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MAIN STEAM TUNNEL PRESSURE
STUDY FOR MAIN STEAM LINE BREAK

COMMONWEALTH EDISON COMPANY

BYRON - UNIT 1

PROJECT FILE NO. 13.6

NSLD
Calc. No. 3C8-0282-001
Date August 11, 1982
Safety Related Yes
Project No(s). 4391-00
Page No. i

CALCULATION

REVISION SUMMARY SHEET

REVISION NO.	PREPARED BY/DATE	REVIEWED BY/DATE	APPROVED BY/DATE	REVISED PAGE NOS.
0	Gary J. Schweitzer March 18, 1982	Richard Casey 8-6-82	J. W. Ahrens for RJH 8-11-82	N/A
1	Gary J. Schweitzer Sept. 28, 1982	Raman J. Bhal Sept. 28, 1982	R. J. Hammersley September 28, 1982	1,28,30,31,33,34, 36,37,39,40,42,43, 45,46,48,49,51,53, 54, and 55
2	Gary J. Schweitzer Oct. 18, 1984	Vijay Kumar Sehgal October 18, 1984	R. J. Hammersley October 23, 1984	All except Appendix A (Rev. 0 & 1 Microfiche is to be retained)

COMMONWEALTH EDISON COMPANY
CALCULATION REVISION PAGE

CALCULATION NO. *3C8-0282-001* PAGE NO.:II

REV: *3* STATUS: *Verified* QA SERIAL NO. OR CHRON NO. DATE:

PREPARED BY: *Thomas J. Kane* Thomas J. Kane DATE: *10/21/96*

REVISION SUMMARY:
Revised Page 2
Added Pages ii, B1 through B42
Revised to Incorporate Mass and Energy Release Data from FTI 32-1258100-00 for RSG.

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DO ANY ASSUMPTIONS IN THIS CALCULATION REQUIRE LATER VERIFICATION ☐ YES ☒ NO

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APPROVED BY: *Robert J. Peterson* Robert J. Peterson DATE: *10/22/96* (CI)

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PREPARED BY ______________________ DATE:

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APPROVED BY: ______________________ DATE: __________

TABLE OF CONTENTS

* See Appendix B for Unit 1 results based on FTI 32-1258100-00 for RSG

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Cont'd)

2

LIST OF FIGURES (Cont'd)

2

I. UNAPPROVED DATA

All information used in this design calculation was obtained from the Byron/Braidwood FSAR or was received from PMD and is therefore considered by NSLD to be approved data except for the following:

None

II. INTRODUCTION

A very important design criteria for the main steam tunnel and valve room subcompartments involves retaining functional integrity indefinitely which includes withstanding peak transient differential pressures under a postulated accident mode.

A previous calculation (Reference 1) addressed this criteria by determining design pressures for the main steam tunnel and valve rooms. At the time that the calculation was performed, the NRC required (Reference 2) a factor equal to 1.4 be applied to the calculated peak differential pressures for use as design pressures. The factor was to provide a design margin to accommodate possible plant modifications in the future. At the operating licensing stage, though, the NRC only requires that the calculated peak differential pressures be less than the design pressures. Since the Byron project has reached this stage, the 1.4 factor is not used in the calculation of the peak pressures.

It is evident if no design changes occurred since the construction permit stage, the 40% margin would still hold true, thus satisfying the requirements in Reference 2. But modifications have been made since the calculation per Reference 1 was performed. The primary modification involved isolating the auxiliary feedwater line tunnel from the valve rooms. As a result, less volume is available for expansion of steam coming from a main steam line break.

Therefore, the purpose of this study is to calculate peak pressures using the as-built specifications from which a new set of design margins can be determined. It is noted that temperature is not a primary concern in this calculation, but for convenience corresponding temperature profiles will also be presented for each of the pressure profiles.

Reference 1 as well as Revisions 0 and 1 of this calculation considered four break locations which included: the second quadrant lower valve room; the second quadrant main steam tunnel next to the valve room; the main steam tunnel connecting the first and second quadrants; and 2
the first quadrant main steam tunnel next to the valve room. In addition to the four break locations, this calculation also considers two break locations in the last segment of the main steam tunnel which opens into the turbine building.

III. ANALYTICAL MODELS AND COMPUTER PROGRAMS

The analytical models and computer programs used in this analysis are filed and documented in the Computer Software Library. The program names used are:

REL 09.8.026-5.70

PPP 09.8.099-1.1I

PPP 0.9.099-1.2I 2

IV. ASSUMPTIONS

1. The initial conditions in the steam tunnel and the valve rooms are 14.7 psia pressure at a temperature of 90°F and a relative humidity of 30%.

2. Only one break occurred per analysis.

3. The Moody choke flow multiplier of 0.6 was used as required by the Nuclear Regulatory Commission (NRC) (Reference 2) for choked flow check between nodes.

4. The area of a flow path is the effective area (i.e., the cross sectional area of the path excluding areas occupied by grating, pipes, louvers, etc.).

5. The mass and energy release rates for the postulated main steam line rupture were taken from Reference 6. 2

6. The doors and HVAC louvers/panels in the upper chambers of the valve rooms are initially assumed closed or intact. A differential pressure equal to 1.5 psi will blow open the doors and panels to atmosphere.

V. METHOD OF ANALYSIS

The main steam line rupture was assumed to be a doubled-ended
guillotine break. The RELAP4/MOD5 (Reference 3) computer code
was used to determine pressure transients for six cases, 2
each having a different break location. In the first case,
the break was located in the second quadrant lower valve
room (See Figure 1). The second case involved locating the
break in the second quadrant main steam tunnel next to the
valve room. The break for the third case was located in the main 2
steam tunnel connecting the second and first quadrants. The
fourth case involved locating the break in the first quadrant
tunnel next to the valve room. The break for the fifth case
was located in the last 90° section of the tunnel before 2
entering the turbine building. The last break was located in
the straight section of the tunnel which opens into the tur-
bine building.

The steam tunnel was modeled using five nodes and each of the valve rooms were modeled using four nodes. When including atmosphere, the entire model consisted of 14 nodes as seen in Figure 2 which shows the entire nodalization scheme of the main steam tunnel and valve rooms. The initial conditions presented in Table 1 for these nodes were taken from Reference 1. The remaining input data were determined in Appendix A.

The areas of the 21 junctions (flow paths), which connect the nodes (See Figure 2), are presented in Table 2. The areas are equivalent to the minimum vent areas between the nodes and were determined in Appendix A as were the remaining input data. The Moody flow multiplier was taken to be .6 as required by the NRC.

Table 3 shows the blowdown rates and properties versus time
from a postulated ruptured main steam line as provided by
Reference 6. This table was used in all six cases as input
to RELAP4/MOD5 2

It is finally noted that throughout the analysis, heat transfer out of the tunnel and valve rooms was not considered for conservatism.

VI. RESULTS

A summary of the resulting peak differential pressures is presented in Table 1. Also included in the table are the design pressures previously calculated and the resulting design margins for each of the subcompartments (nodes). Table 4 presents a summary of the resulting peak differential pressures for interior walls in the valve rooms and for walls separating the main steam tunnel and valve room. Previously determined design pressures and design margins are also presented in this table.

Figures 3 thru 20 present the pressure transients for each of the nodes for all six break locations. Specifically, Figures 4, 7, 10, 13, 16, and 19 refer to the main steam tunnel (main steam tunnel is made up of nodes 6, 7, 8, 13, and 14) and the remaining figures refer to the two valve rooms. 2

Figures 21 thru 38 present the corresponding temperature transients for each of the nodes for all six break locations. A summary of the maximum temperatures obtained in the one-second duration is presented in Table 5. 2

VII. CONCLUSIONS

With one exception, all of the calculated peak pressures for the exterior boundaries of the main steam tunnel and safety valve rooms as presented in Table 1 are less than the design pressures presented in Exhibit 30 of Reference 1. The design margins for these boundaries varied from 25 to 61 percent. The exception concerns the last segment of tunnel (node 14) which opens into the turbine building. The calculated peak pressure is approximately 8% higher than the design 2
pressure presented in Exhibit 30 of Reference 1. It is noted that a break location in this segment of the tunnel was not considered previously in Reference 1 and Revisions 0 and 1 of this calculation. Revision 2 of this calculation did assume a line break in the last segment of the tunnel and has shown higher calculated pressure. As a result, the structural integrity of the last calculated section of the tunnel (node 14) may require re-evaluation for the higher pressure. The differential pressures used for the design of the remaining sections of the main steam tunnel and valve room boundaries, however, are still conservative.

The elimination of the auxiliary feedwater line tunnel from the model reduced the total available volume by no more than ½ of one percent. Therefore, the design margins as determined for nodes 7 and 9 are reasonable. However, the large 2
design margins determined for the boundaries of the valve rooms and node 6 appeared, at first, to be excessive. The 2
primary reason for this change is believed to be a known error in the computer program used for the calculation of Reference 1. This program, WARLOC, was found to produce node pressures that are too high when treating superheated vapor. This effect is described in Reference 4.

For the interior walls, all the differential pressures as presented in Table 4 were less than the design pressures presented in Exhibit 31 of Reference 1 except for the wall separating the upper chambers of the valve room. The calculated peak pressure for this wall was .2 psi higher than the design pressure. It is anticipated, though, that a difference of this magnitude will not present a problem. It is typical to include further conservatisms when designing reinforced concrete walls which, in this case, would allow the wall to absorb the additional .2 psi and still maintain a safety margin, but this would need to be verified. For the remaining interior walls, the design margins varied from 4.3 to 31.7 percent. 2

With regard to the temperature transients presented in Figures 21 thru 38, it is noted that for nodes 7 and 8, the maximum temperatures presented in Table 5 do not represent peak temperatures. For each of these nodes, the bounding temperature transient was still on the rise after one second. But for nodes 2 thru 5, and 9 thru 12, a peak temperature of 333°F was obtained. After one second, the temperatures for these nodes were either decreasing or leveling off. Now considering that heat transfer will begin to become a factor after a few minutes and the mass blowdown rate is decreasing with time, it can be reasonably concluded the 333°F temperature will be the limiting peak for all nodes, but, this would have to be looked at in a more detailed analysis which would include heat sinks and a longer blowdown duration. 2 2

VIII. REFERENCES

1. Sargent & Lundy Calculation No. MAD-75717, "Main Steam Line Break In Main Steam Tunnel," July 1976. (Approved)

2. Standard Review Plan (NUREG-0800), Section 6.2.1.2 entitled, "Subcompartment Analysis," Revision 2, July 1981.

3. RELAP4/MOD5 (REL 09.8.026-5.70), "A Computer Program For Transient Thermal-Hydraulic Analysis of Nuclear Reactors and Related Systems," ANCR-NUREG-1335, September 1976.

4. Inter-Office Memorandum from Igor Domashovetz to R. H. Jason, entitled, "Comparative Study Between the RELAP4/MOD5 and WARLOC Computer Codes for a Main Steam Tunnel Temperature Transient," November 23, 1981.

5. Sargent & Lundy Drawings;

Drawing No.	Revision	Sheet No.	Date
M-159	H	1	11-27-79
M-159	G	3	11-27-79
M-160	G	1	11-27-79
M-187	H	1	11-27-79
M-188	G	1	11-27-79
M-536	N	2	02-20-80
M-536	P	5	04-16-79
S-688	R	1	08-02-78
S-758	G	1	11-29-76
S-762	L	1	06-05-81
S-765	H	1	03-16-78
S-895	N	1	07-17-78
S-896	M	1	05-25-78
S-899	L	1	05-25-78
S-900	P	1	08-29-80
S-1056	R	1	08-29-80
S-1057	W	1	08-29-80
S-1061	K	1	08-29-80
S-1062	K	1	03-31-78

6. Table 6.2-15a, page 6.2-37C, B/B PSAR, Amendment 11, April 1975. 2

 2

TABLE 1

SUBCOMPARTMENT NODAL DESCRIPTION

MAIN STEAM LINE BREAK IN MAIN STEAM TUNNEL OR VALVE ROOMS

VOLUME NO.	DESCRIPTION	HEIGHT, ft	CROSS-SECTIONAL AREA, FT^2	VOLUME ft^3	INITIAL CONDITIONS TEMP. °F	PRESS. psia	HUMID.* %	DBA BREAK CONDITIONS BREAK LOC. VOL. NO.	BREAK LINE	BREAK AREA ft^2	BREAK TYPE	CALC. PEAK PRESS DIFF. psid	DESIGN PEAK PRESS DIFF. psid	DESIGN MARGIN %
1	Atmosphere	$5x10^3$	$1x10^3$	10^7	90	14.7	30	-	-	-	-	-	-	-
2	2nd Quadrant Upper Valve Chamber	12.33	133.25	4895.7	90	14.7	30	5	Main Steam	1.4	Double-ended Guillotine	17.4	26.2	51
3	2nd Quadrant Upper Valve Chamber	12.33	183.7	4895.7	90	14.7	30	5	Main Steam	1.4	Double-ended Guillotine	17.4	26.2	51
4	2nd Quadrant Lower Valve Chamber	24.00	213.0	6007.0	90	14.7	30	5	Main Steam	1.4	Double-ended Guillotine	19.7	28.6	45
5	2nd Quadrant Lower Valve Chamber	24.00	213.0	6007.0	90	14.7	30	5	Main Steam	1.4	Double-ended Guillotine	19.7	28.6	45
6	2nd Quadrant Main Steam Tunnel	19.00	317.0	13695.0	90	14.7	30	6	Main Steam	1.4	Double-ended Guillotine	16.4	26.5	61

* Relative humidity.

 2

TABLE 1 (Cont'd)

SUBCOMPARTMENT NODAL DESCRIPTION

MAIN STEAM LINE BREAK IN MAIN STEAM TUNNEL OR VALVE ROOMS

VOLUME NO.	DESCRIPTION	HEIGHT, ft	CROSS-SECTIONAL AREA, FT^2	VOLUME ft^3	INITIAL CONDITIONS TEMP. °F	PRESS. psia	HUMID.* %	DBA BREAK CONDITIONS BREAK LOC. VOL. NO.	BREAK LINE	BREAK AREA ft^2	BREAK TYPE	CALC. PEAK PRESS DIFF. psid	DESIGN PEAK PRESS DIFF. psid	DESIGN MARGIN %
7	Main Steam Tunnel	19.00	203.0	34865.0	90	14.7	30	7	Main Steam	1.4	Double-ended Guillotine	15.5	21.3	38
8	1st Quadrant Main Steam Tunnel	20.00	432.0	35016.0	90	14.7	30	8	Main Steam	1.4	Double-ended Guillotine	8.8	11.2	28
9	1st Quadrant Upper Valve Chamber	12.33	133.25	4895.7	90	14.7	30	5**	Main Steam	1.4	Double-ended Guillotine	17.4	26.2	51
10	1st Quadrant Upper Valve Chamber	12.33	183.7	4895.7	90	14.7	30	5**	Main Steam	1.4	Double ended Guillotine	17.4	26.2	51
11	1st Quadrant Lower Valve Chamber	24.00	213.0	6007.0	90	14.7	30	5**	Main Steam	1.4	Double-ended Guillotine	19.7	28.6	45

* Relative humidity.

** Differential pressures calculated for 1st Quadrant valve chambers are also applicable to corresponding 2nd Quadrant valve chambers.

TABLE 1 (Cont'd)

SUBCOMPARTMENT NODAL DESCRIPTION

MAIN STEAM LINE BREAK IN MAIN STEAM TUNNEL OR VALVE ROOMS

VOLUME NO.	DESCRIPTION	HEIGHT, ft	CROSS-SECTIONAL AREA, ft^2	VOLUME ft^3	INITIAL CONDITIONS TEMP. °F	PRESS. psia	HUMID.* %	LBA BREAK CONDITIONS BREAK LOC. VOL. NO.	BREAK LINE	BREAK AREA ft^2	BREAK TYPE	CALC. PEAK PRESS DIFF. psid	DESIGN PEAK PRESS DIFF. psid	DESIGN MARGIN %
12	1st Quadrant Lower Valve Chamber	24.00	213.0	6007.0	90	14.7	30	5**	Main Steam	1.4	Double-ended Guillotine	19.7	28.6	45
13	1st Quadrant Main Steam Tunnel	29.00	432.0	17388.4	90	14.7	30	13	Main Steam	1.4	Double-ended Guillotine	10.6	13.2	25
14	1st Quadrant Main Steam Tunnel	19.00	280.0	13529.9	90	14.7	30	14	Main Steam	1.4	Double-ended Guillotine	11.1	10.3	-8

2

* Relative humidity.

** Differential pressures calculated for 1st Quadrant valve chambers are also applicable to corresponding 2nd Quadrant valve chambers.

TABLE 2

SUBCOMPARTMENT VENT PATH DESCRIPTION

MAIN STEAM LINE BREAK IN MAIN STEAM TUNNEL OR VALVE ROOM

ENT ATH O.	FROM VOL. NODE NO.	TO VOL. NODE NO.	DESCRIPTION OF VENT PATH FLOW[1] CHOKED[3] UNCHOKED	AREA[2] ft^2	LENGTH[2] ft	HYDRAULIC DIAMETER ft	HEAD LOSS, K: FRICTION K, ft/d	TURNING LOSS, K	EXPAN-SION, K	CONTRAC-TION, K	TOTAL
1	14	1	Main Steam Tunnel to Turbine Building Choked (13,14)	270.8	28.0	13.9	-	-	-	-	1.0656
2	2	5	2nd Quadrant Upper Valve Chamber to Lower Valve Chamber Unchoked	121.0	16.4	5.7	-	-	-	-	1.5207
3	3	4	2nd Quadrant Upper Valve Chamber to Lower Valve Chamber Unchoked	121.0	16.4	5.7	-	-	-	-	1.5207
4	6	4	2nd Quadrant Lower Valve Chamber to Main Steam Tunnel Unchoked	73.0	17.2	4.5	-	-	-	-	1.5685
5	6	5	2nd Quadrant Lower Valve Chamber to Main Steam Tunnel Choked (5)	73.0	17.2	4.5	-	-	-	-	1.5685
6	5	4	Openings Between 2nd Quadrant Lower Valve Chambers Unchoked	100.0	16.1	7.1	-	-	-	-	1.5071

2

[1] See Figures 1 and 2.
[2] Length/Area is the inertial term input directly into RELAP4/MOD5.
[3] Number in parentheses indicates the volume number of the break location which caused choke flow in the vent. For break locations not indicated, unchoked flow had occurred for the vent.

TABLE 2 (Cont'd)

SUBCOMPARTMENT VENT PATH DESCRIPTION

MAIN STEAM LINE BREAK IN MAIN STEAM TUNNEL OR VALVE ROOM

VENT PATH NO.	FROM VOL. NODE NO.	TO VOL. NODE NO.	DESCRIPTION OF VENT PATH FLOW[1] CHOKED[3] UNCHOKED	AREA[2] ft²	LENGTH[2] ft	HYDRAULIC DIAMETER ft	HEAD LOSS, K: FRICTION K, ft/d	TURNING LOSS, K	EXPANSION, K	CONTRACTION, K	TOTAL
7	6	7	2nd Quadrant Main Steam Tunnel to Main Steam Tunnel Unchoked	199.8	102.0	13.3	-	-	-	-	2.1860
8	7	8	Main Steam Tunnel to 1st Quadrant Main Steam Tunnel Unchoked	199.8	132.4	13.3	-	-	-	-	2.7530
9	12	9	1st Quadrant Upper Valve Chamber to Lower Valve Chamber Unchoked	121.0	16.4	5.7	-	-	-	-	1.5207
10	9	10	Openings Between 1st Quadrant Upper Valve Chambers Unchoked	100.0	11.2	4.5	-	-	-	-	1.5120
11	11	10	1st. Quadrant Upper Valve Chamber to Lower Valve Chamber Unchoked	121.0	16.4	5.7	-	-	-	-	1.5207
12	12	11	Openings Between 1st Quadrant Lower Valve Chambers Unchoked	100.0	16.1	7.1	-	-	-	-	1.5071

[1] See Figures 1 and 2.
[2] Length/Area is the inertial term input directly into RELAP4/MOD5.
[3] Number in parentheses indicates the volume number of the break location which caused choke flow in the vent. For break locations not indicated, unchoked flow had occurred for the vent.

TABLE 2 (Cont'd)

SUBCOMPARTMENT VENT PATH DESCRIPTION

MAIN STEAM LINE BREAK IN MAIN STEAM TUNNEL OR VALVE ROOM

VENT PATH NO.	FROM VOL. NODE NO.	TO VOL. NODE NO.	DESCRIPTION OF VENT PATH FLOW[1] CHOKED[3] UNCHOKED	AREA[2] ft^2	LENGTH[2] ft	HYDRAULIC DIAMETER ft	HEAD LOSS, K: FRICTION K, ft/d	TURNING LOSS, K	EXPANSION, K	CONTRACTION, K	TOTAL
13	8	13	1st Quadrant Main Steam Tunnel Unchoked	373.6	42.0	17.6	-	-	-	-	2.2600
14	13	14	1st Quadrant Main Steam Tunnel Unchoked	270.8	42.0	13.9	-	-	-	-	2.2600
15	8	11	1st Quadrant Lower Valve Chamber to Main Steam Tunnel Unchoked	73.0	17.2	4.5	-	-	-	-	1.5685
16	8	12	1st Quadrant Lower Valve Chamber to Main Steam Tunnel Unchoked	73.0	17.2	4.5	-	-	-	-	1.5685
17	2	3	Openings Between 2nd Quadrant Upper Valve Chambers Unchoked	100.0	11.2	4.5	-	-	-	-	1.5120
18	2	1	HVAC Panels in 2nd Quadrant Upper Valve Chambers Choked (5, 6)	51.3	15.2	5.9	-	-	-	-	2.900

[1] See Figures 1 and 2.
[2] Length/Area is the inertial term input directly into RELAP4/MOD5.
[3] Number in parentheses indicates the volume number of the break location which caused choke flow in the vent. For break locations not indicated, unchoked flow had occurred for the vent.

TABLE 2 (Cont'd)

SUBCOMPARTMENT VENT PATH DESCRIPTION

MAIN STEAM LINE BREAK IN MAIN STEAM TUNNEL OR VALVE ROOM

VENT PATH NO.	FROM VOL. NODE NO.	TO VOL. NODE NO.	DESCRIPTION OF VENT PATH FLOW[1] CHOKED[3] UNCHOKED	AREA[2] ft^2	LENGTH[2] ft	HYDRAULIC DIAMETER ft	HEAD LOSS, K FRICTION K, ft/d	TURNING LOSS, K	EXPANSION, K	CONTRACTION, K	TOTAL
19	3	1	Door and HVAC Panels in 2nd Quadrant Upper Valve Chambers Choked (5, 6)	75.8	25.3	5.4	-	-	-	-	2.900
20	9	1	HVAC Panels in 1st Quadrant Upper Valve Chamber Choked (5)[4]	51.3	15.2	5.9	-	-	-	-	2.900
21	10	1	Door and HVAC Panels in 1st Quadrant Upper Valve Chamber Choked (5)[4]	75.8	25.3	5.4	-	-	-	-	2.900
22(a)[5]	0	5	Main Steam Line Break in Node 5 Fill	1.0	0.0	0.0	-	-	-	-	0.000
22(b)[5]	0	6	Main Steam Line Break in Node 6 Fill	1.0	0.0	0.0	-	-	-	-	0.000
22(c)[5]	0	7	Main Steam Line Break in Node 7 Fill	1.0	0.0	0.0	-	-	-	-	0.000
22(d)[5]	0	8	Main Steam Line Break in Node 8 Fill	1.0	0.0	0.0	-	-	-	-	0.000

[1] See Figures 1 and 2.
[2] Length/Area if the inertial term input directly into RELAP4/MOD5.
[3] Number in parentheses indicates the volume number of the break location which caused choke flow in the vent. For break locations not indicated, unchoked flow had occurred for the vent.
[4] Choking results for 2nd quadrant valve room are applied to 1st quadrant valve room.
[5] Four cases were considered each having a different break location.

TABLE 3

BLOWDOWN RATES AND ENTHALPY FOR RUPTURED MAIN STEAM LINE*

TIME (SEC)	FLOW (LB/SEC)	ENTHALPY (Btu/LB)
0.0	11,000	1,195.4
2.0	10,434	1,195.1
4.0	9,608	1,196.9
6.0	9,017	1,197.7
8.0	8,613	1,199.4
10.0	9,318	1,199.8
10.1	2,098	1,201.1
20.0	1,993	1,199.2
30.0	1,879	1,208.1
50.0	1,625	1,206.1
75.0	1,064	1,203.0
100.0	814	1,201.5

* See Reference 6.

