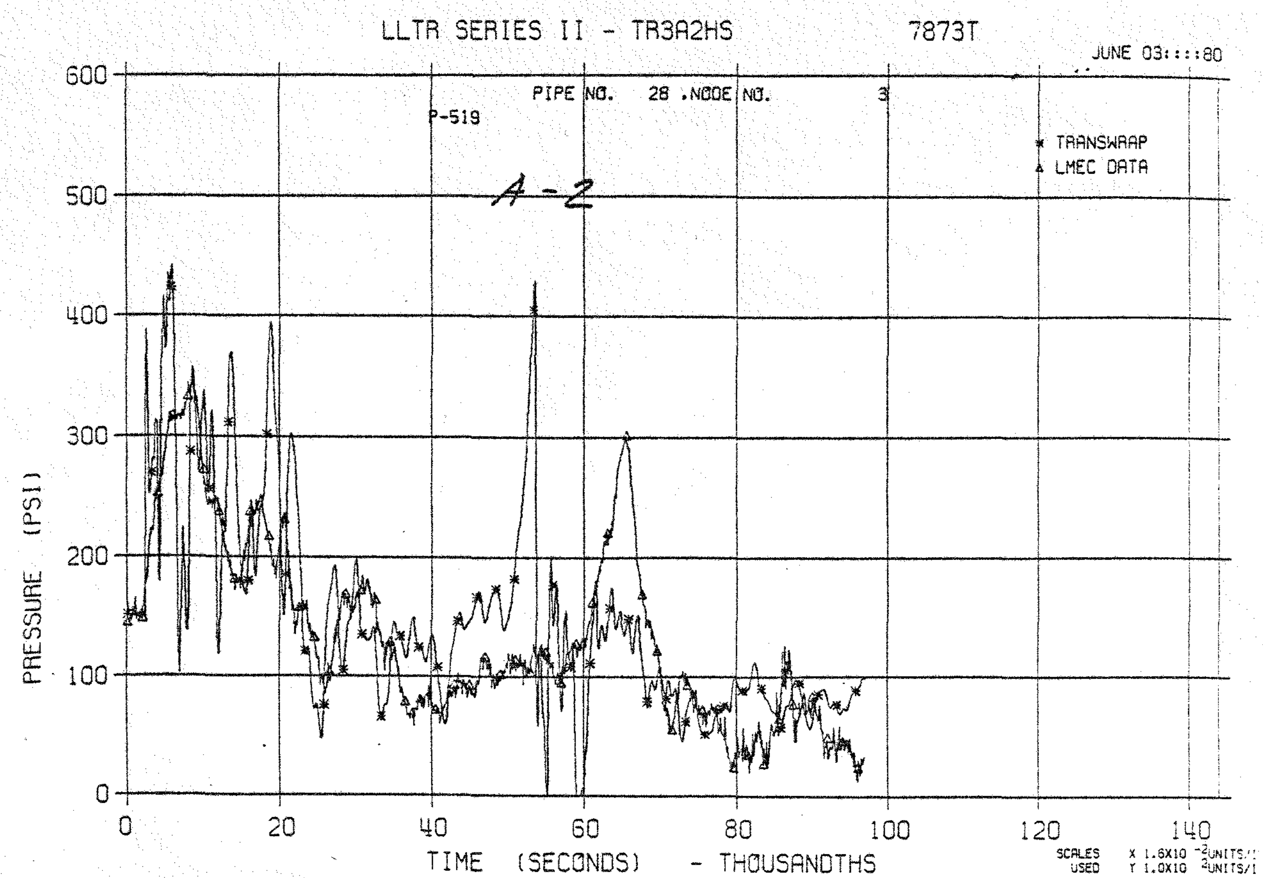


FIGURE 48

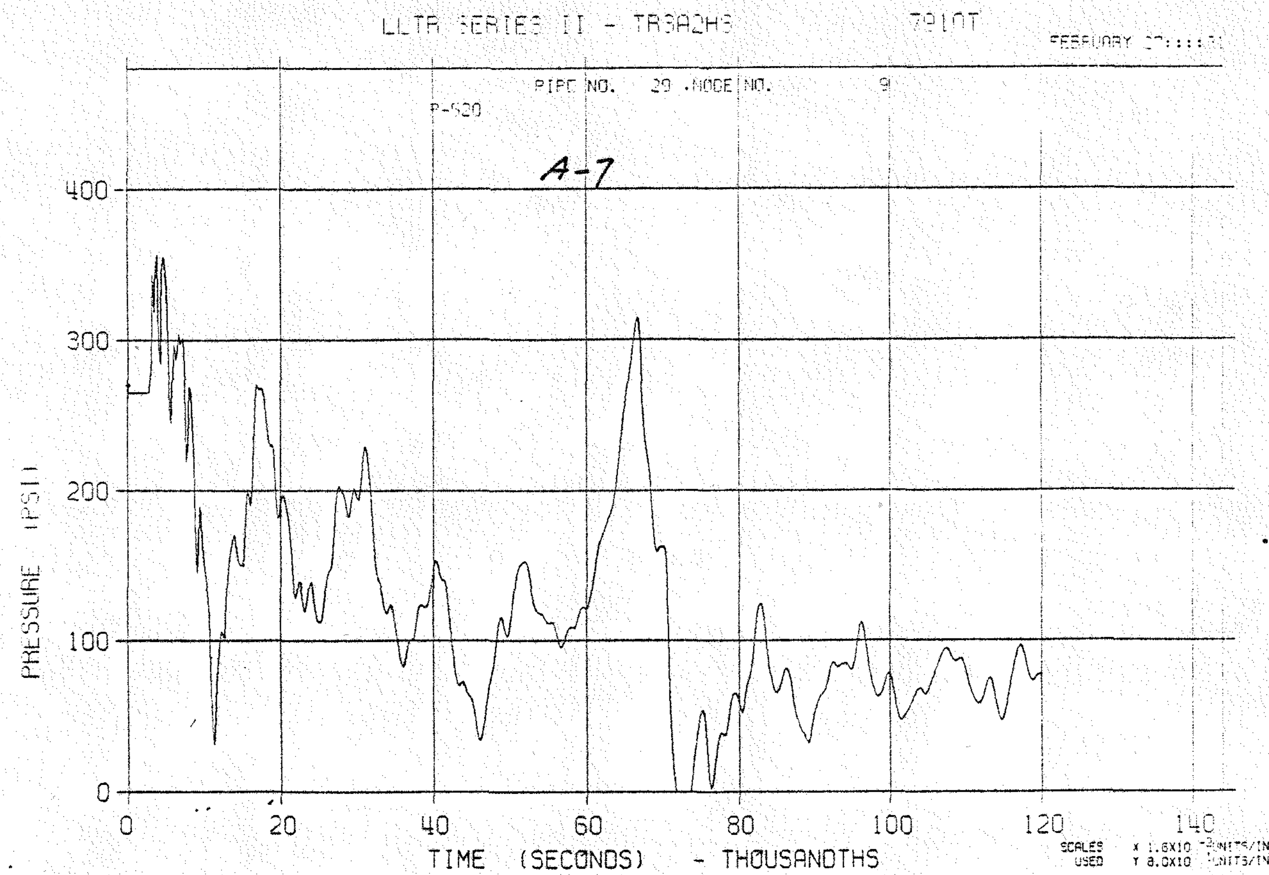
PL 9





PL 11

FIGURE 49


LLTR SERIES II - TR3A2HS
7910T
FEBRUARY
PIPE NO. 29 .NODE NO. 9
P-520
A-7
PRESSURE (PSI)
400
300
200
100
0
0
20
40
60
80
100
120
140
TIME (SECONDS) - THOUSANDTHS
SCALES USED
X 1.6X10⁻² UNITS/IN
Y 8.0X10 UNITS/IN