TABLE 4

SUMMARY OF PEAK PRESSURES AND DESIGN MARGINS BETWEEN VALVE ROOMS AND MAIN STEAM TUNNEL

WALL LOCATION BETWEEN NODES*	DESIGN PRESSURE (PSID)**	PEAK PRESSURE (PSID)	DESIGN MARGIN (%)***
2-3 and 9-10	6.3	6.49	-2.9
3-4 and 10-11	13.2	12.66	4.3
4-5 and 11-12	17.6	13.36	31.7
2-5 and 9-12	13.2	12.66	4.3
4-6, 5-6, 11-8, and 12-8	19.4	14.88	30.4

* See Figures 1 and 2.
** See Reference 1.
*** Determined using peak pressure as base value.

TABLE 5

SUMMARY OF MAXIMUM TEMPERATURES FOR MAIN STEAM TUNNEL AND VALVE ROOMS

Node No.	Maximum Temperature (°F)	Break* Location
2, 3, 9, 10	333	Lower Valve Room
4, 5, 11, 12	333	Lower Valve Room
6	322	Lower Valve Room
7	309**	Node 7
8	310**	Node 8
13	318	Node 13
14	315	Node 14

2

* See Figures 1 and 2.

** Temperature was still rising from this value after one second.

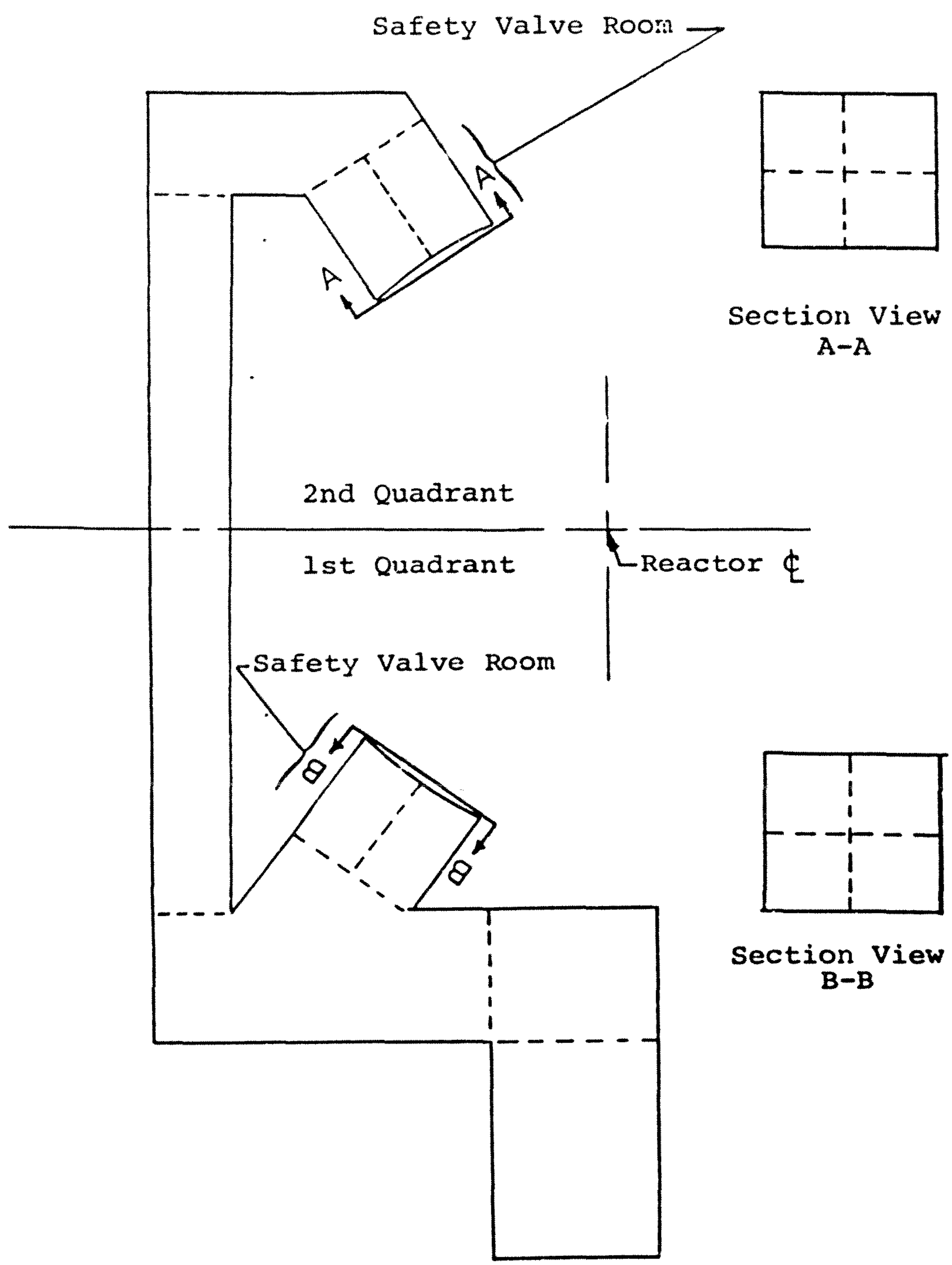


FIGURE 1: MAIN STEAM TUNNEL VIEW PLAN

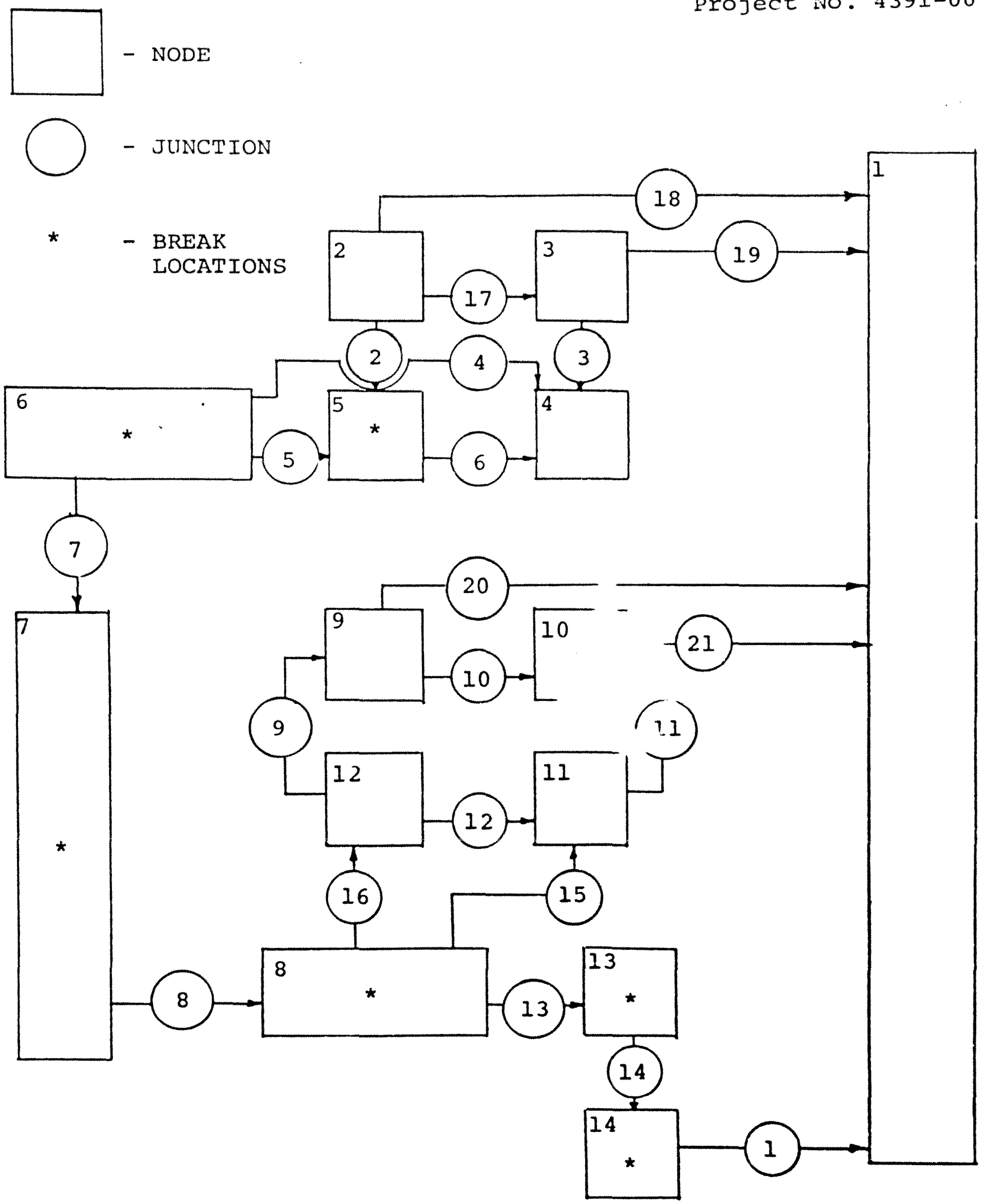
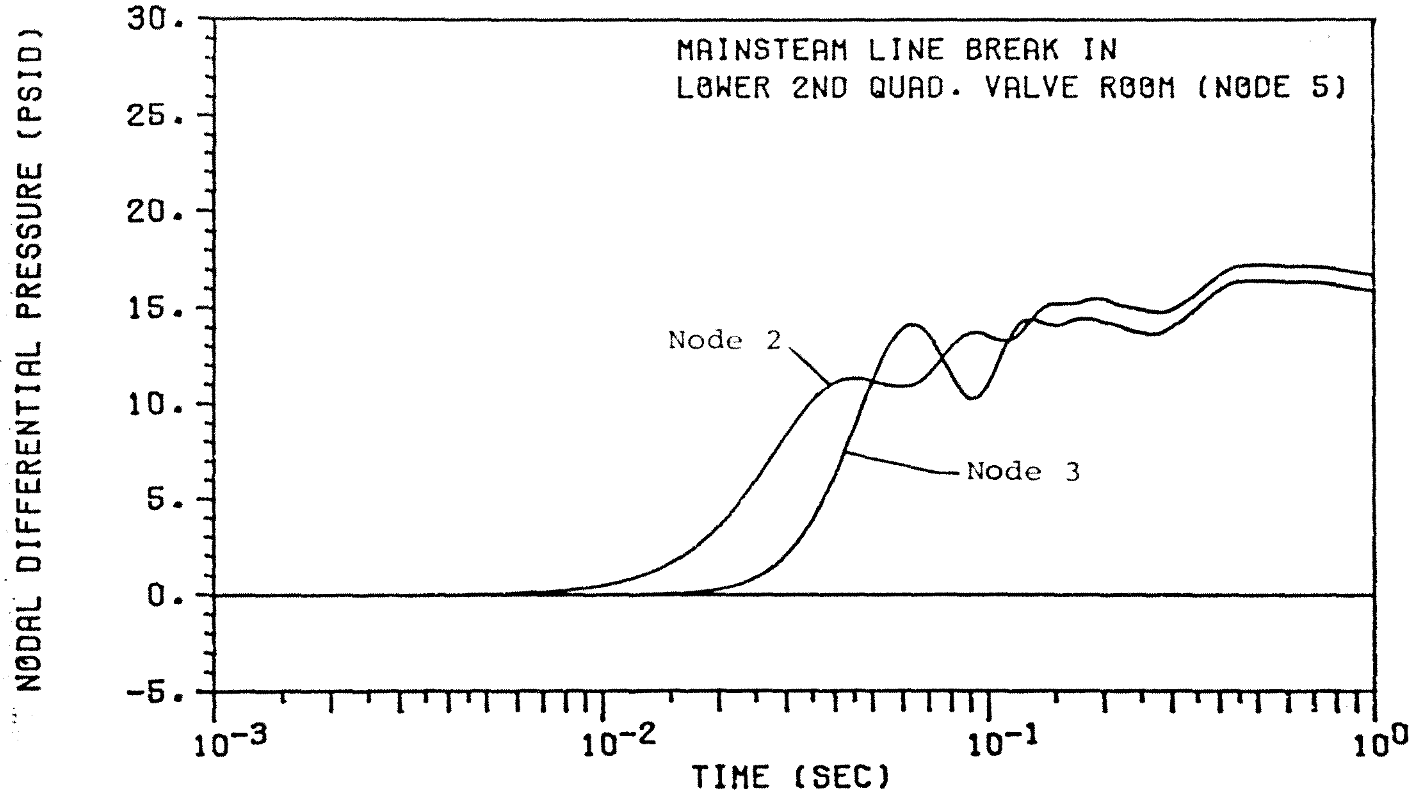


FIGURE 2: Nodalization Schematic

Calc. No. 3C8-0282-001
Revision: 2
Page: 29 |2
Project No. 4391-00

09/16/82 PLT-FILE-834



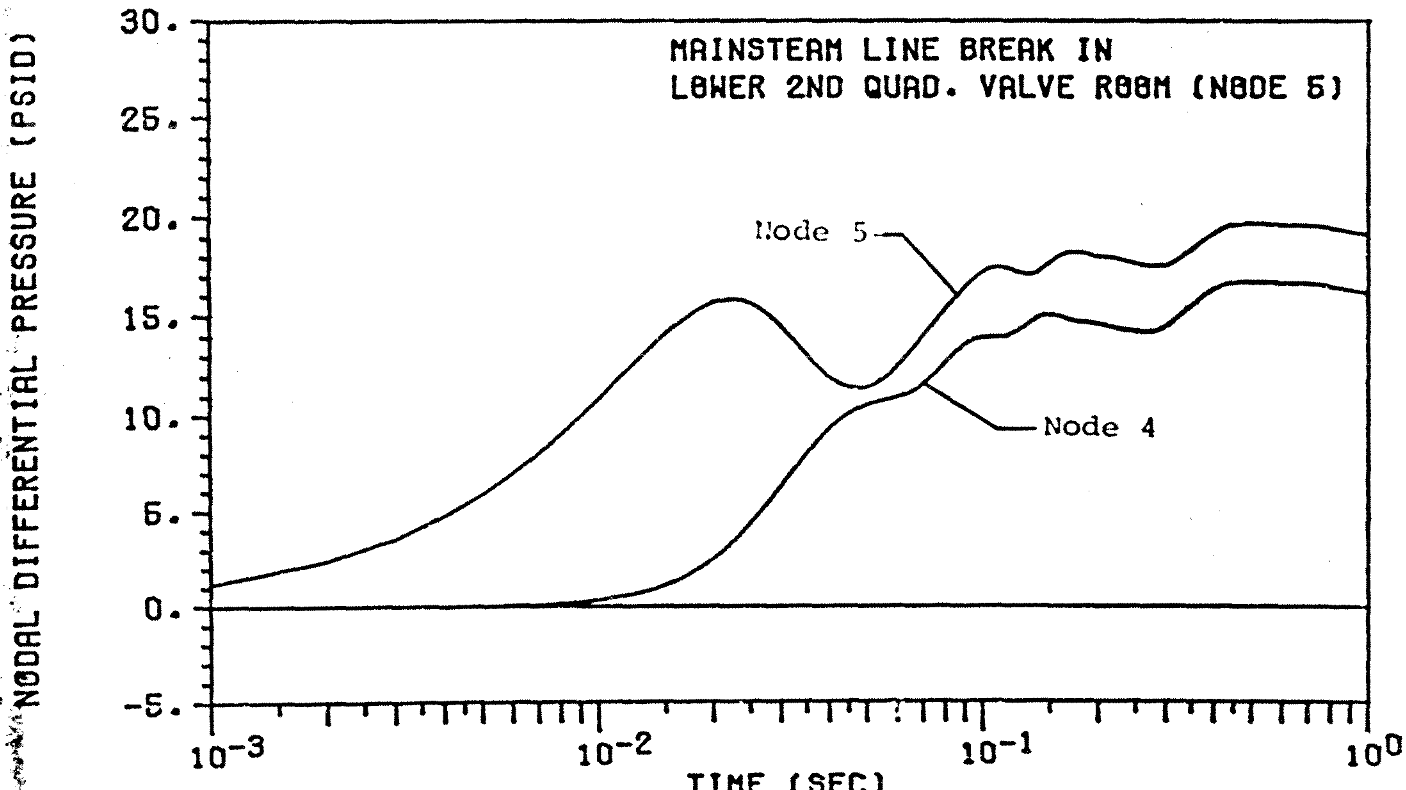
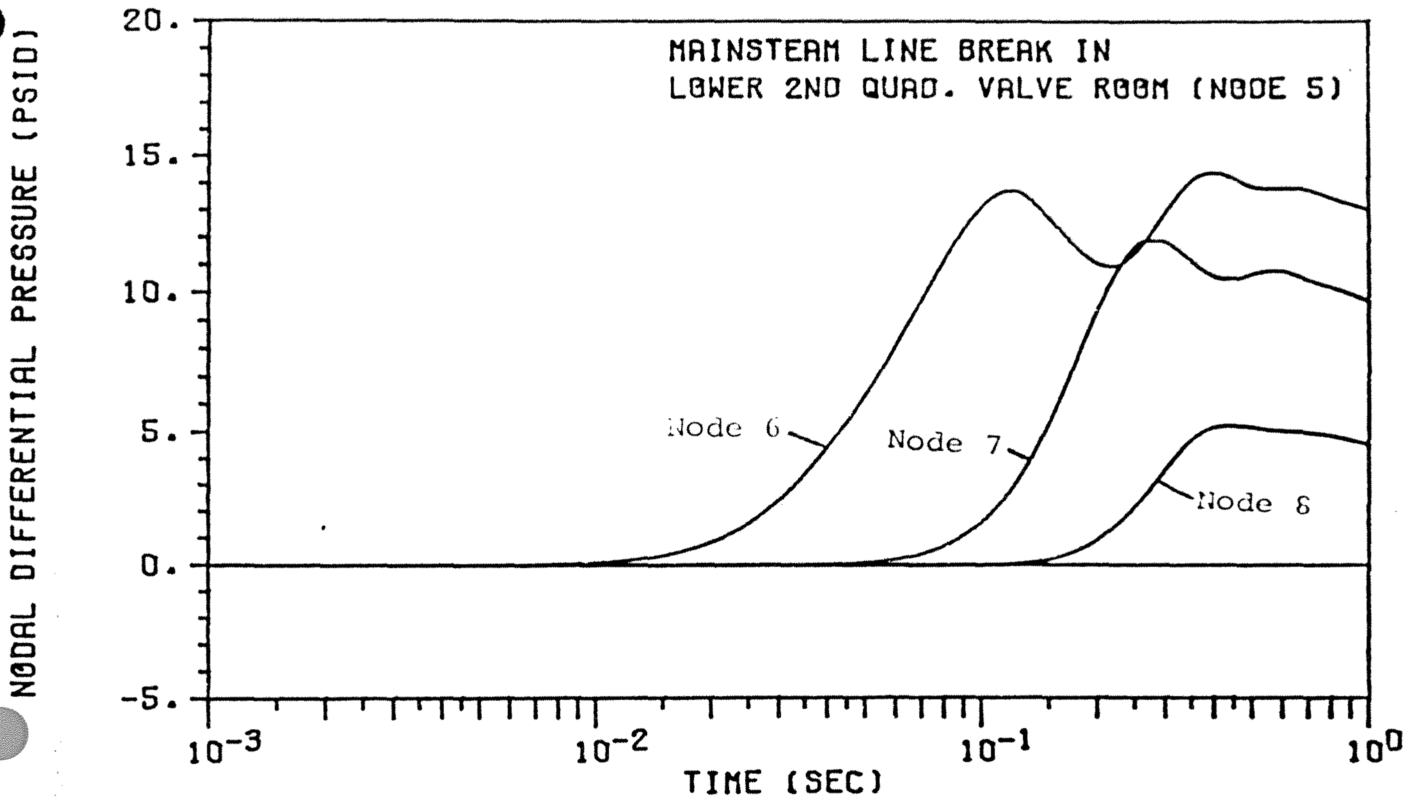


FIGURE 3:
PRESSURE TRANSIENT FOR NODES 2, 3, 4, & 5

07/22/82 PLT-FILE-952



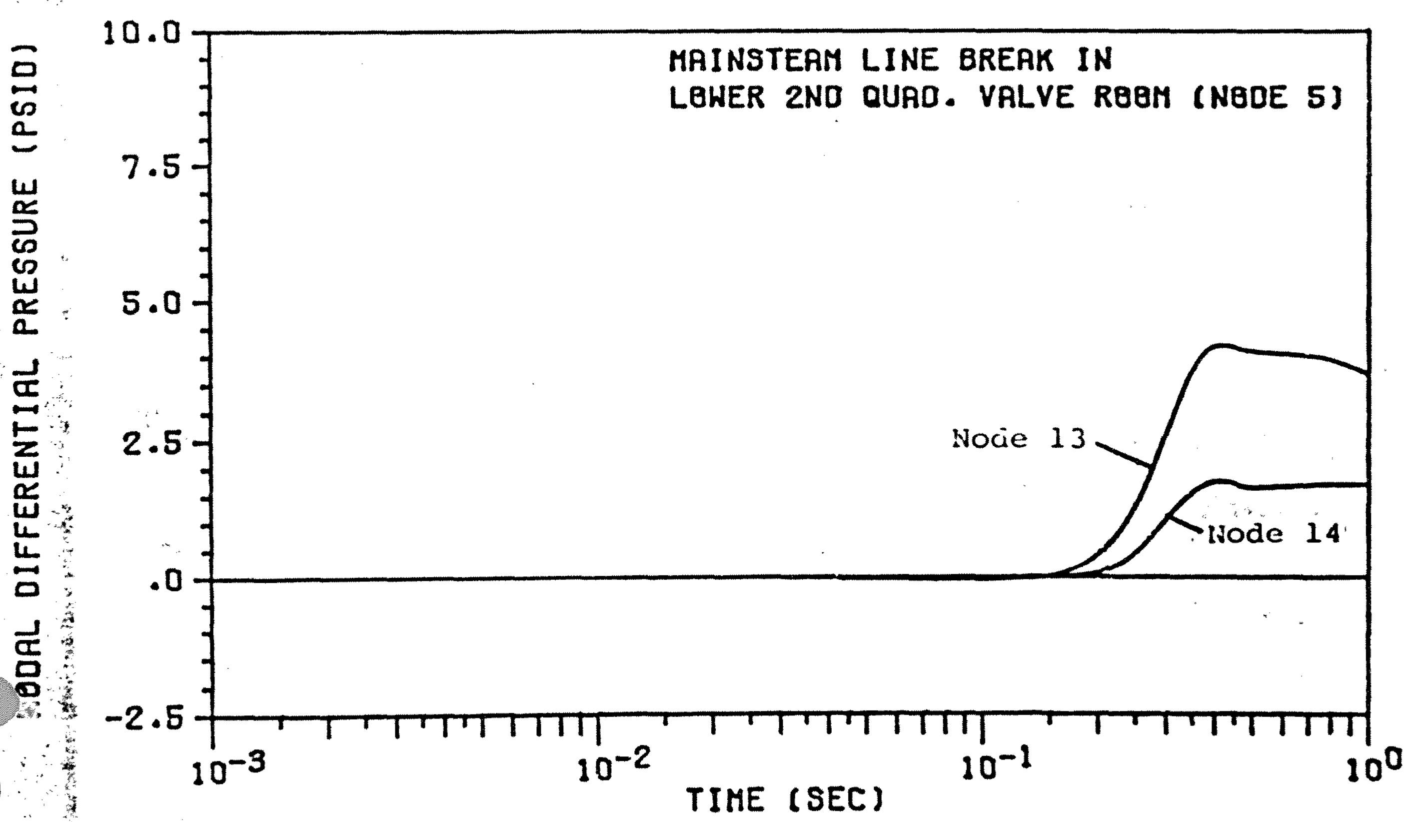
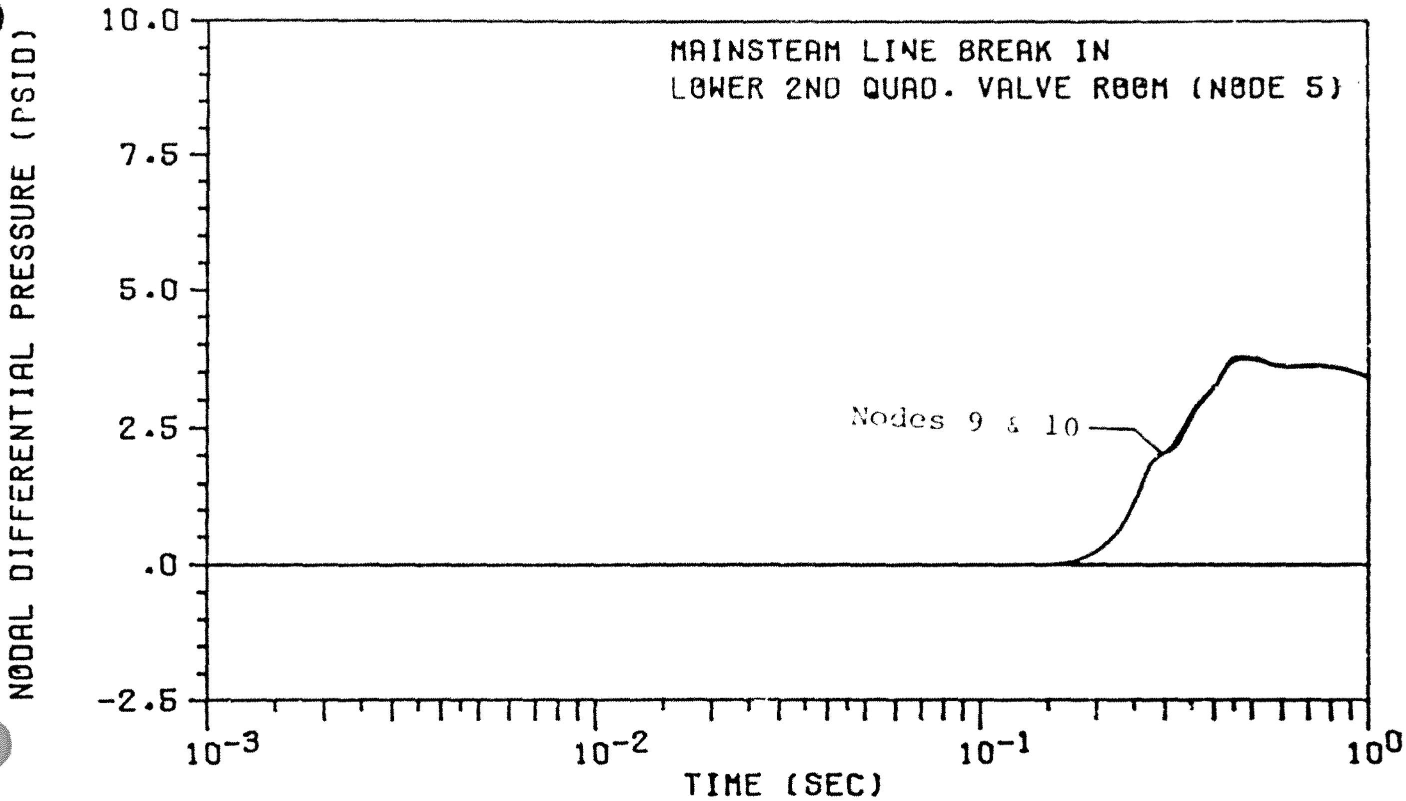