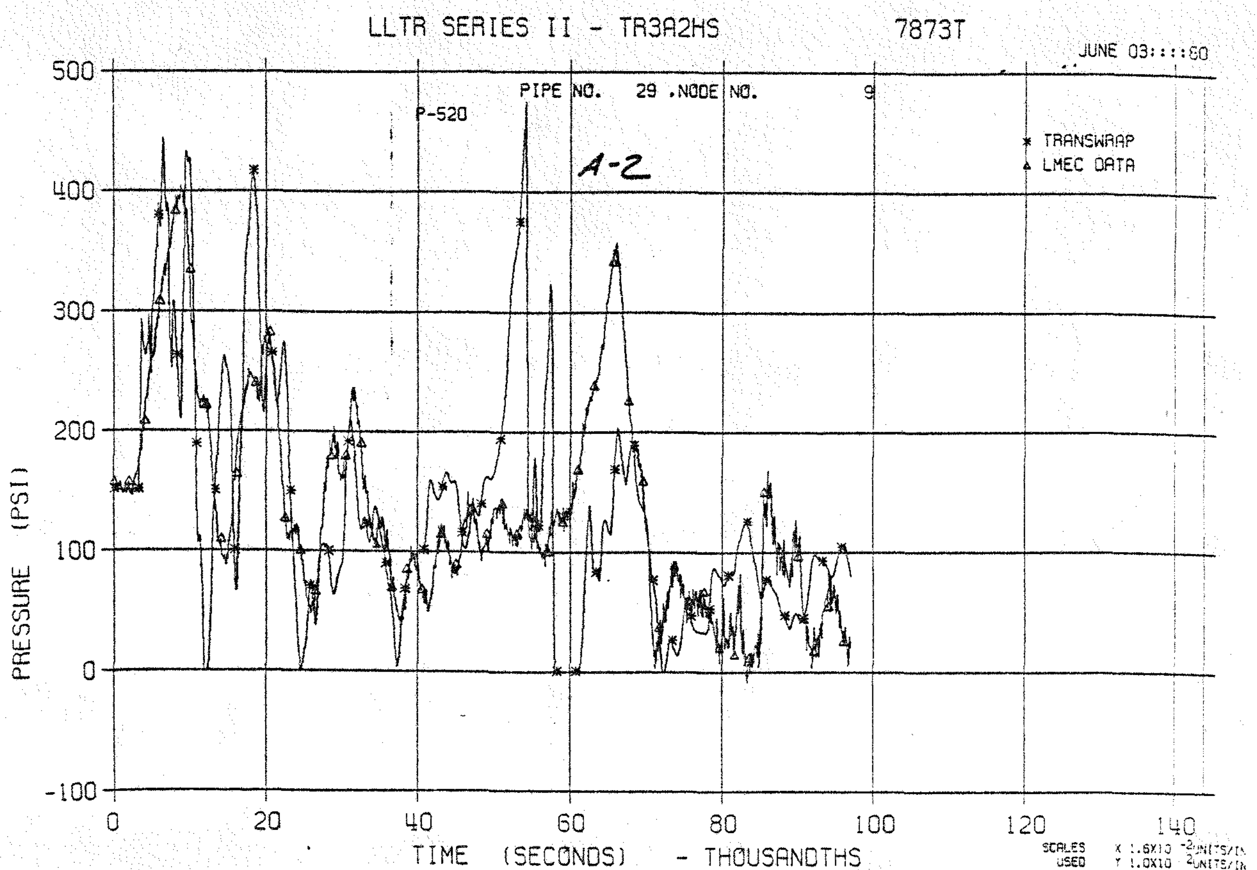
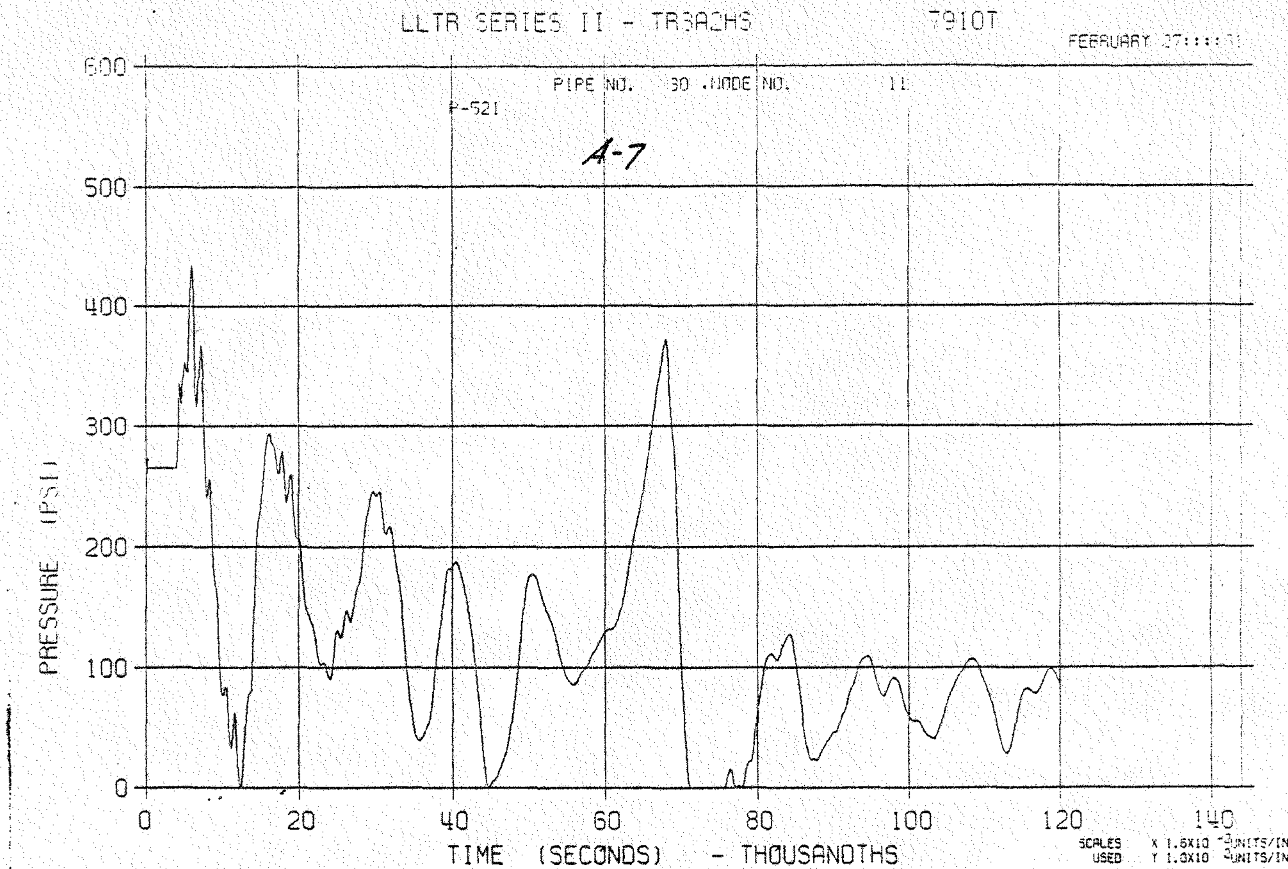