FIGURE 4:
PRESSURE TRANSIENT FOR NODES 6, 7, 8, 13, & 14

09/16/82 PLT-FILE-836



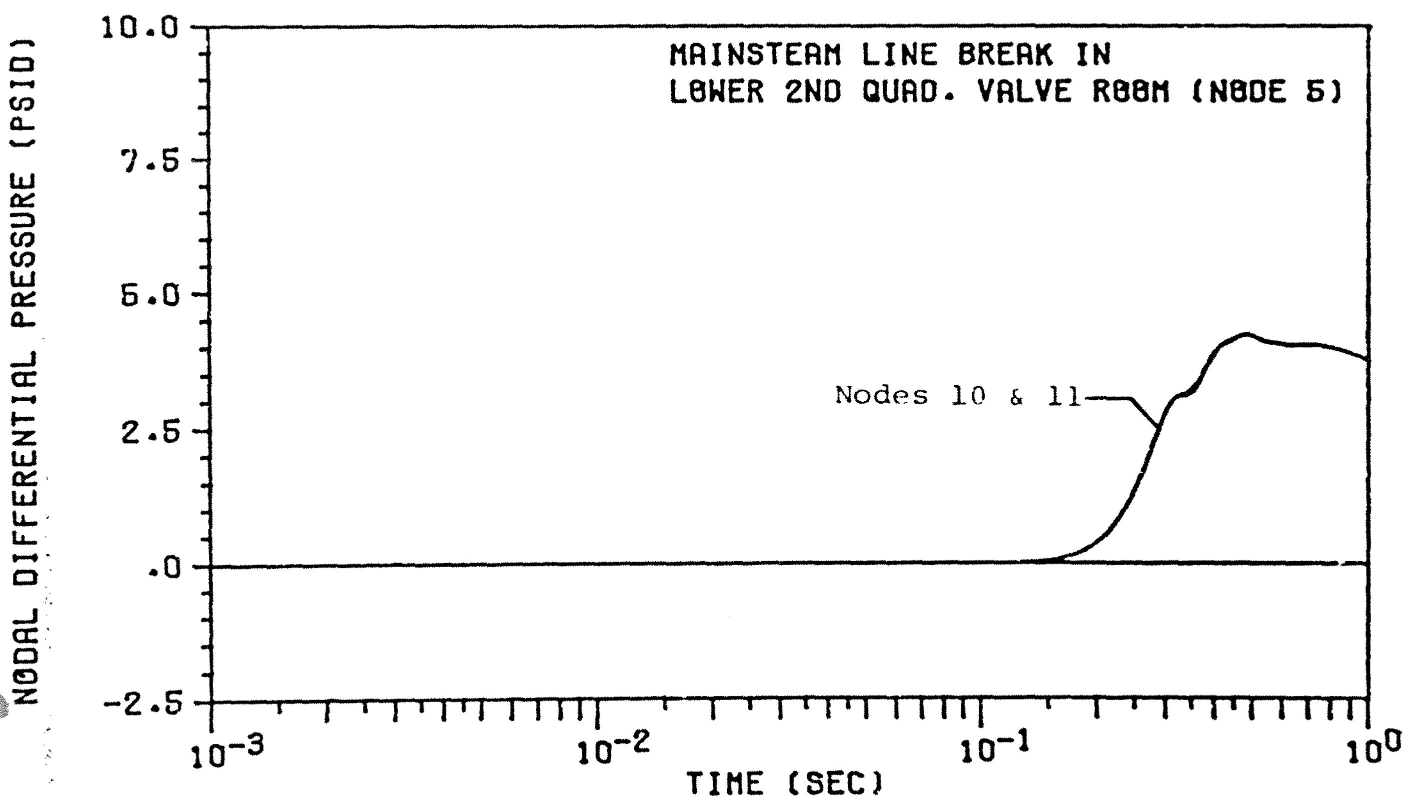


FIGURE 5:
PRESSURE TRANSIENT FOR NODES 9, 10, 11, & 12

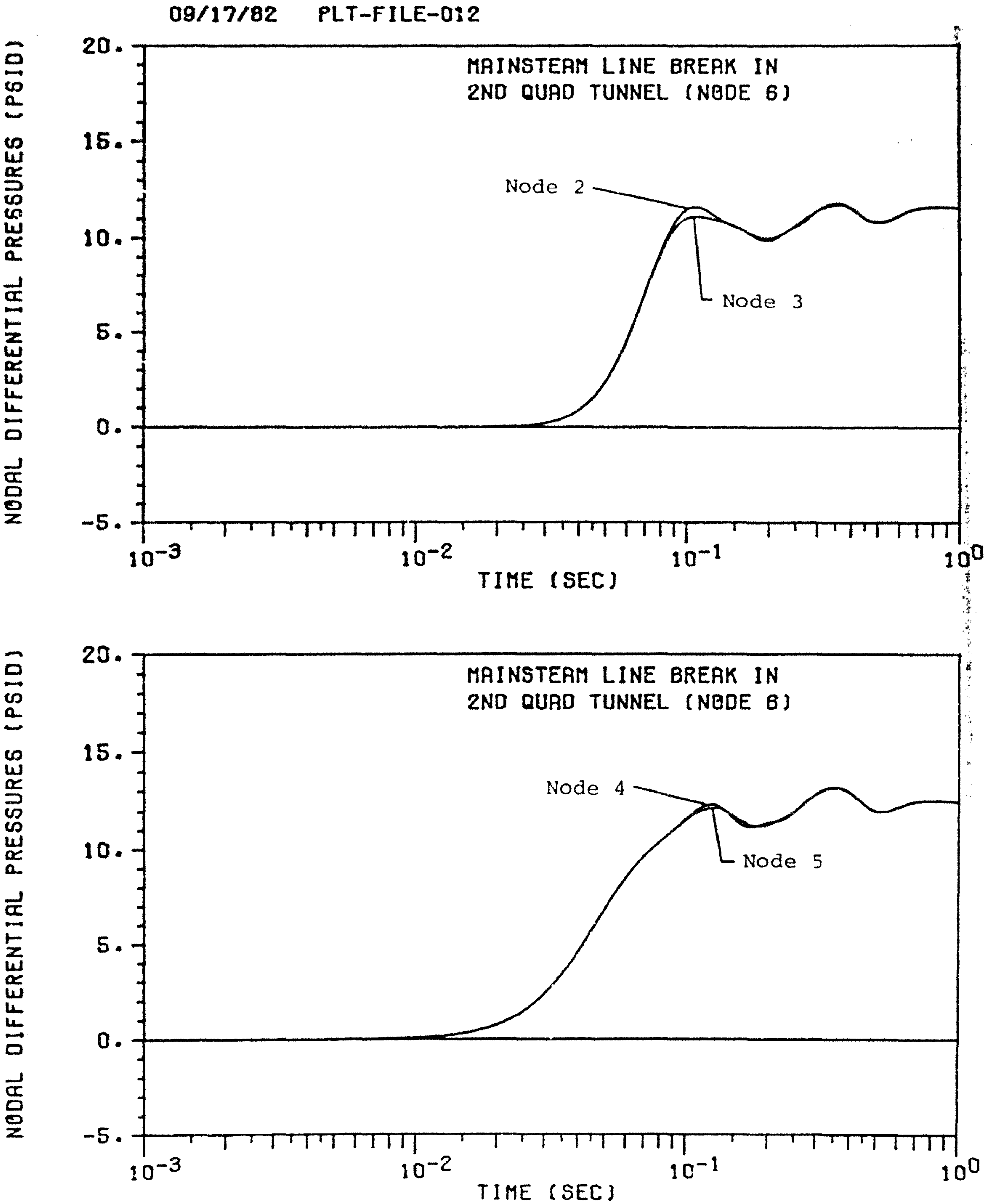
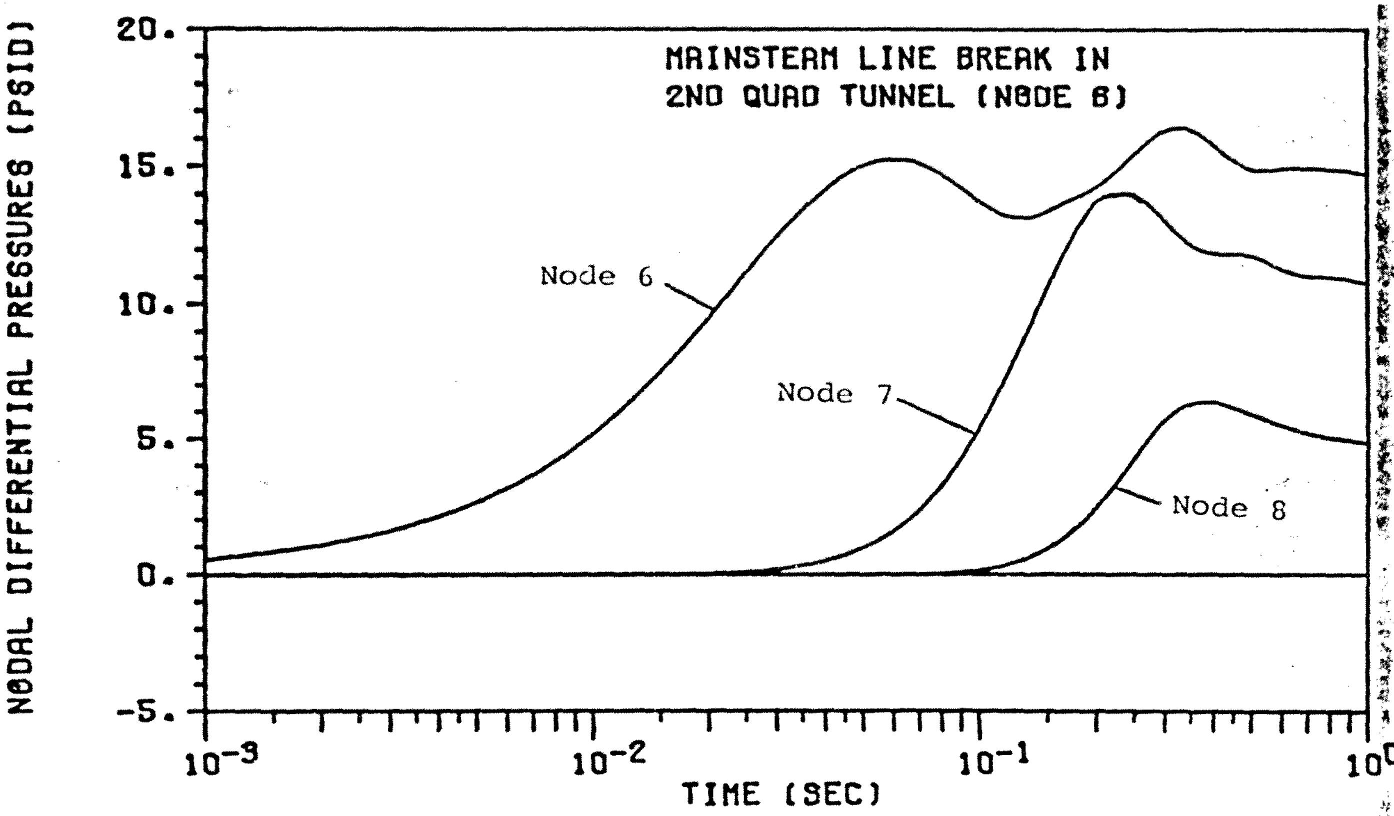


FIGURE 6:
PRESSURE TRANSIENT FOR NODES 2, 3, 4, & 5

07/22/82 PLT-FILE-958



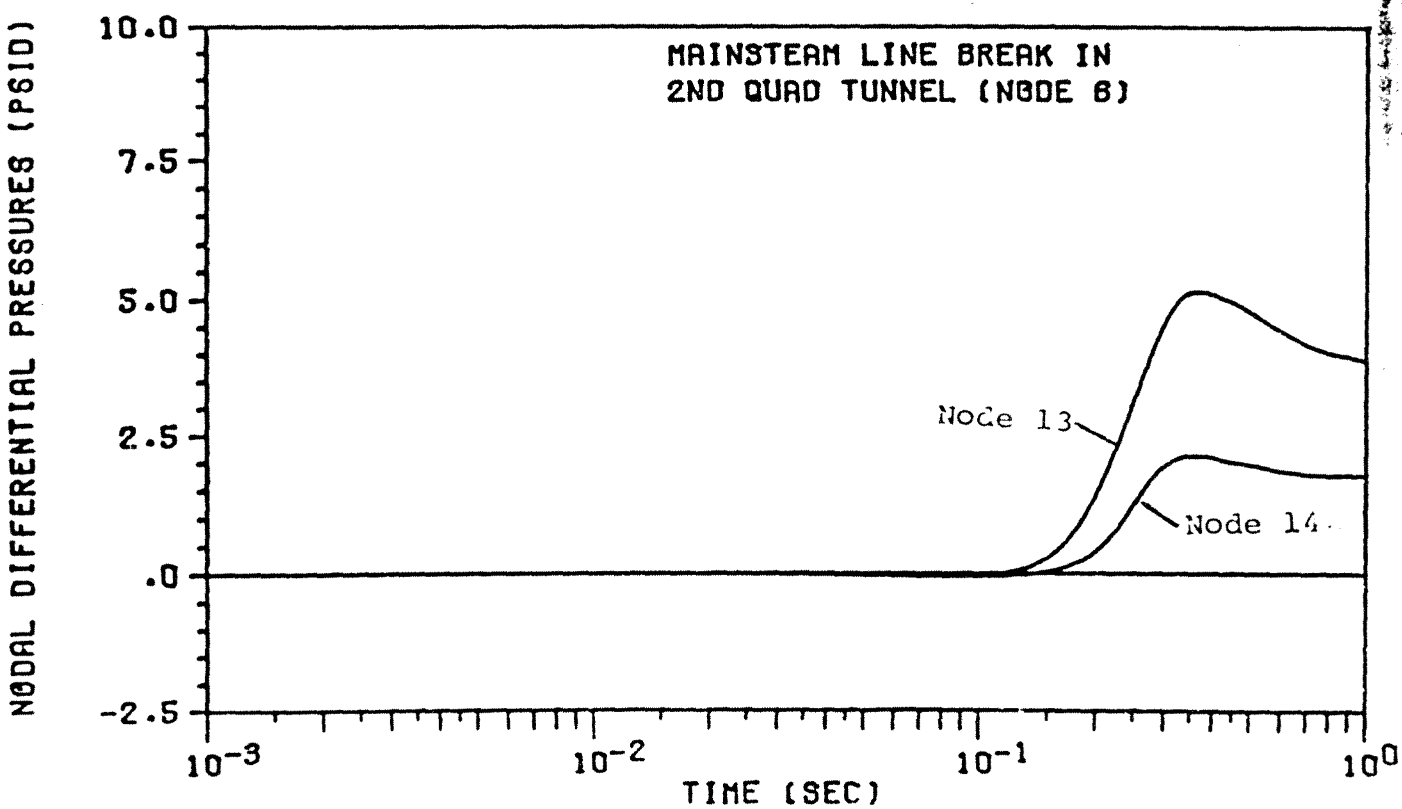


FIGURE 7:
PRESSURE TRANSIENT FOR NODES 6, 7, 8, 13, & 14

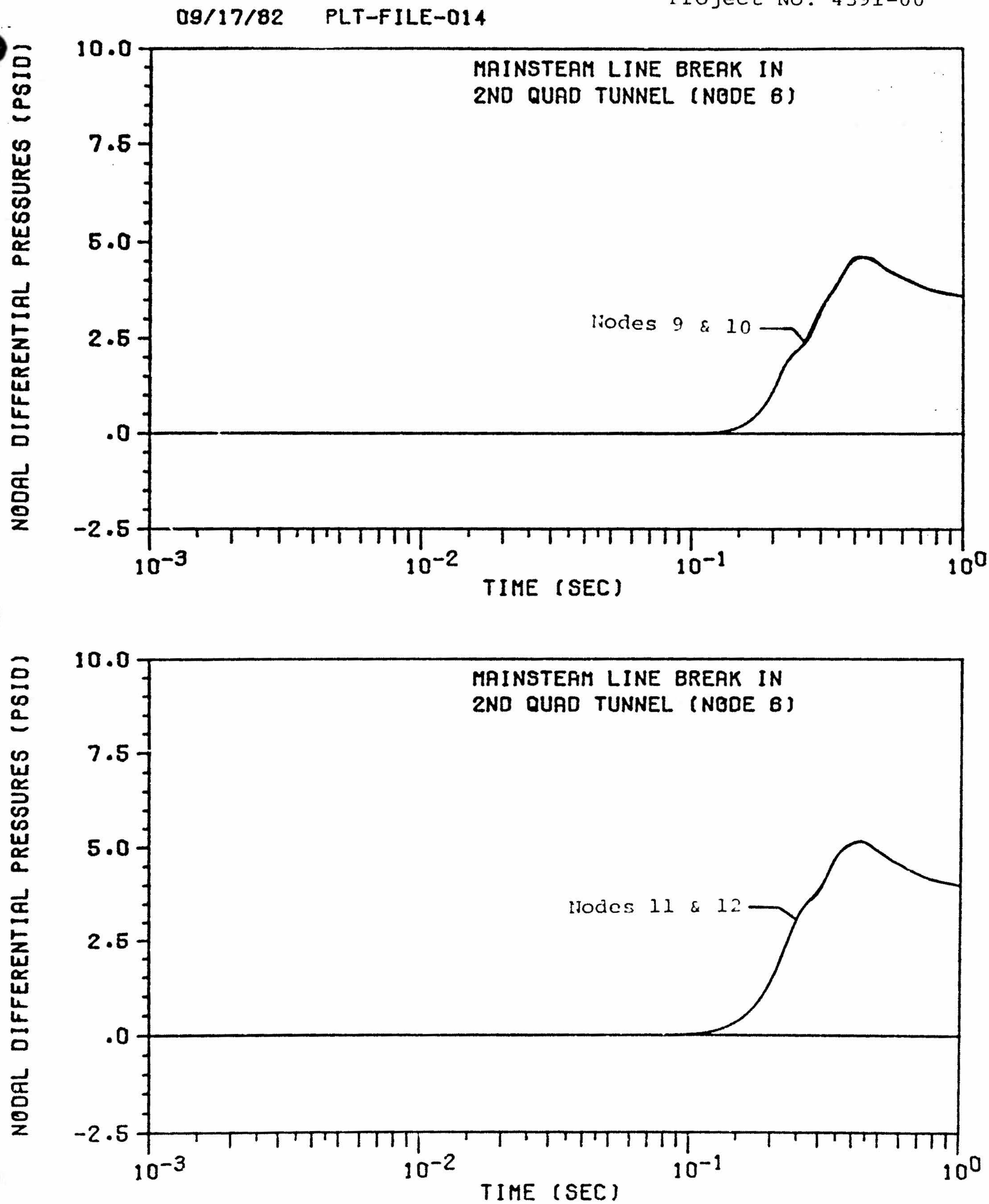
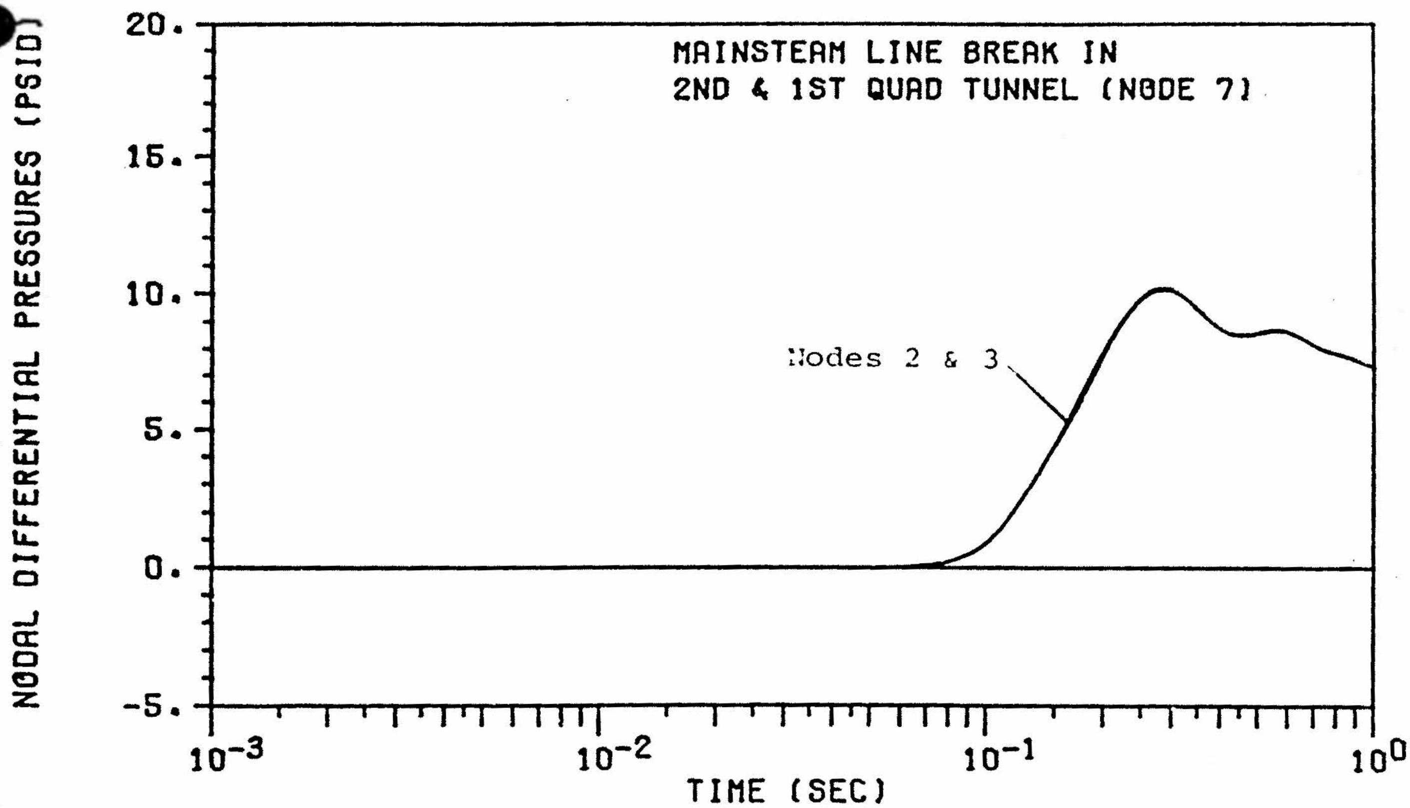


FIGURE 8:
PRESSURE TRANSIENT FOR NODES 9, 10, 11, & 12

09/17/82 PLT-FILE-015



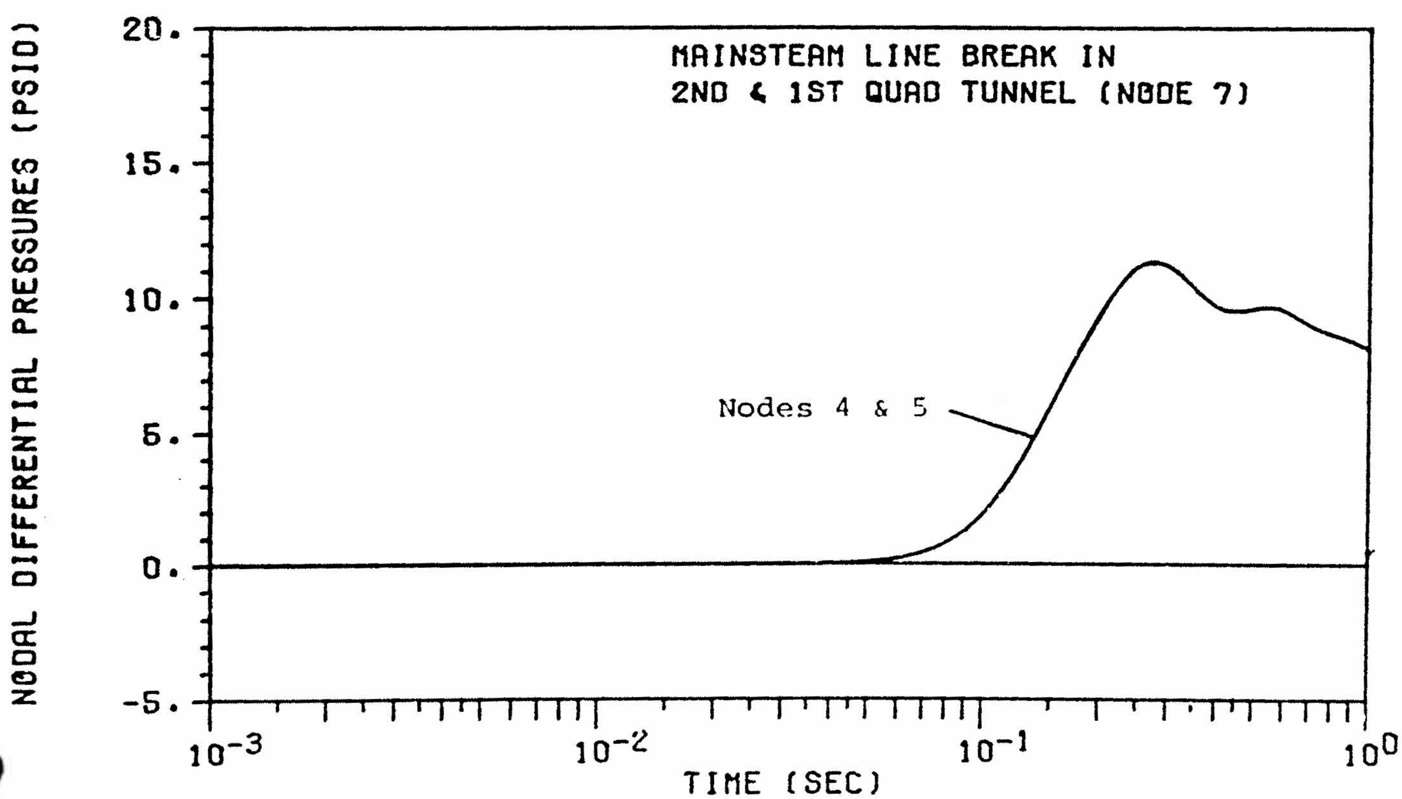
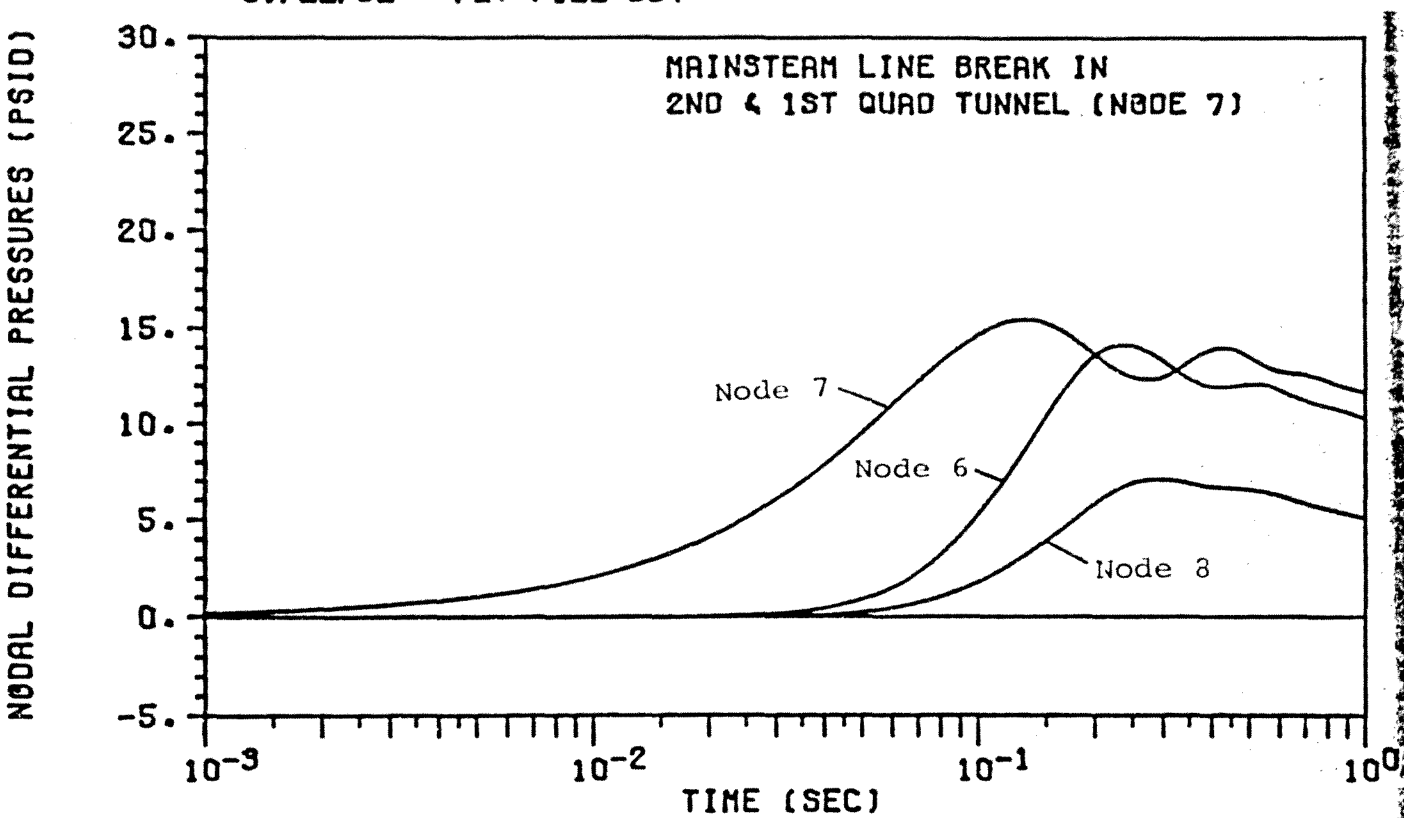


FIGURE 9:
PRESSURE TRANSIENT FOR NODES 2, 3, 4, & 5

07/22/82 PLT-FILE-984



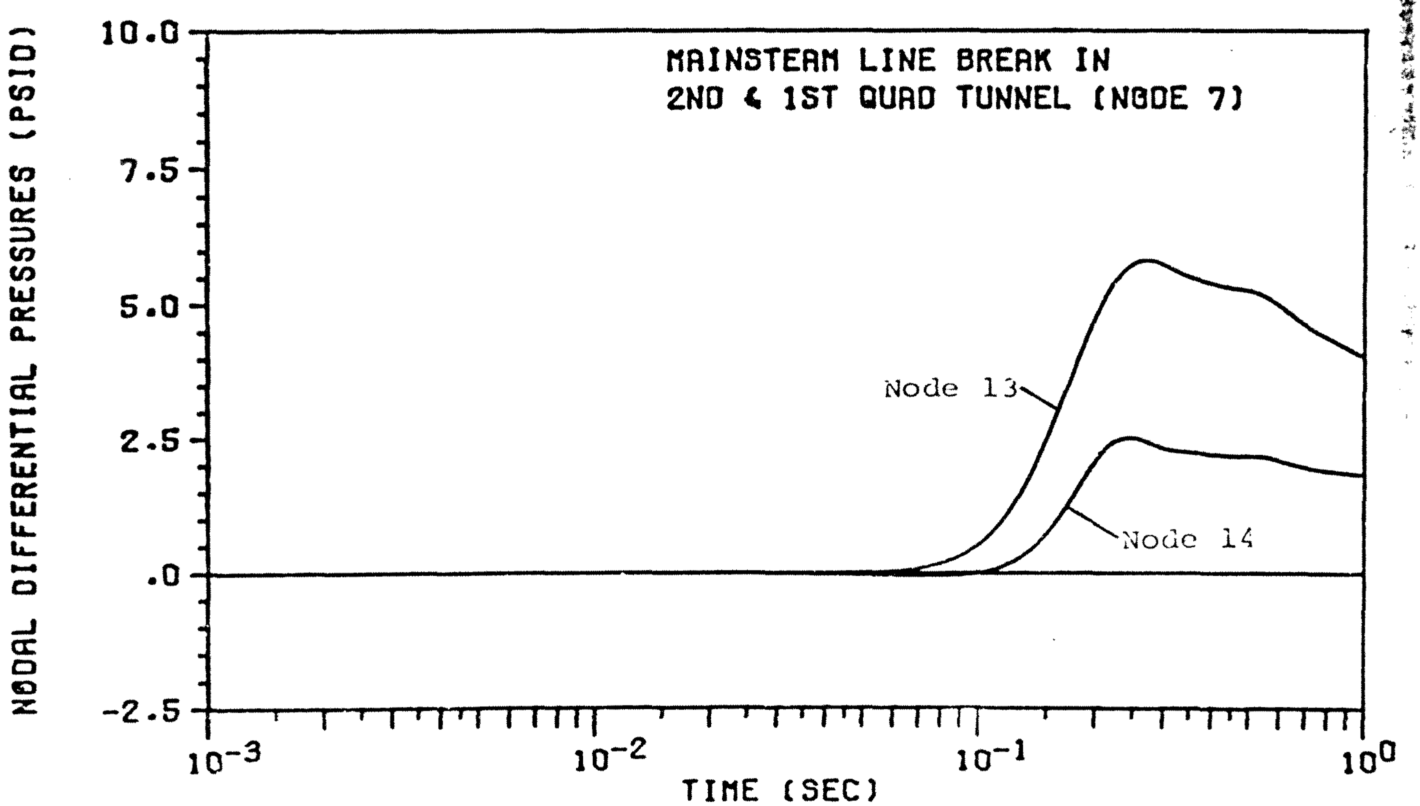


FIGURE 10:
PRESSURE TRANSIENT FOR NODES 6. 7. 8. 13. & 14

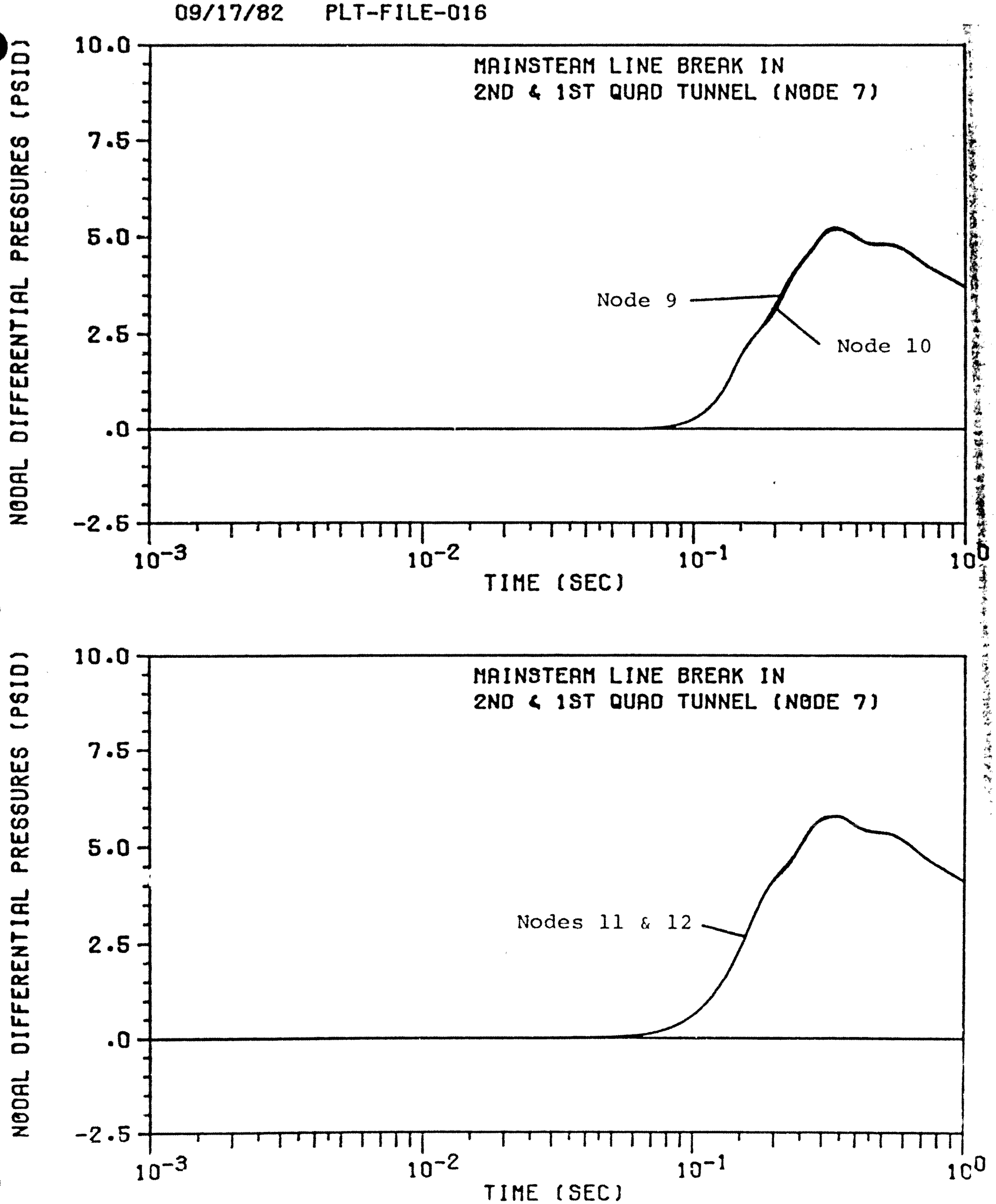
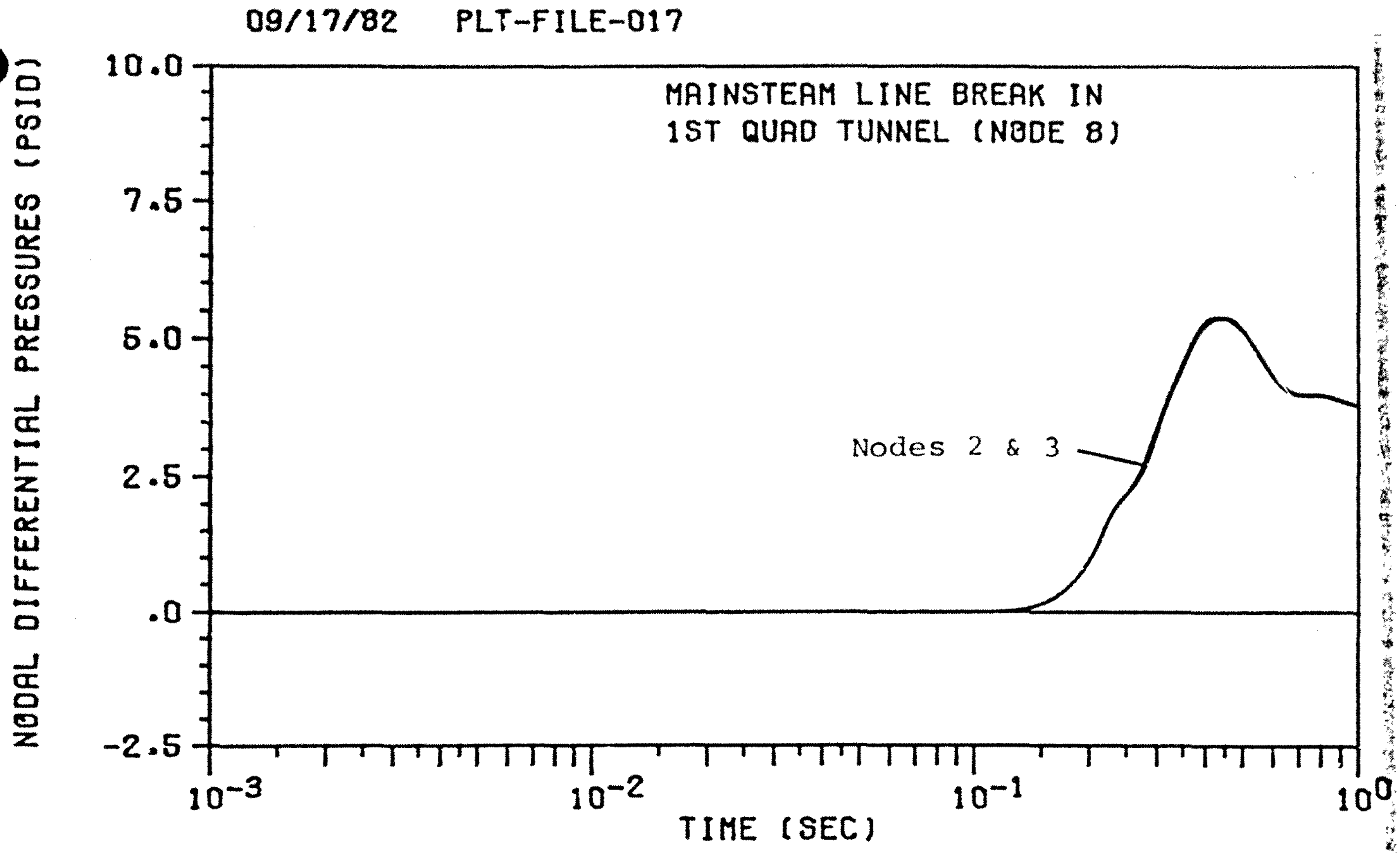


FIGURE 11:
PRESSURE TRANSIENT FOR NODES 9, 10, 11, & 12



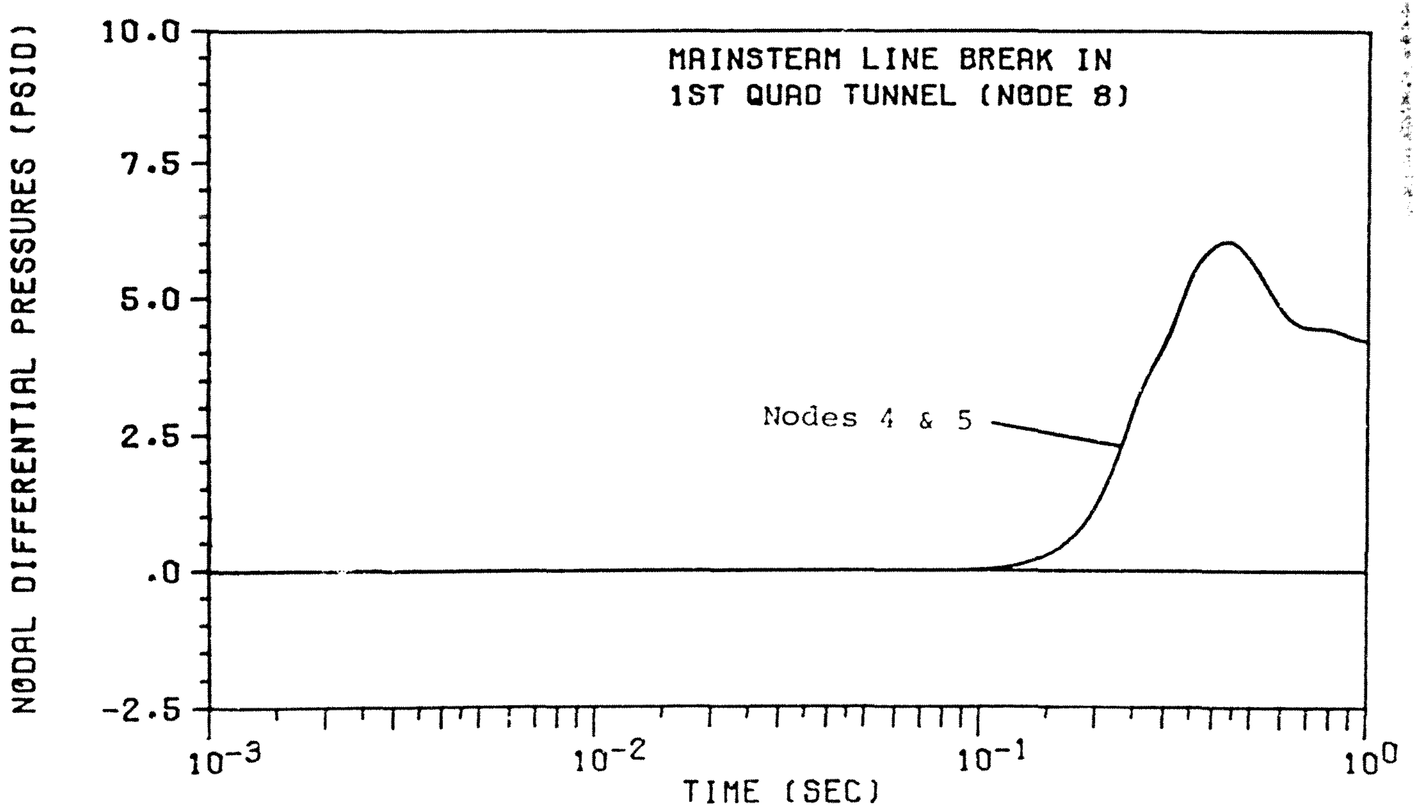
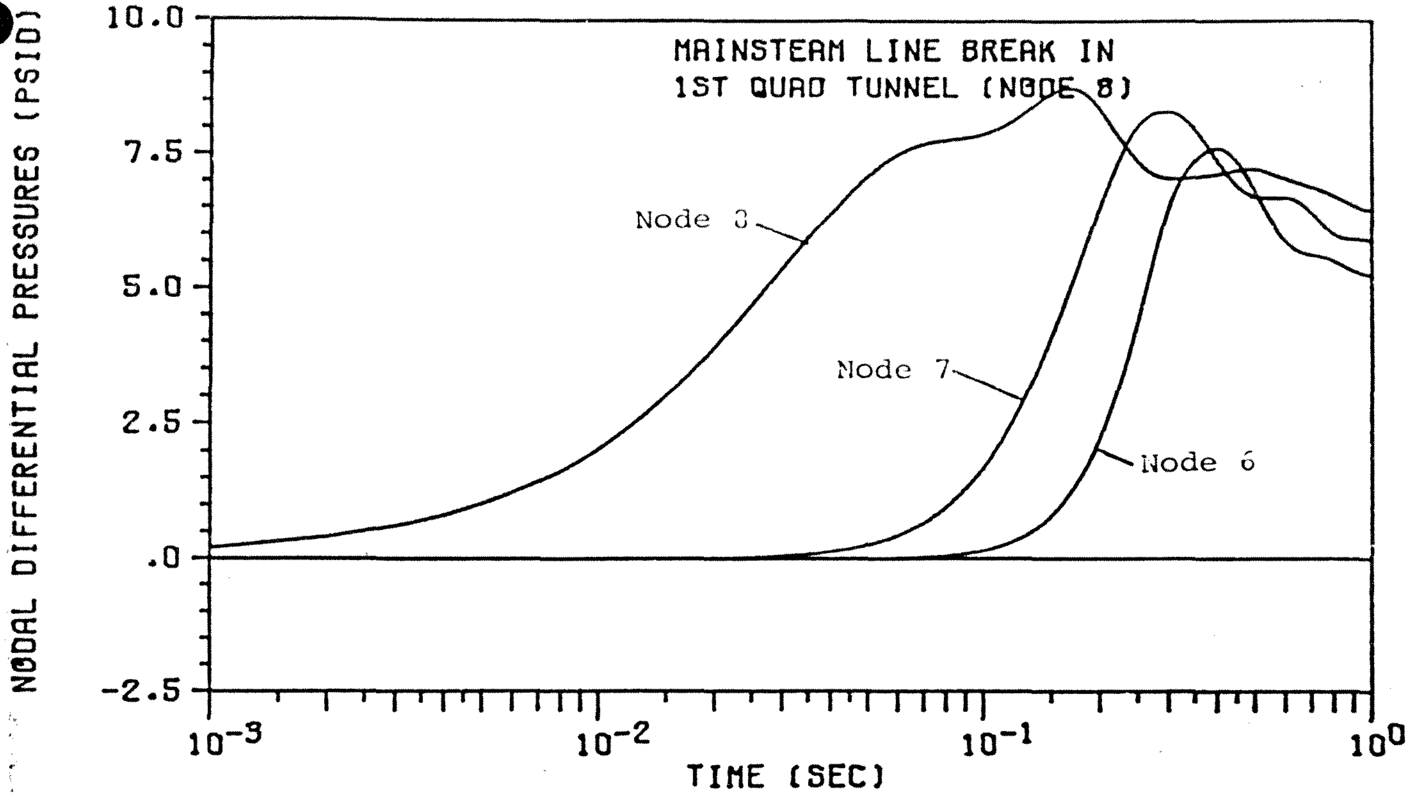