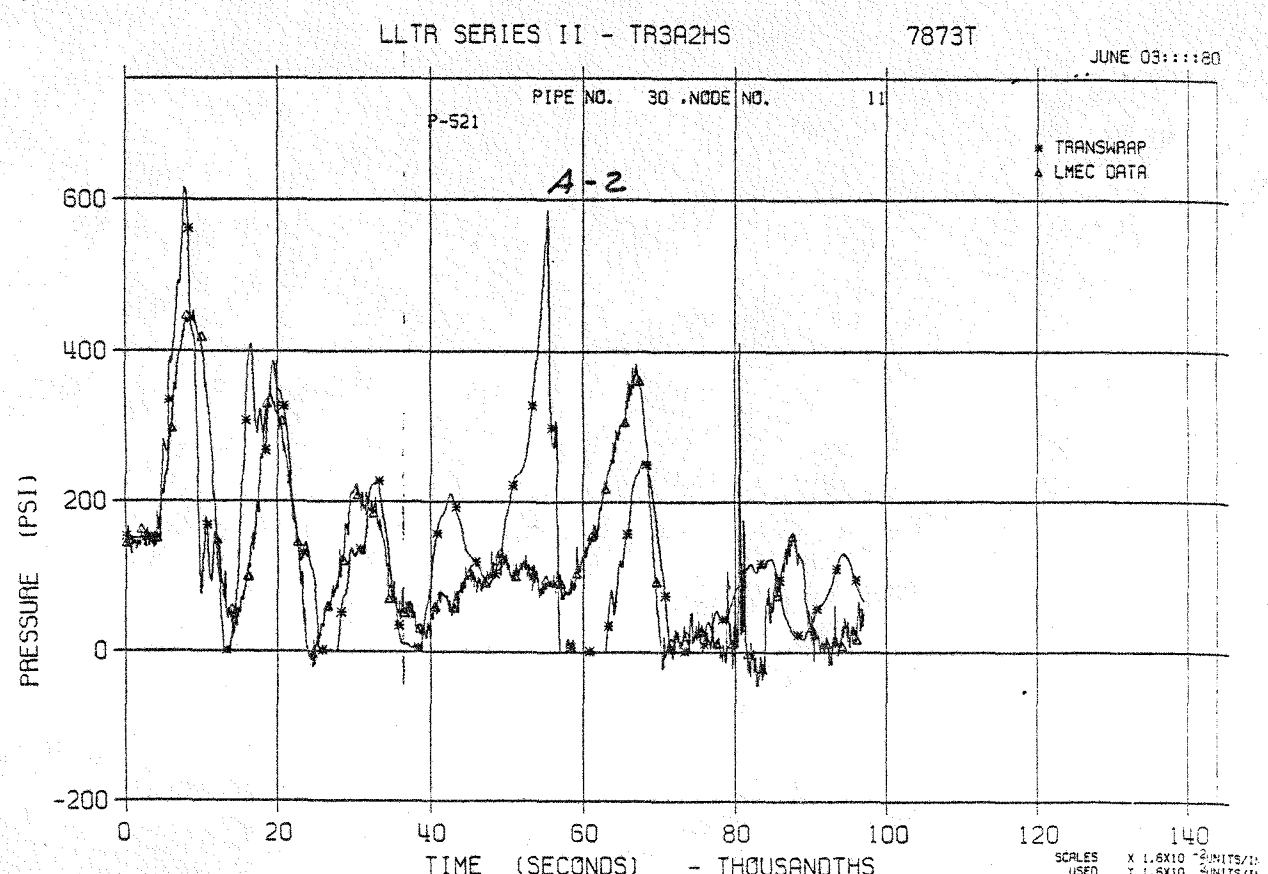