FIGURE 12:
PRESSURE TRANSIENT FOR NODES 2, 3, 4, & 5

07/23/82 PLT-FILE-967



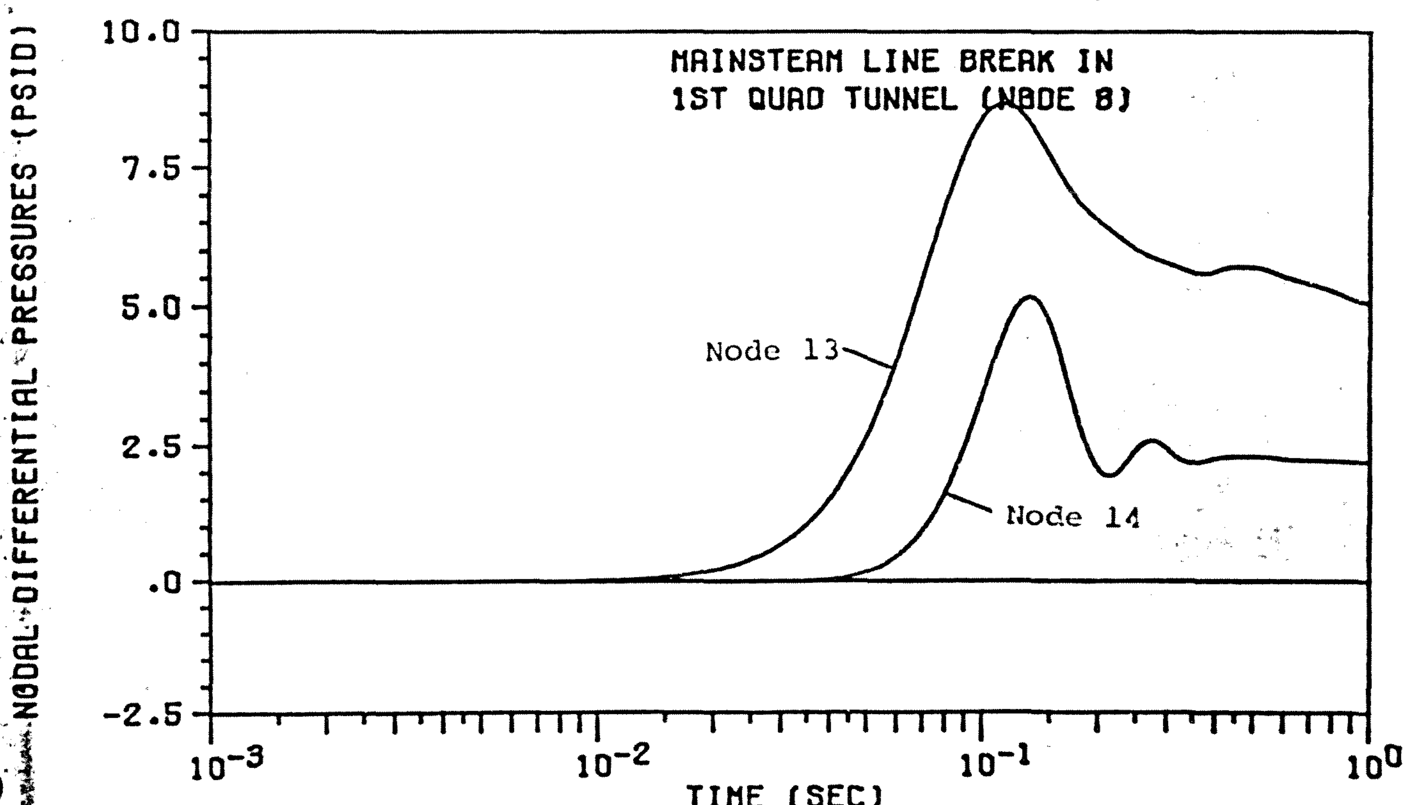


FIGURE 13:
PRESSURE TRANSIENT FOR NODES 6, 7, 8, 13, & 14

09/17/82 PLT-FILE-018

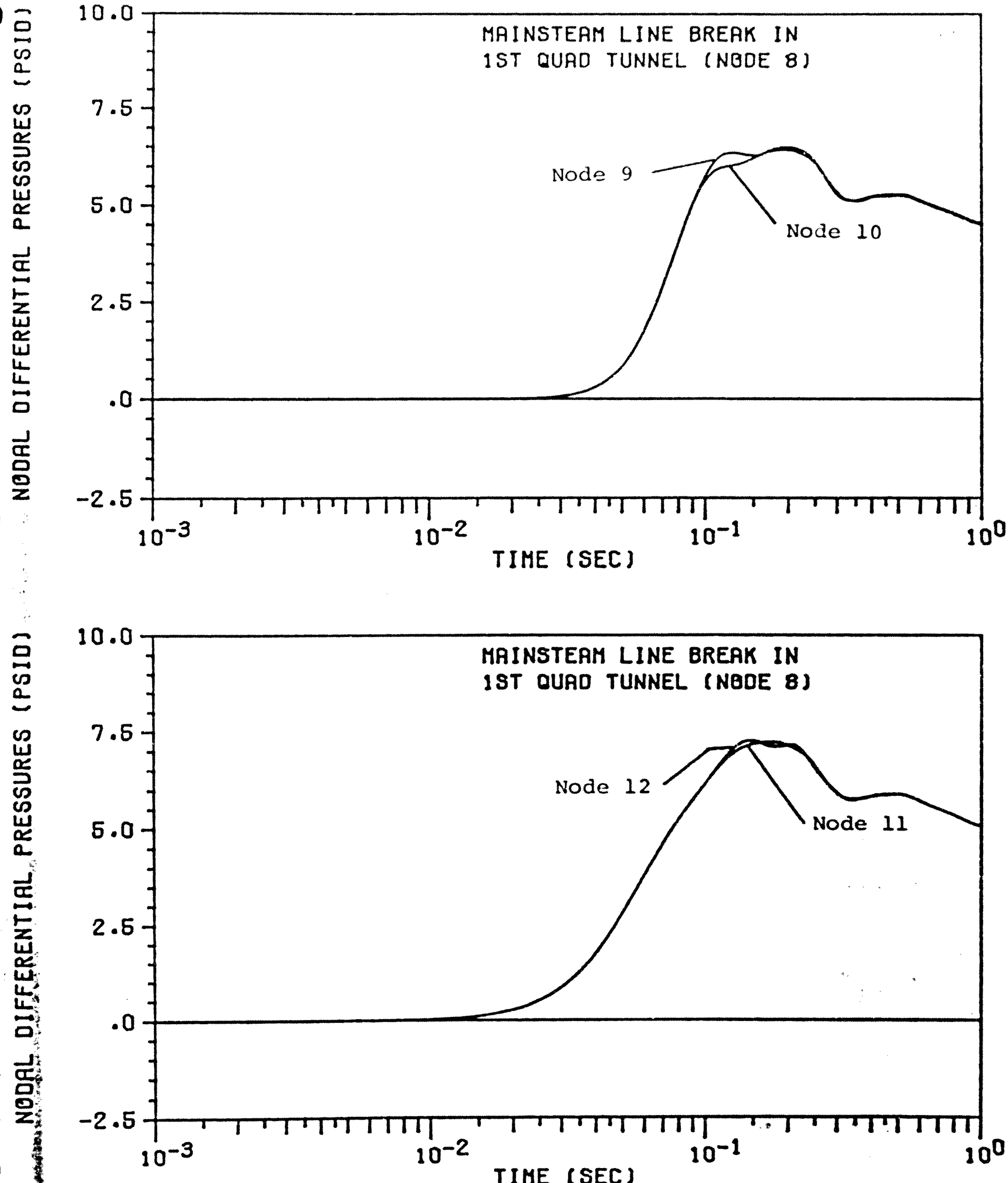
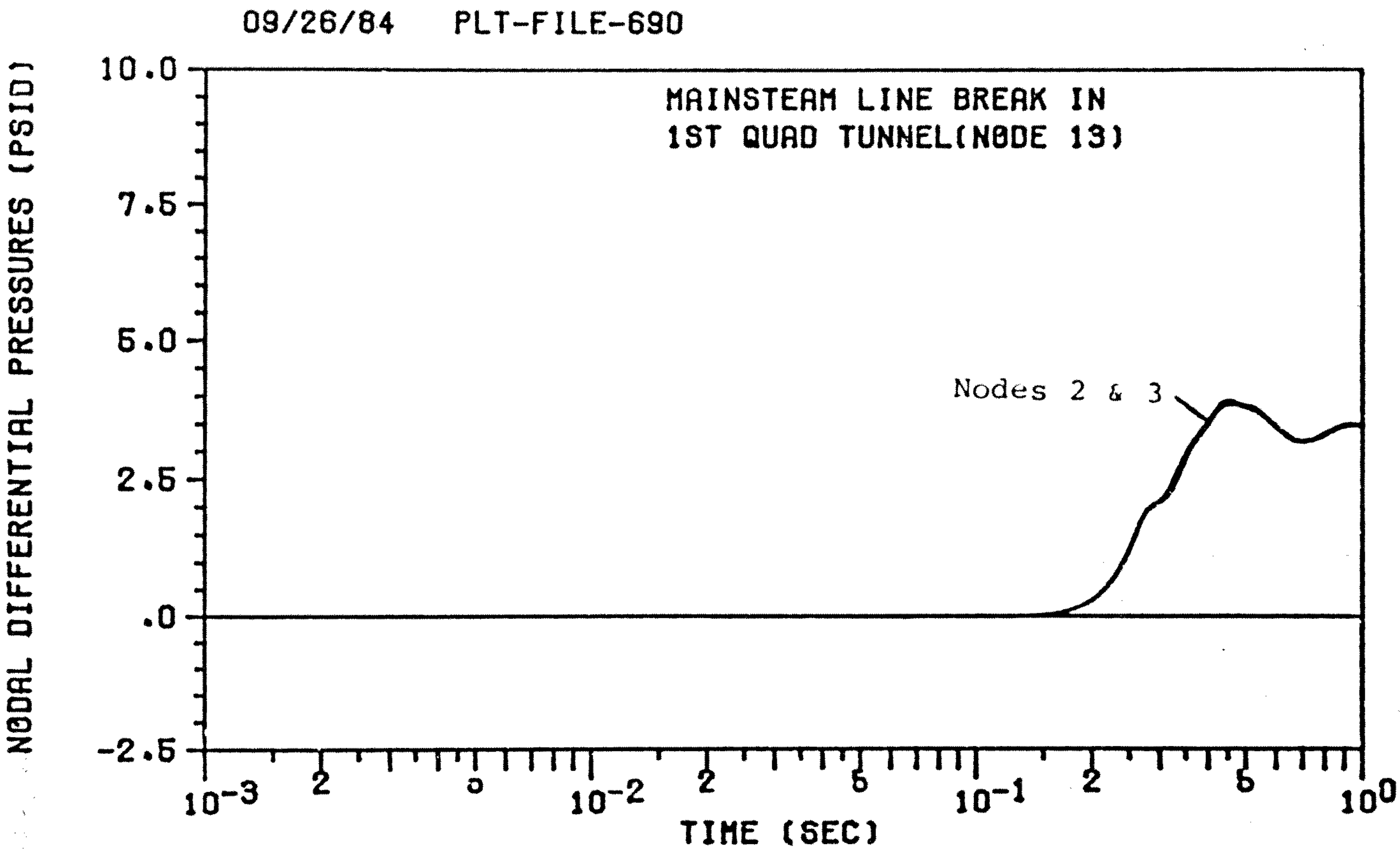


FIGURE 14:
PRESSURE TRANSIENT FOR NODES 9, 10, 11, & 12



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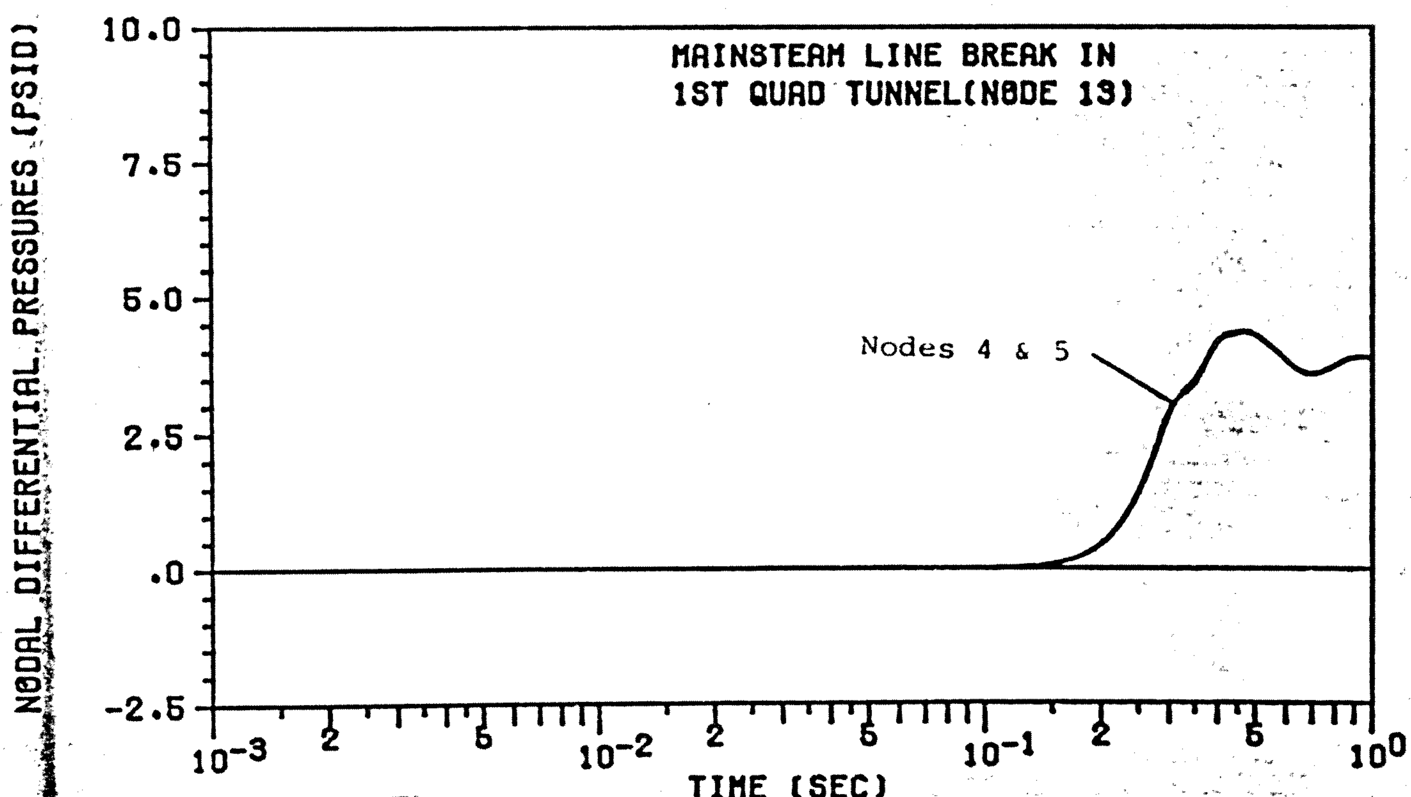
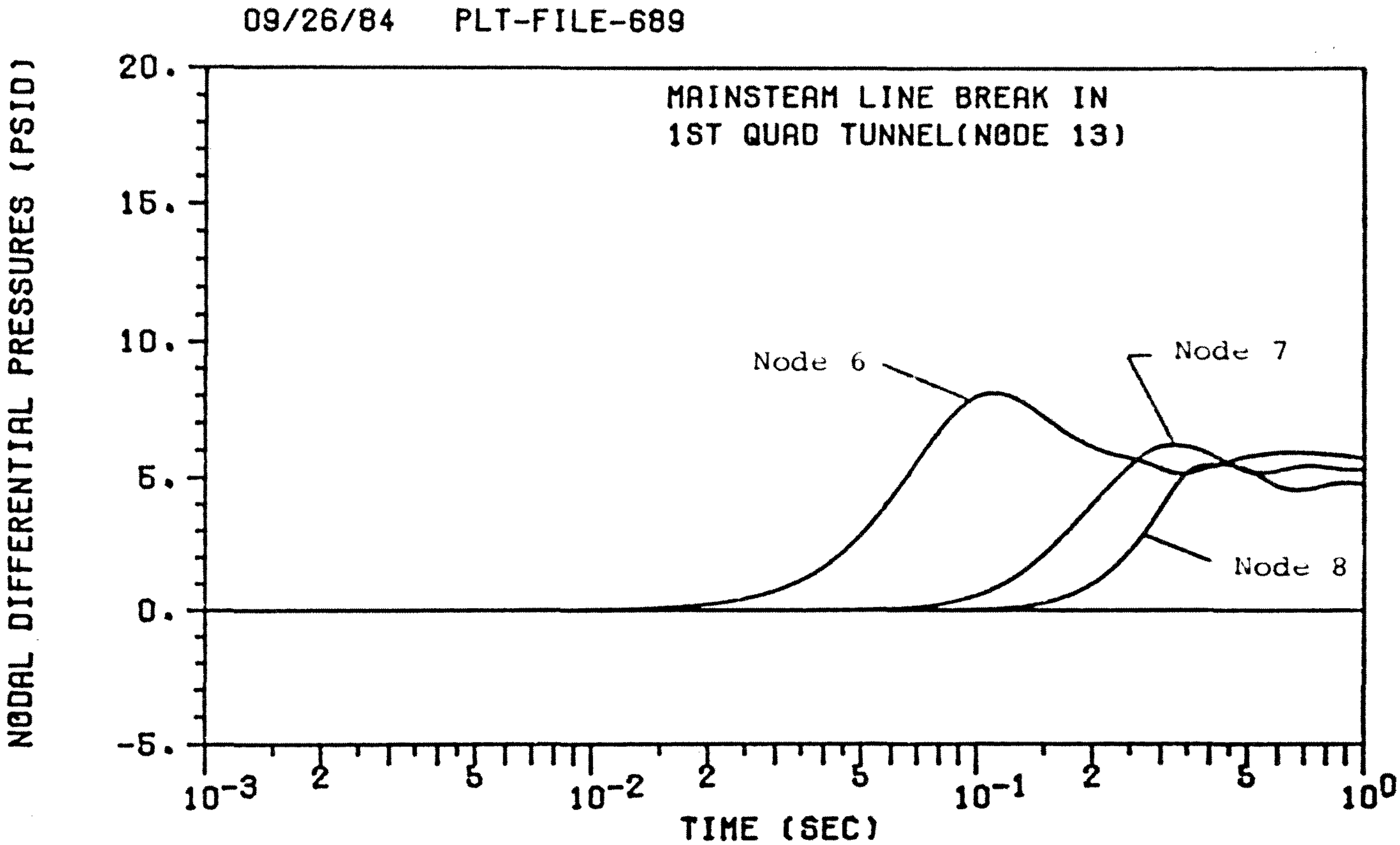


FIGURE 15:
PRESSURE TRANSIENT FOR NODES 2, 3, 4 & 5



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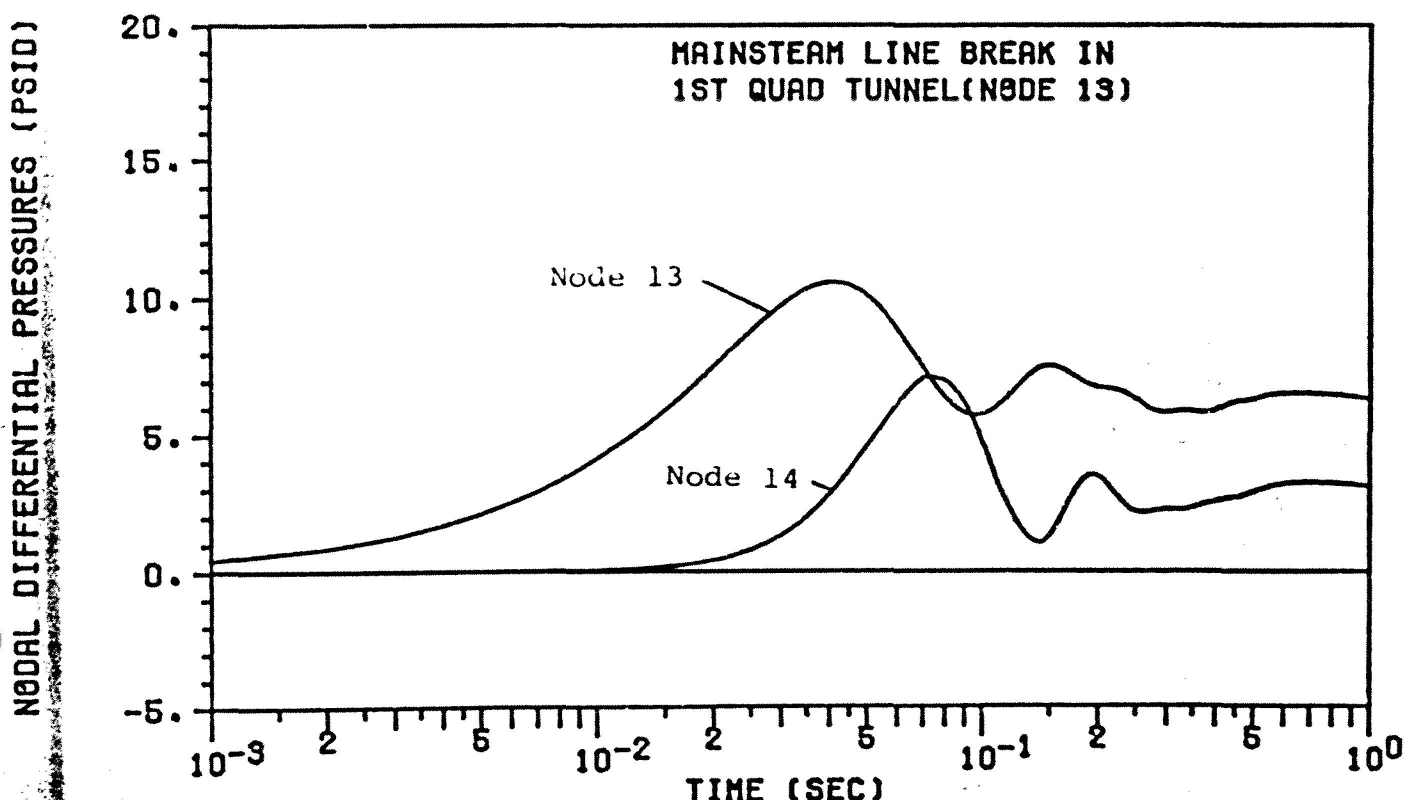
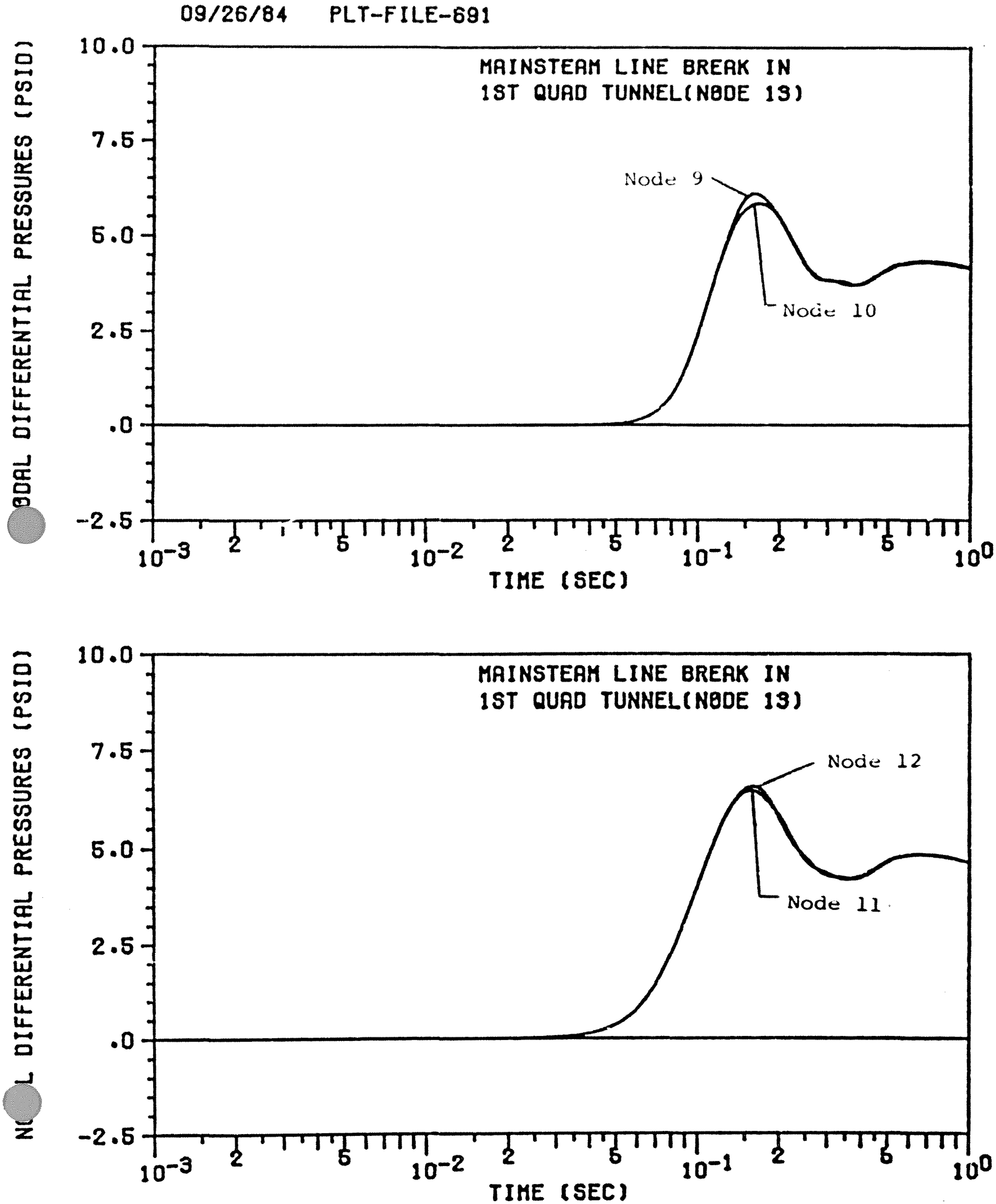


FIGURE 16:
PRESSURE TRANSIENT FOR NODES 6, 7, 8, 13, & 14



2

FIGURE 17:

PRESSURE TRANSIENT FOR NODES 9, 10, 11, & 12

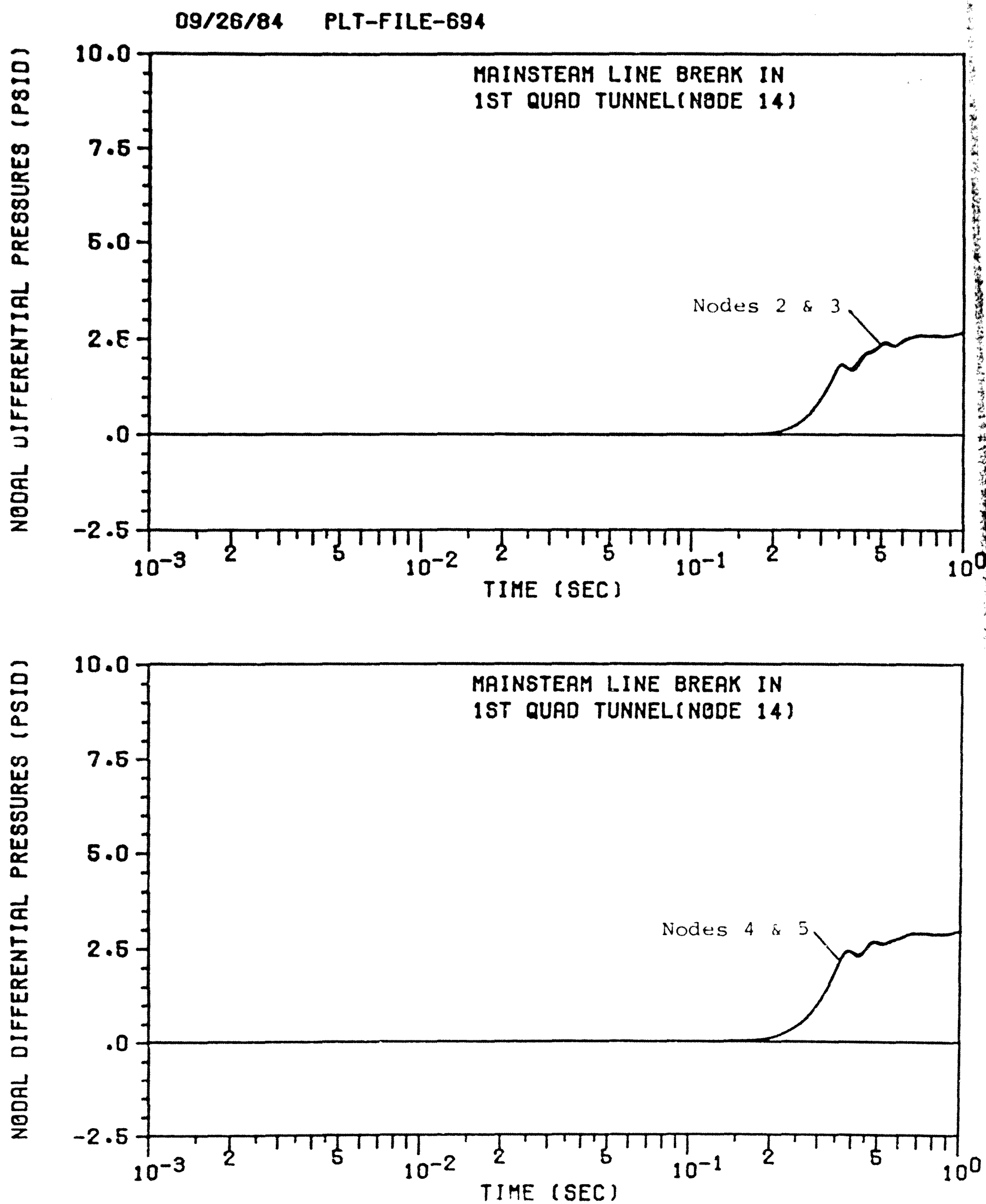


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FIGURE 18:
PRESSURE TRANSIENT FOR NODES 2, 3, 4, & 5

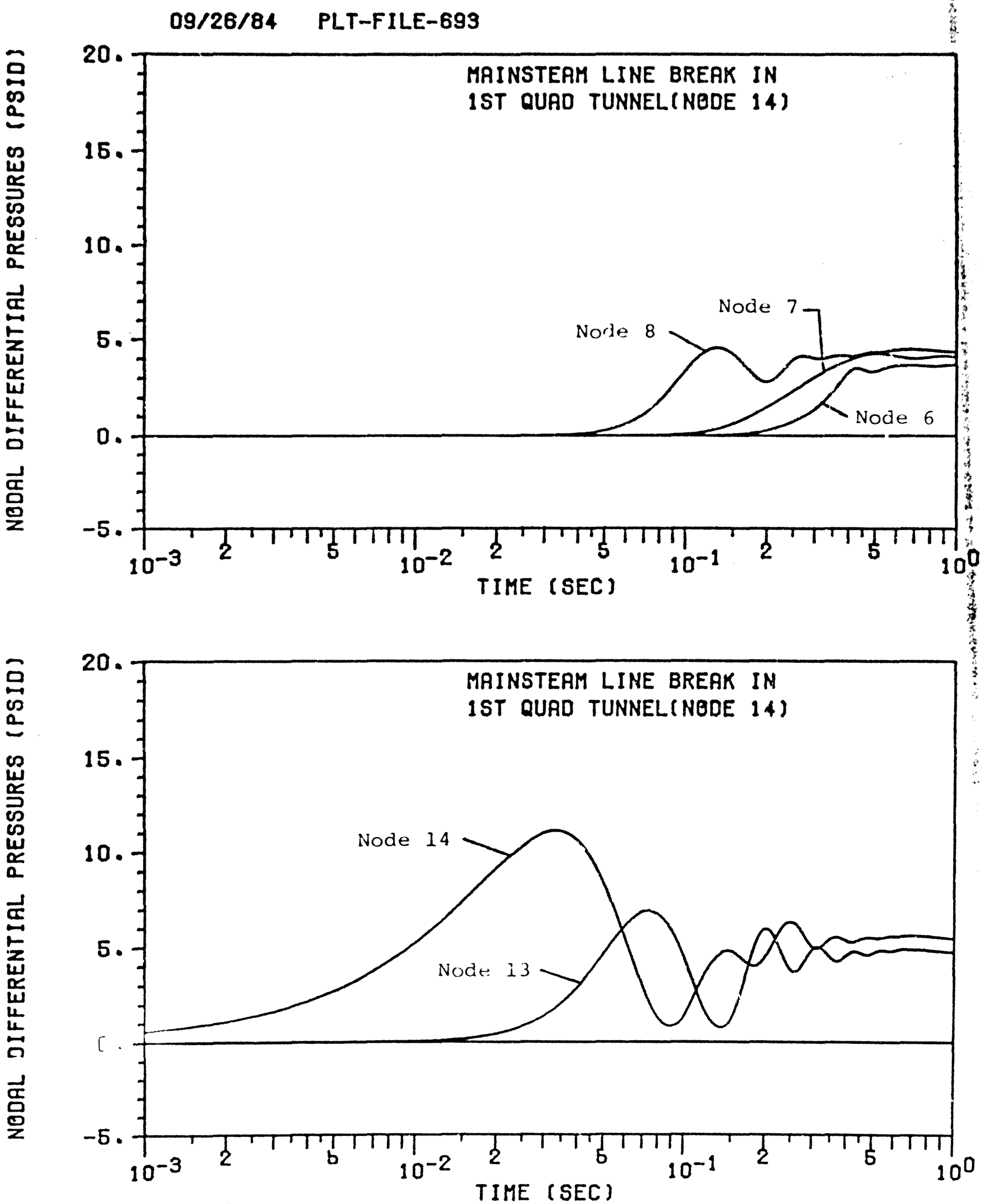

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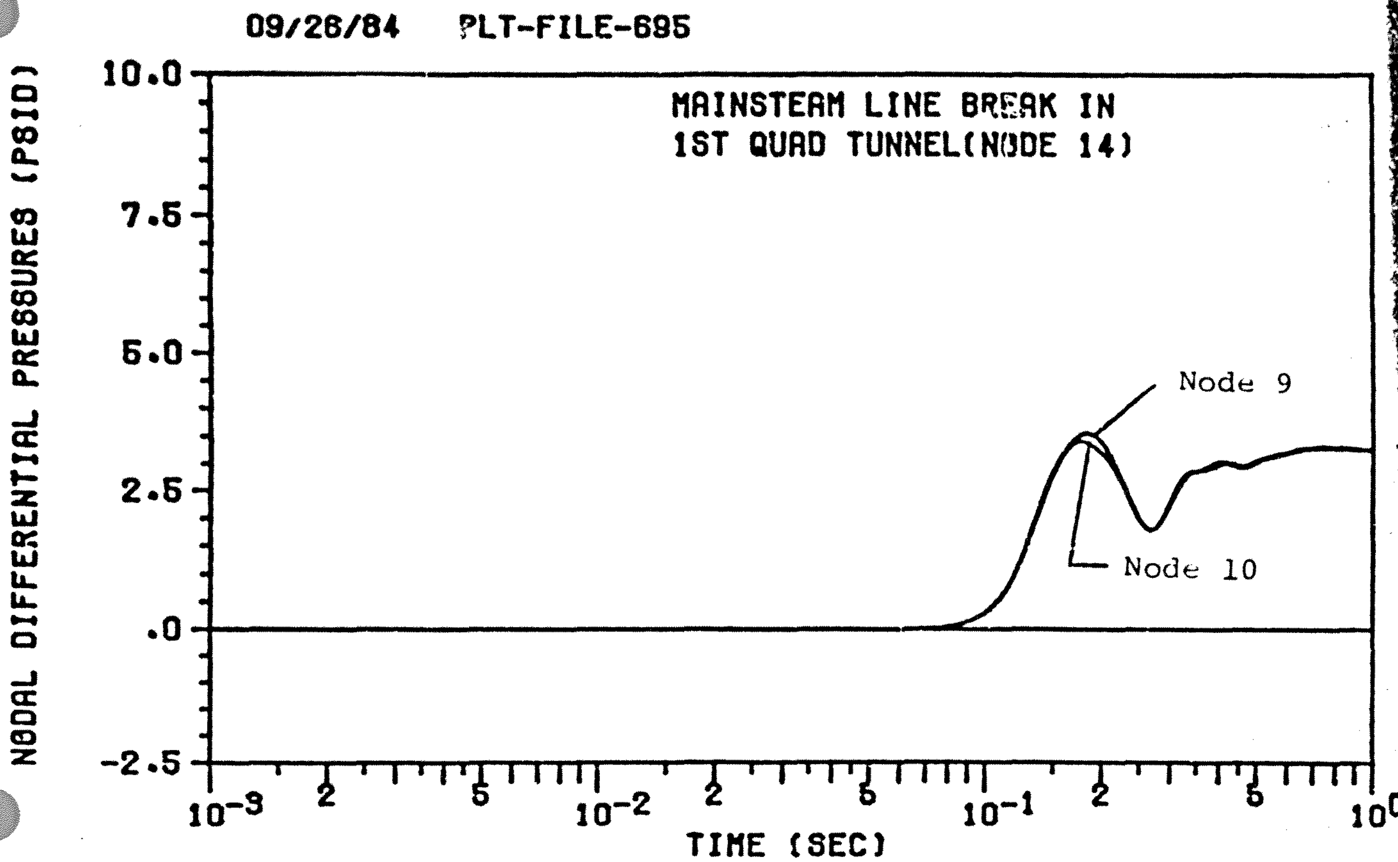
FIGURE 19:

PRESSURE TRANSIENT FOR NODES 6, 7, 8, 13, & 14



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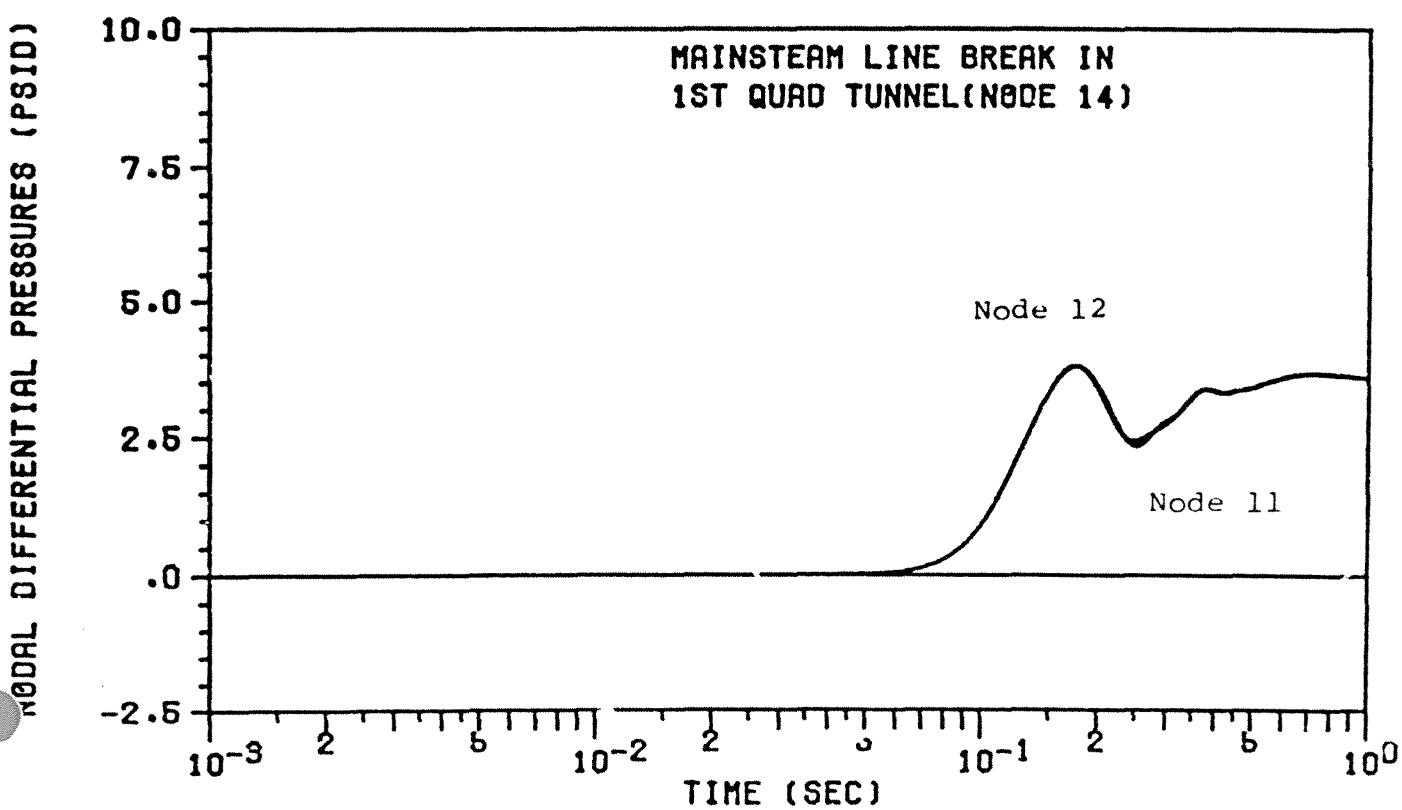
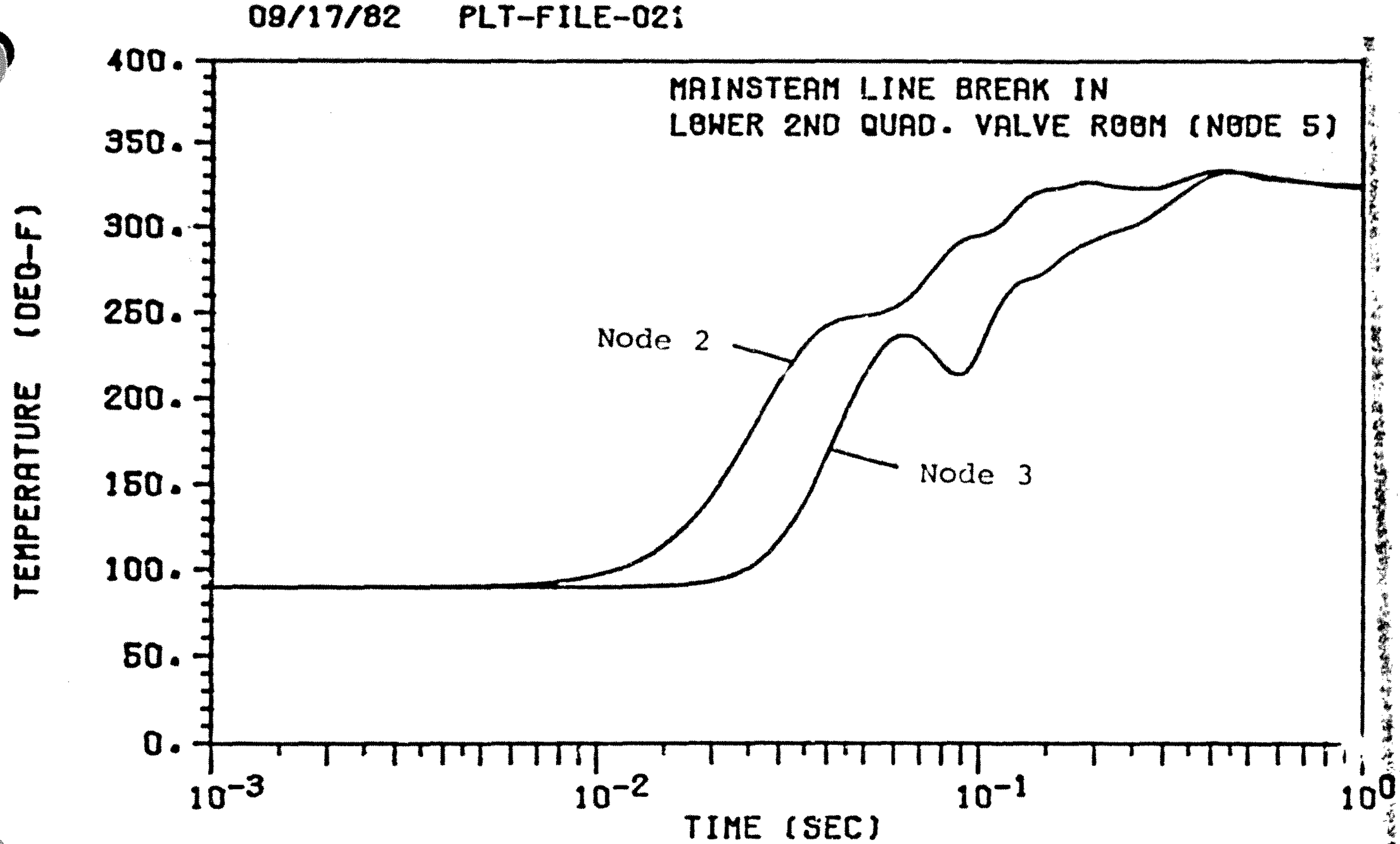