LLTR SERIES II - TR3A2HS
7873T
JUNE 03::::80
PIPE NO. 29 .NODE NO. 9
P-520
A-2
TRANSWRAP
LMEC DATA
PRESSURE (PSI)
500
400
300
200
100
0
-100
0
20
40
60
80
100
120
140
TIME (SECONDS) - THOUSANDTHS
SCALES USED
X 1.6X10 UNITS/IN
Y 1.0X10 UNITS/IN

FIGURE 50

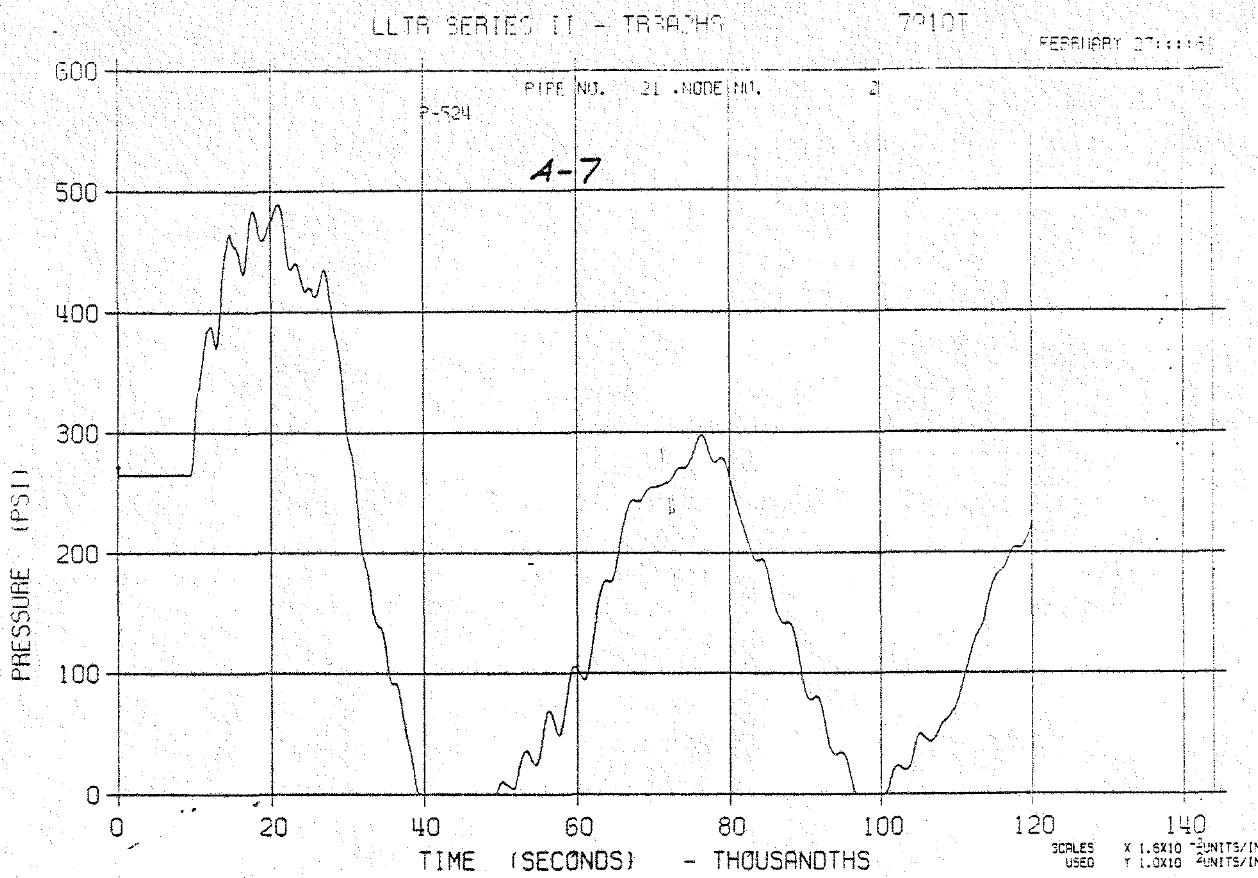


LLTR SERIES II - TR3A2HS
7910T
FEBRUARY 27
PIPE NO. 30 .NODE NO. 11
P-521
A-7
PRESSURE (PSI)
0
100
200
300
400
500
600
0
20
40
60
80
100
120
140
TIME (SECONDS) - THOUSANDTHS
SCALES USED



LLTR SERIES II - TR3A2HS
7873T
JUNE 03::::80
PIPE NO. 30 .NODE NO. 11
P-521
A-2
* TRANSWRAP
Δ LMEC DATA
PRESSURE (PSI)
-200
0
200
400
600
0
20
40
60
80
100
120
140
TIME (SECONDS) - THOUSANDTHS
SCALES USED

FIGURE 51



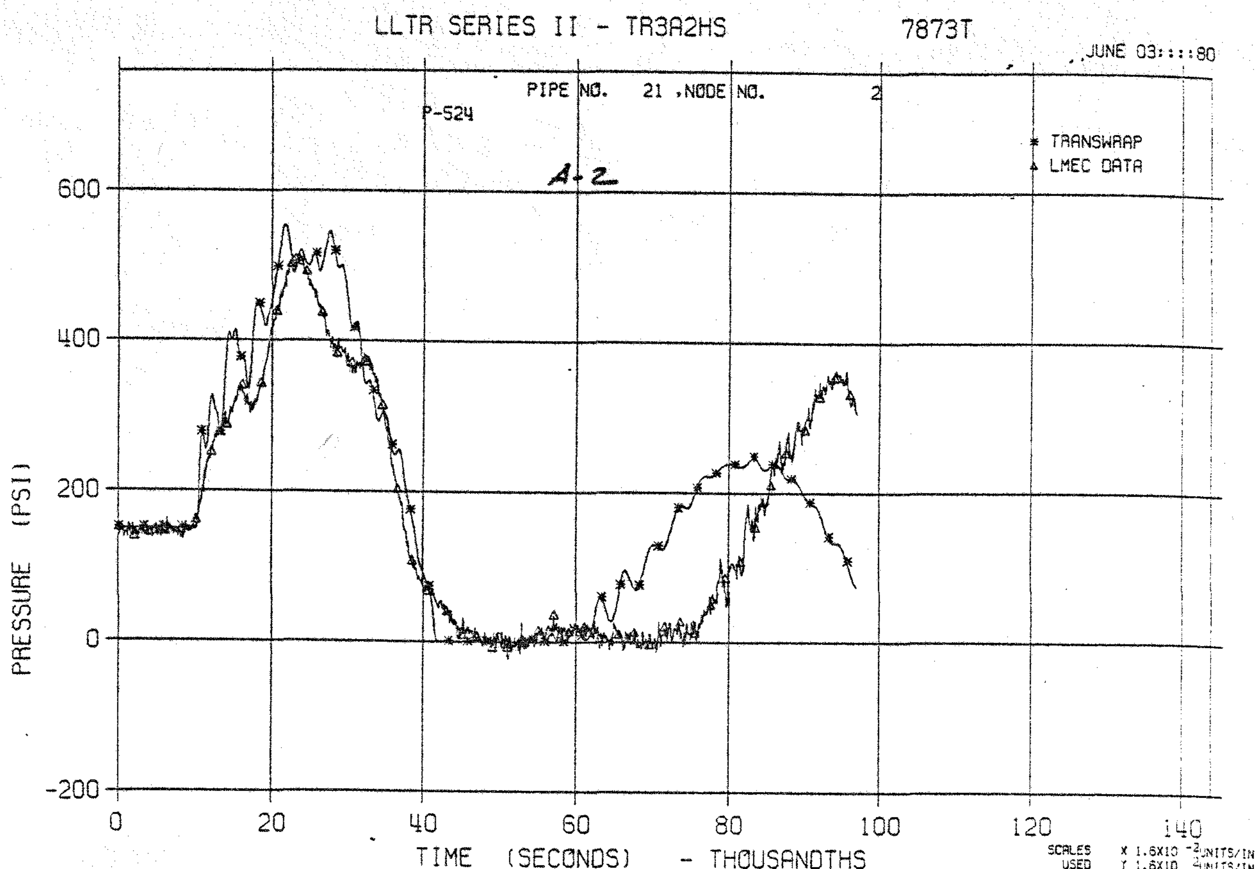