FIGURE 20:
PRESSURE TRANSIENT FOR NODES 9, 10, 11, & 12

09/17/82 PLT-FILE-021



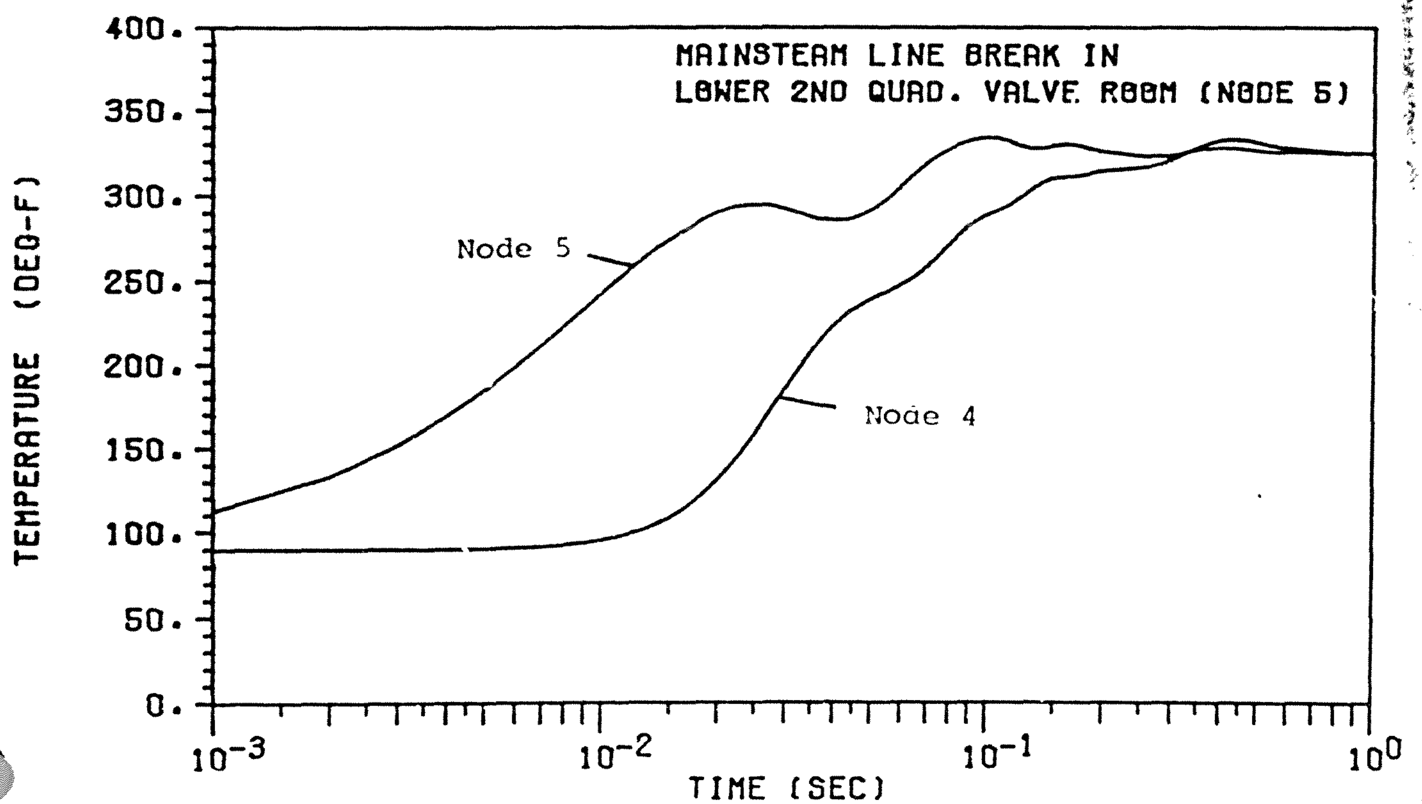
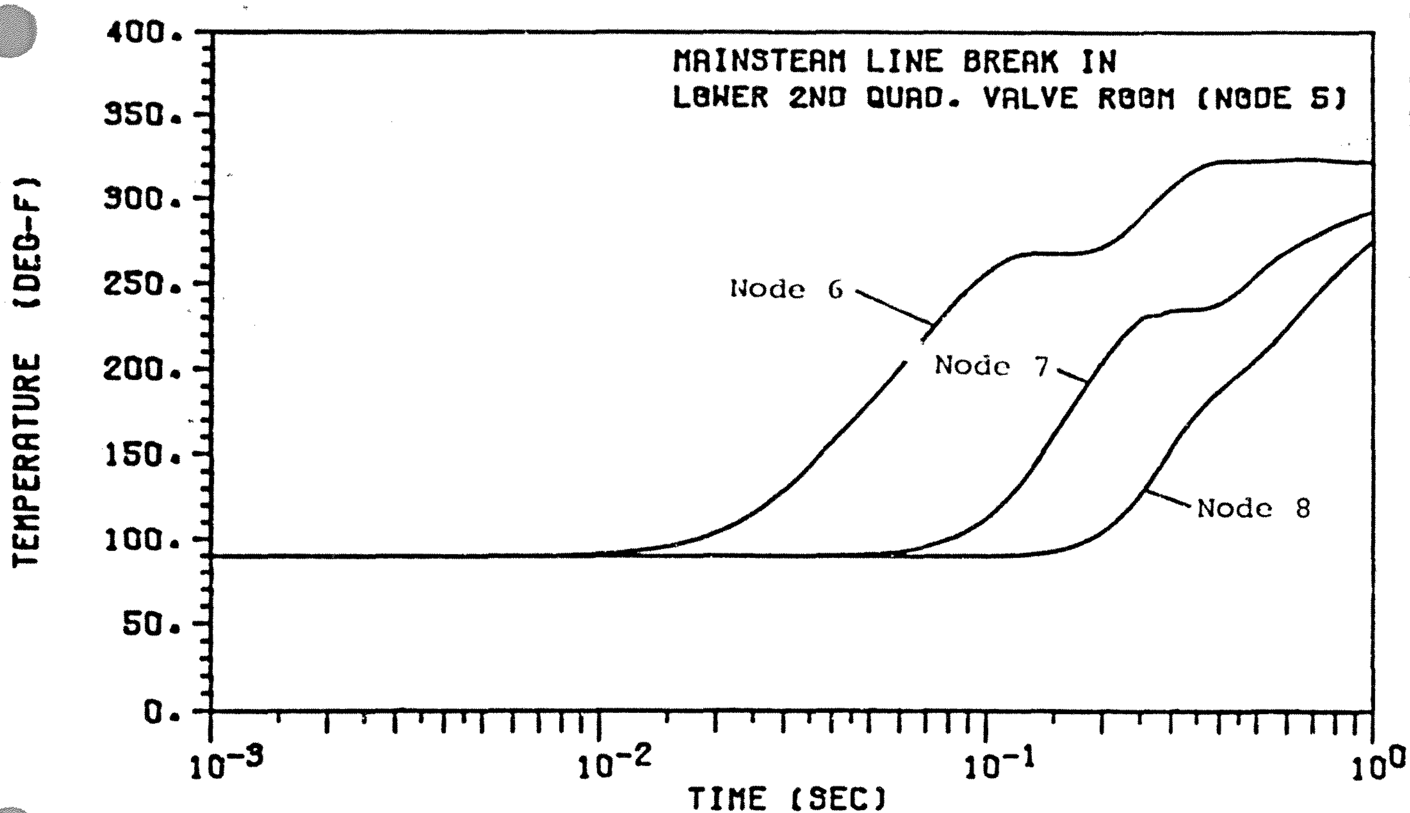


FIGURE 21 :
TEMPERATURE TRANSIENT FOR NODES 2, 3, 4, & 5

2

07/22/82 PLT-FILE-955



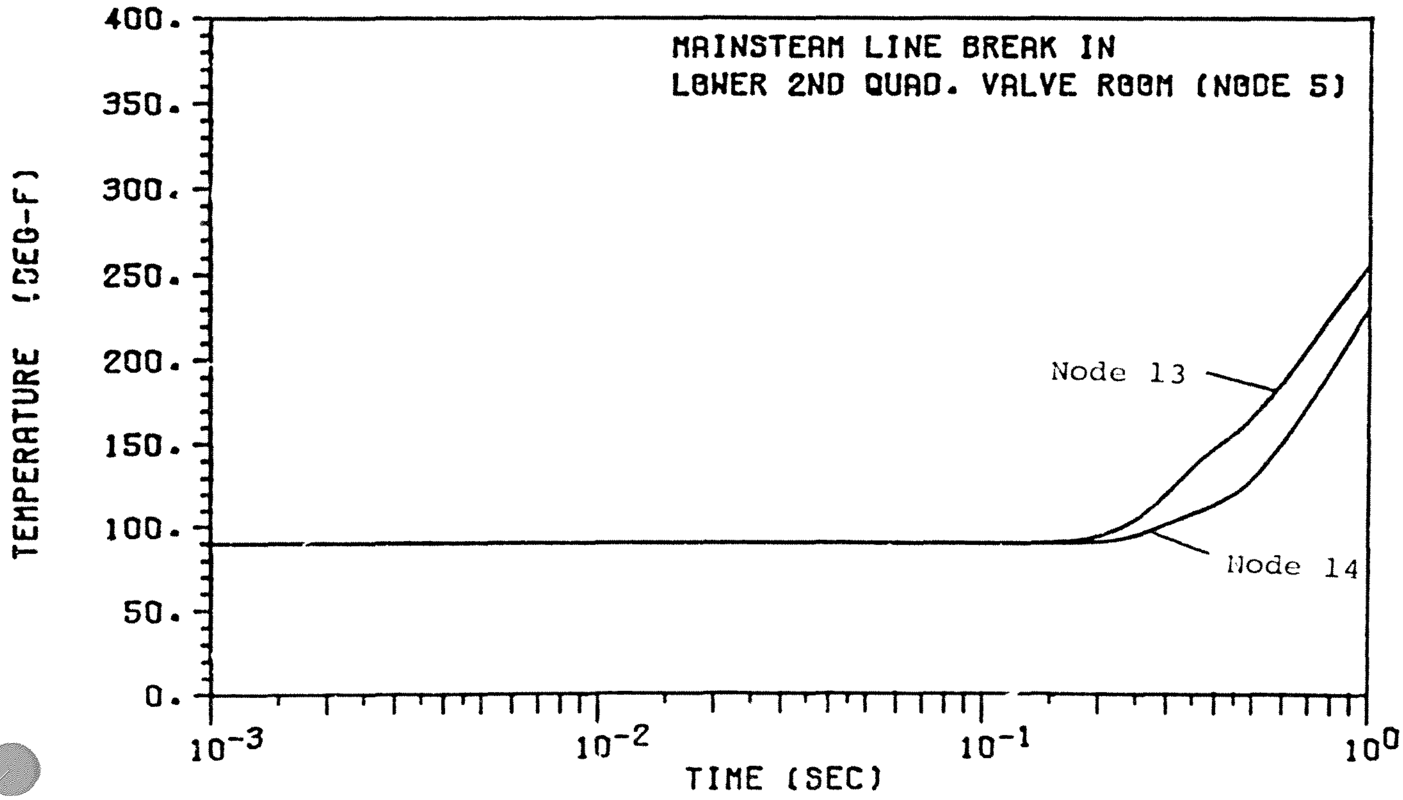
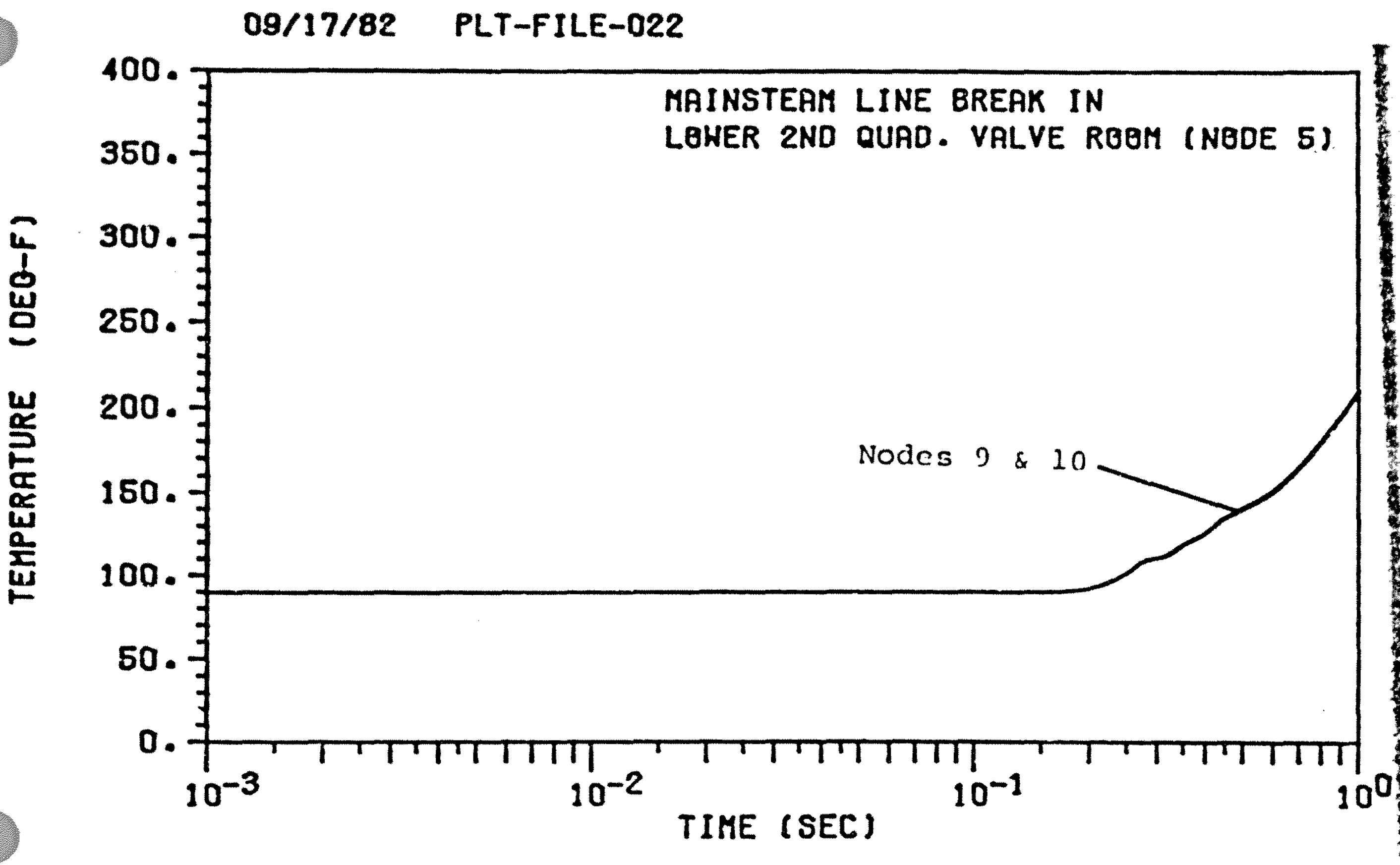


FIGURE 22:
TEMPERATURE TRANSIENT FOR NODES 6, 7, 8, 13, & 14

2



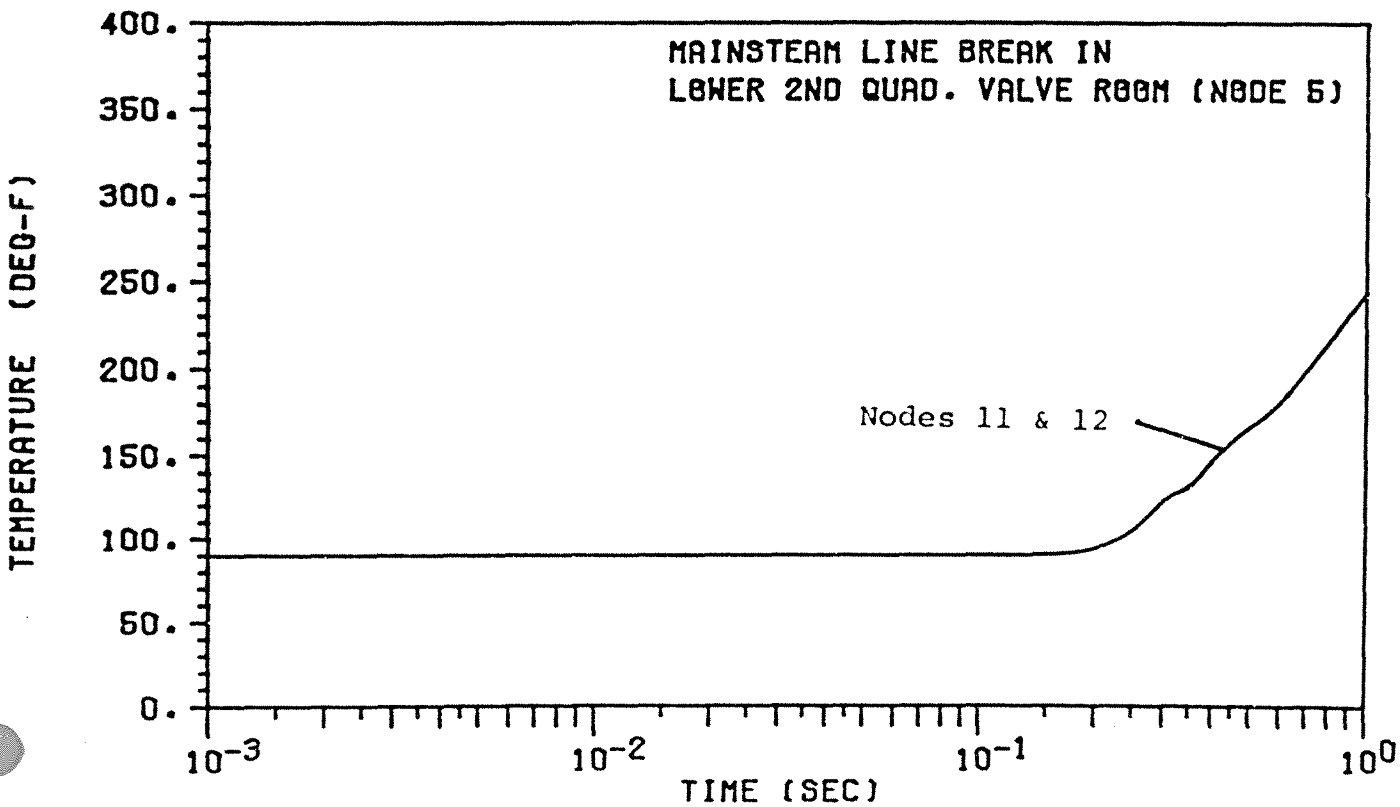
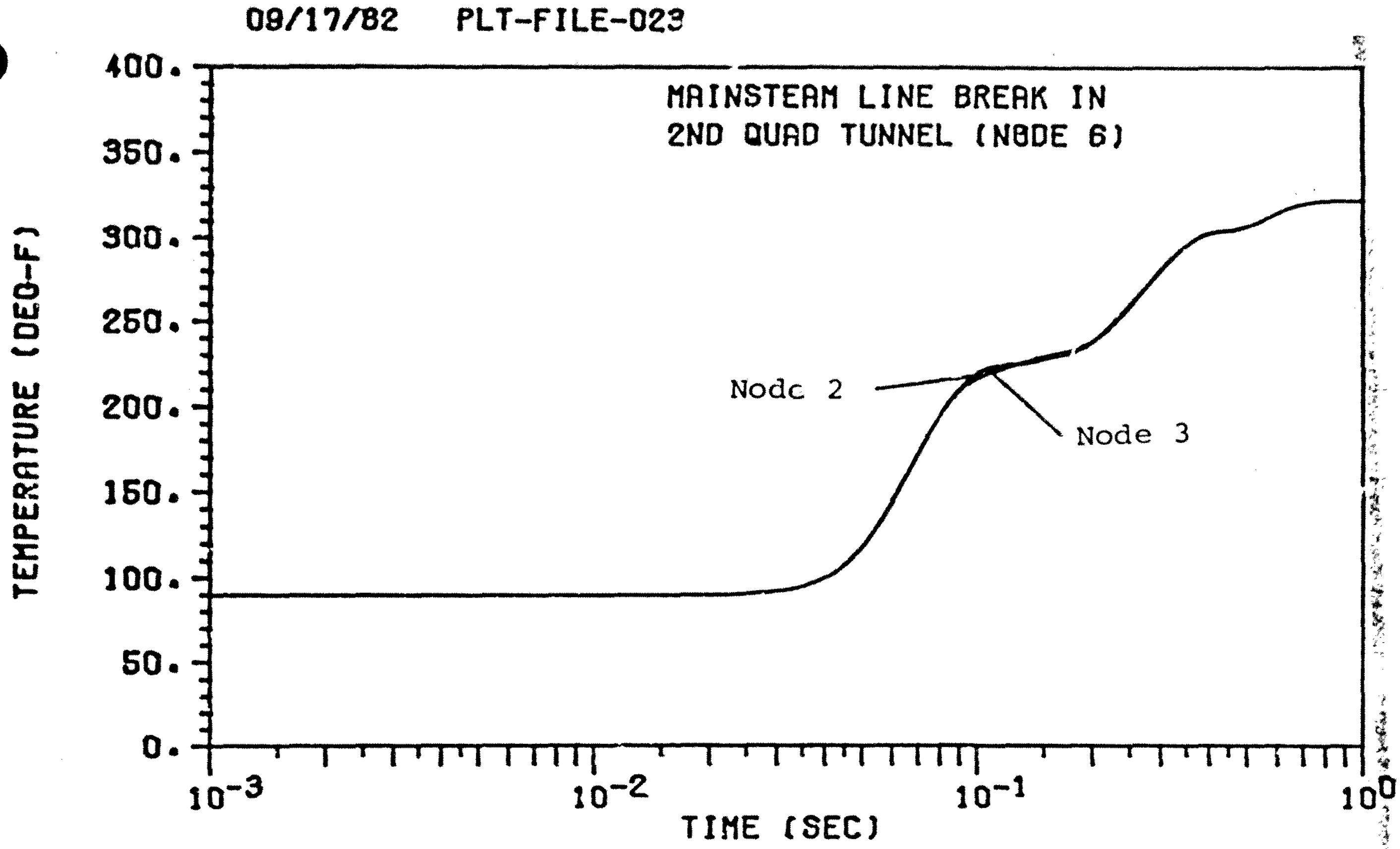