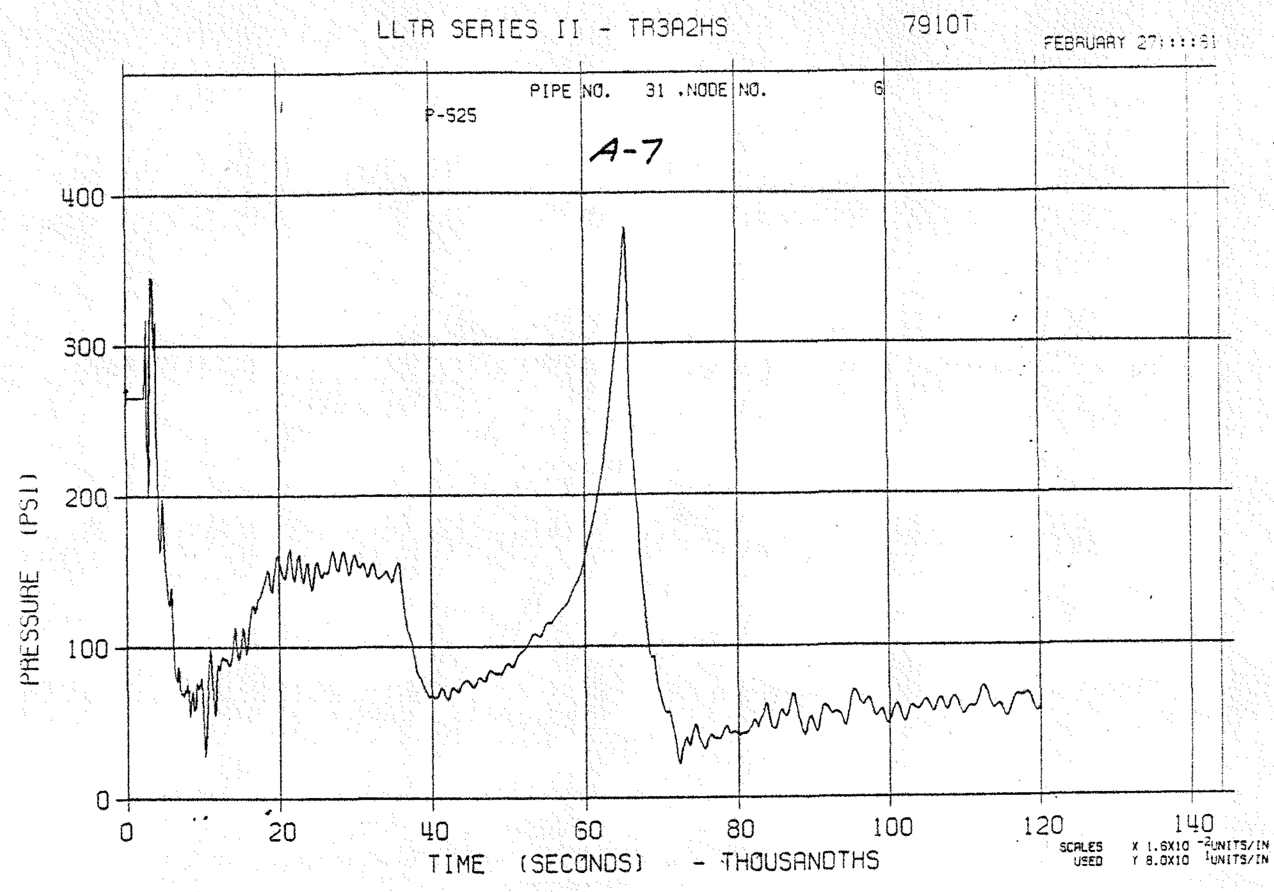
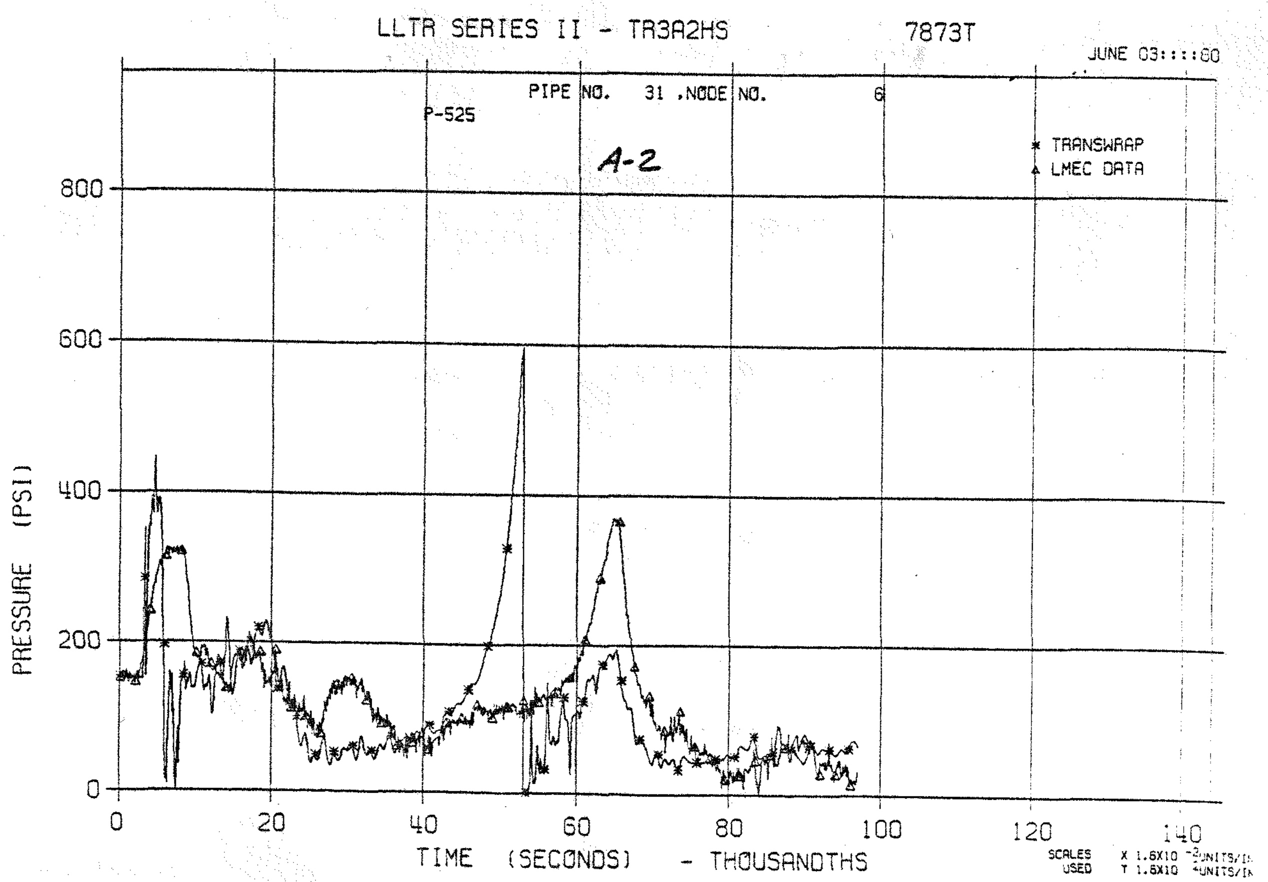


FIGURE 52

PL 16





PL 17

FIGURE 53