FIGURE 23:
TEMPERATURE TRANSIENT FOR NODES 9, 10, 11, & 12 | 2



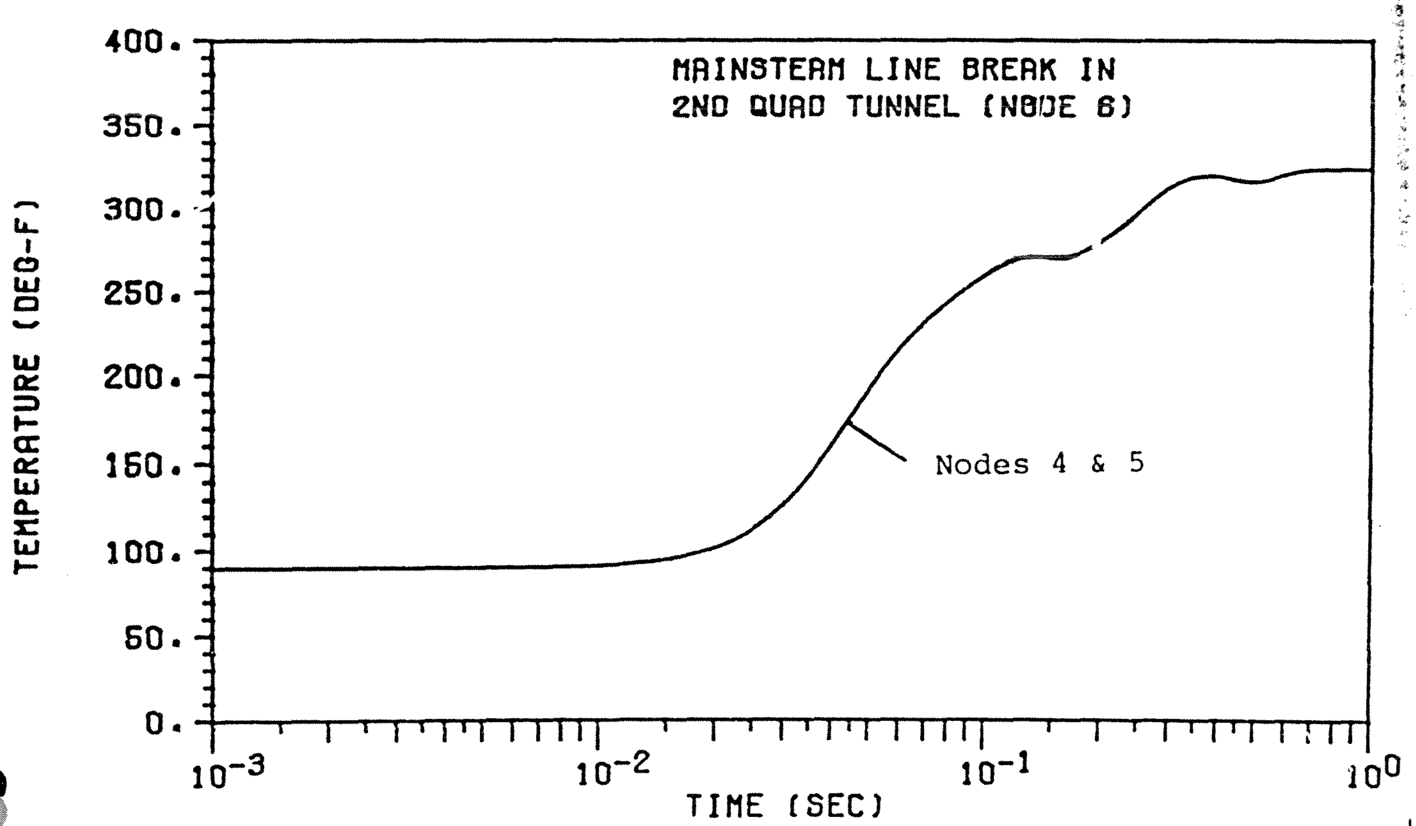
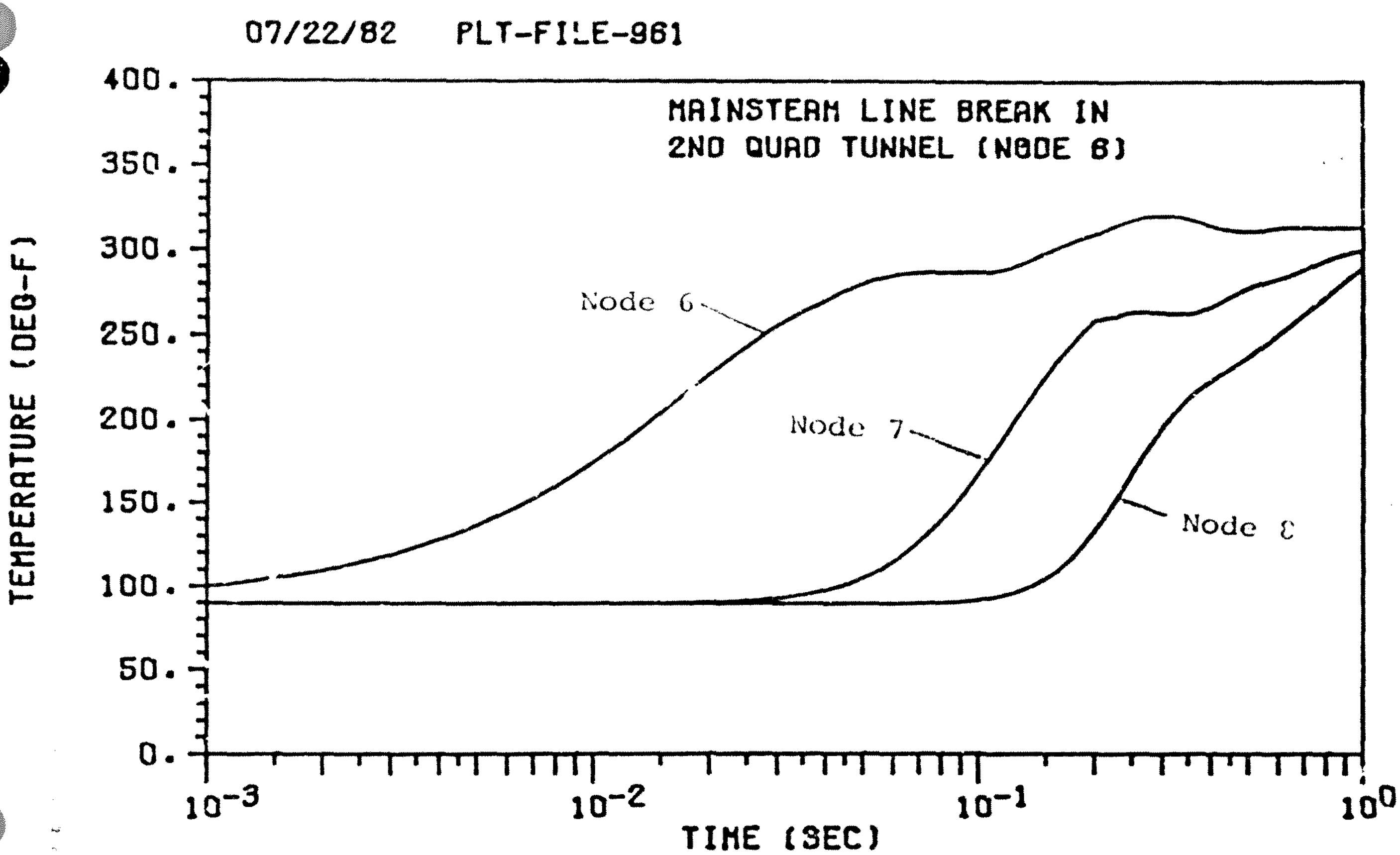


FIGURE 24 :
TEMPERATURE TRANSIENT FOR NODES 2, 3, 4, & 5 | 2



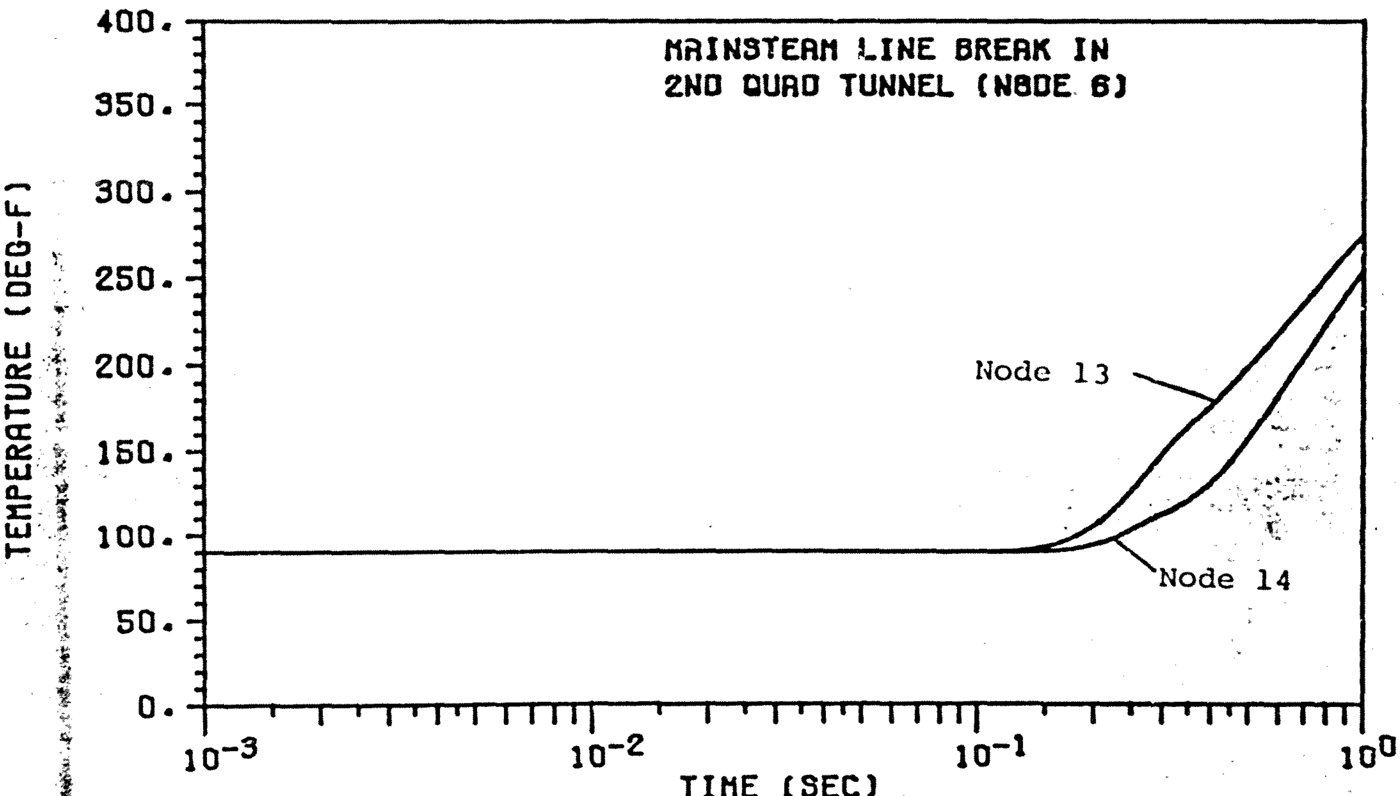
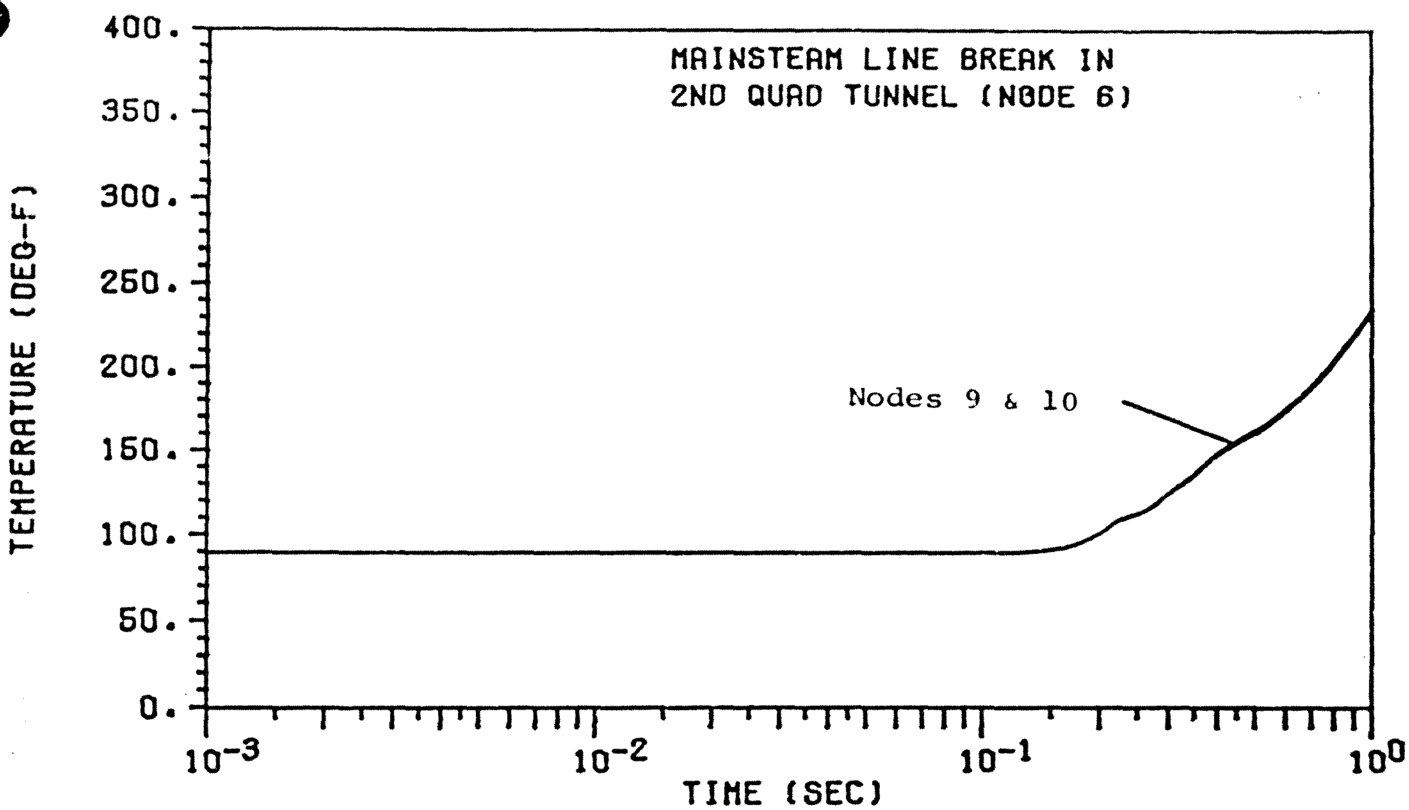


FIGURE 25:
TEMPERATURE TRANSIENT FOR NODES 6, 7, 8, 13, & 14 2

08/17/82 PLT-FILE-024



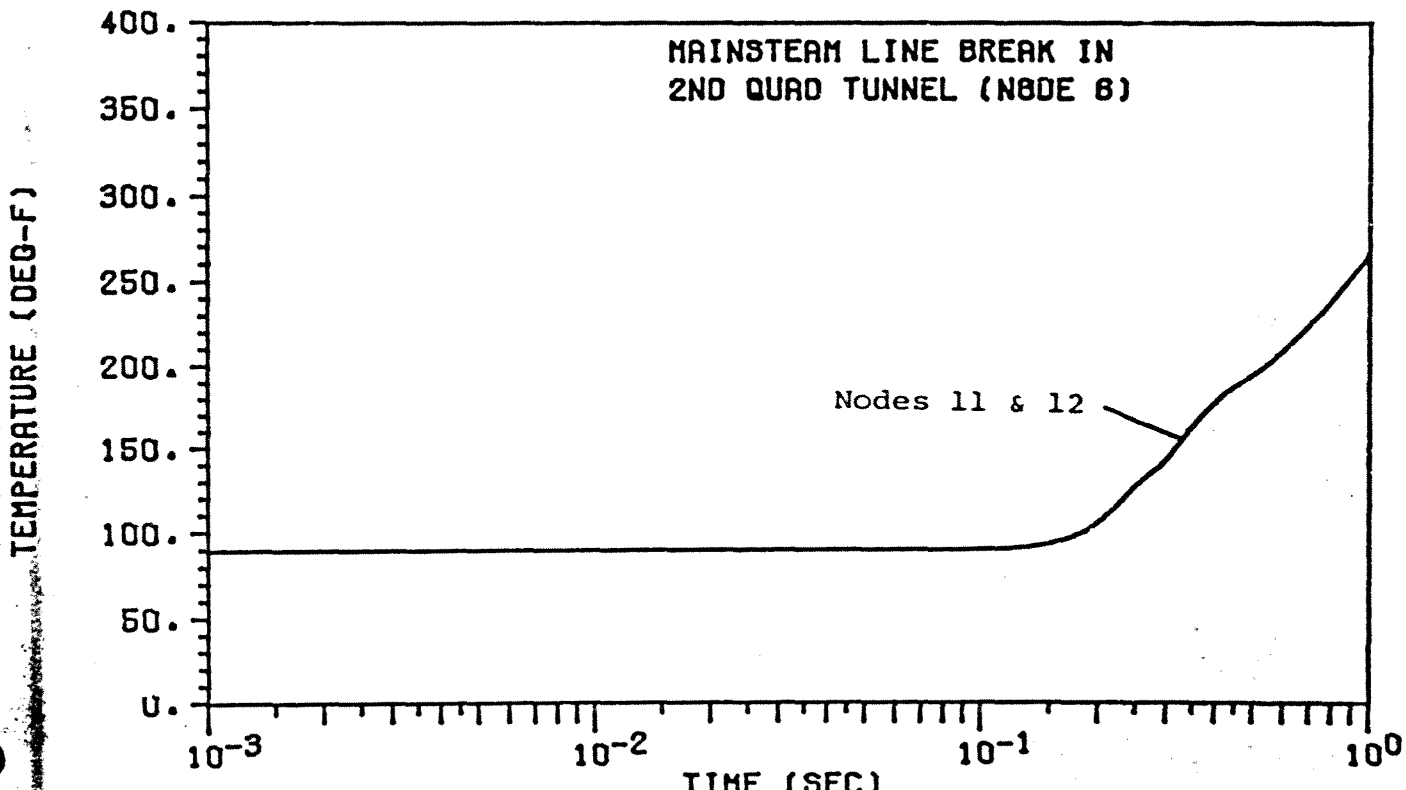
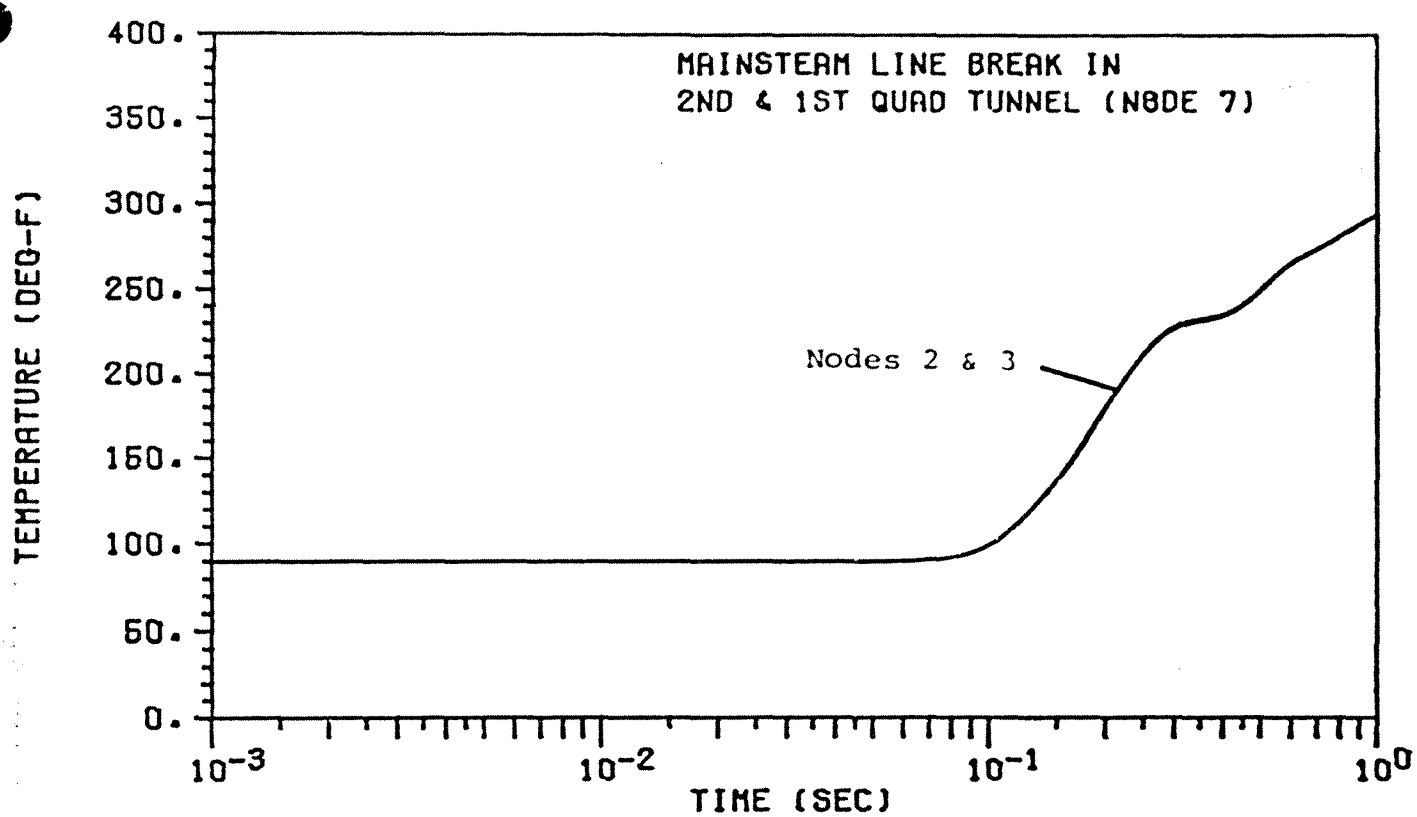


FIGURE 26:
TEMPERATURE TRANSIENT FOR NODES 9, 10, 11, & 12 |2

09/17/82 PLT-FILE-026



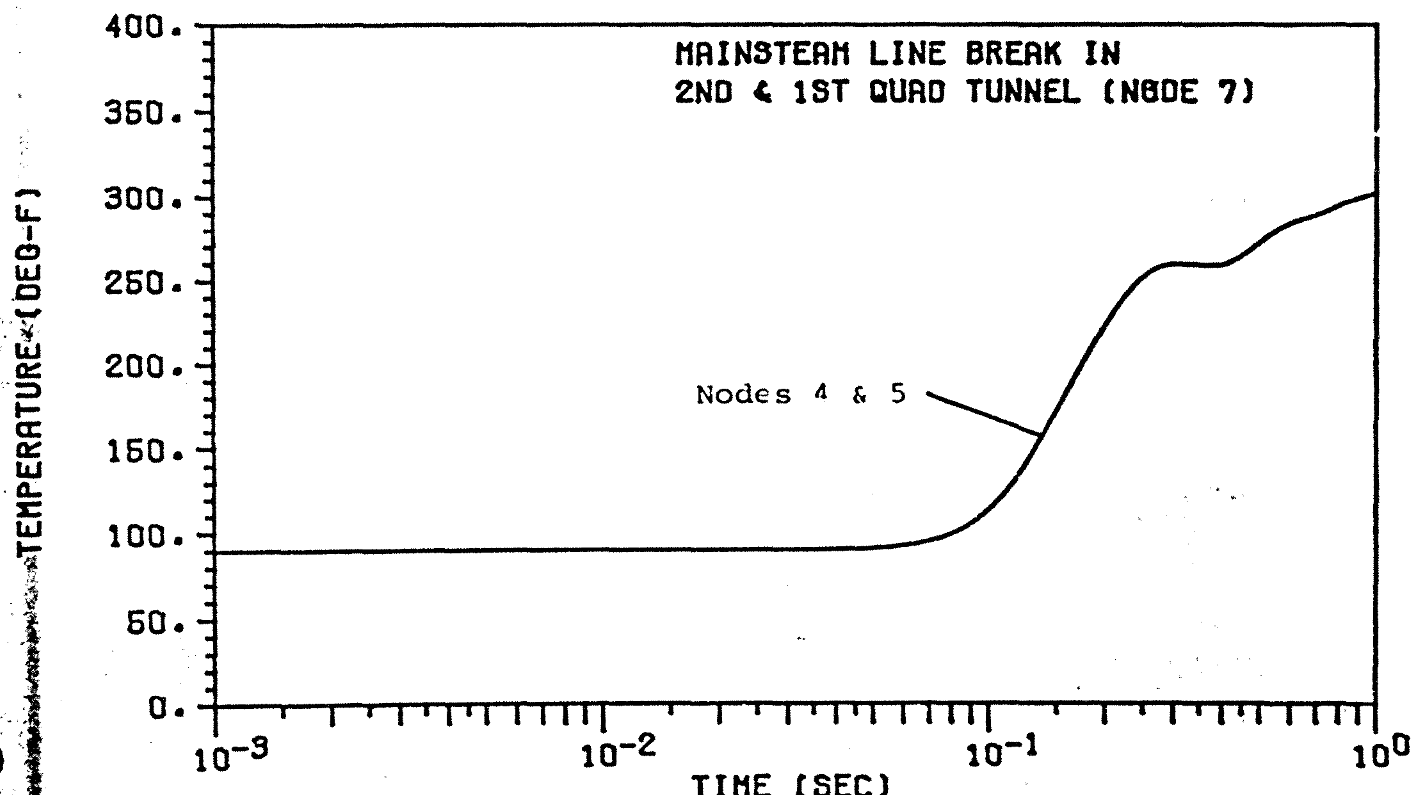
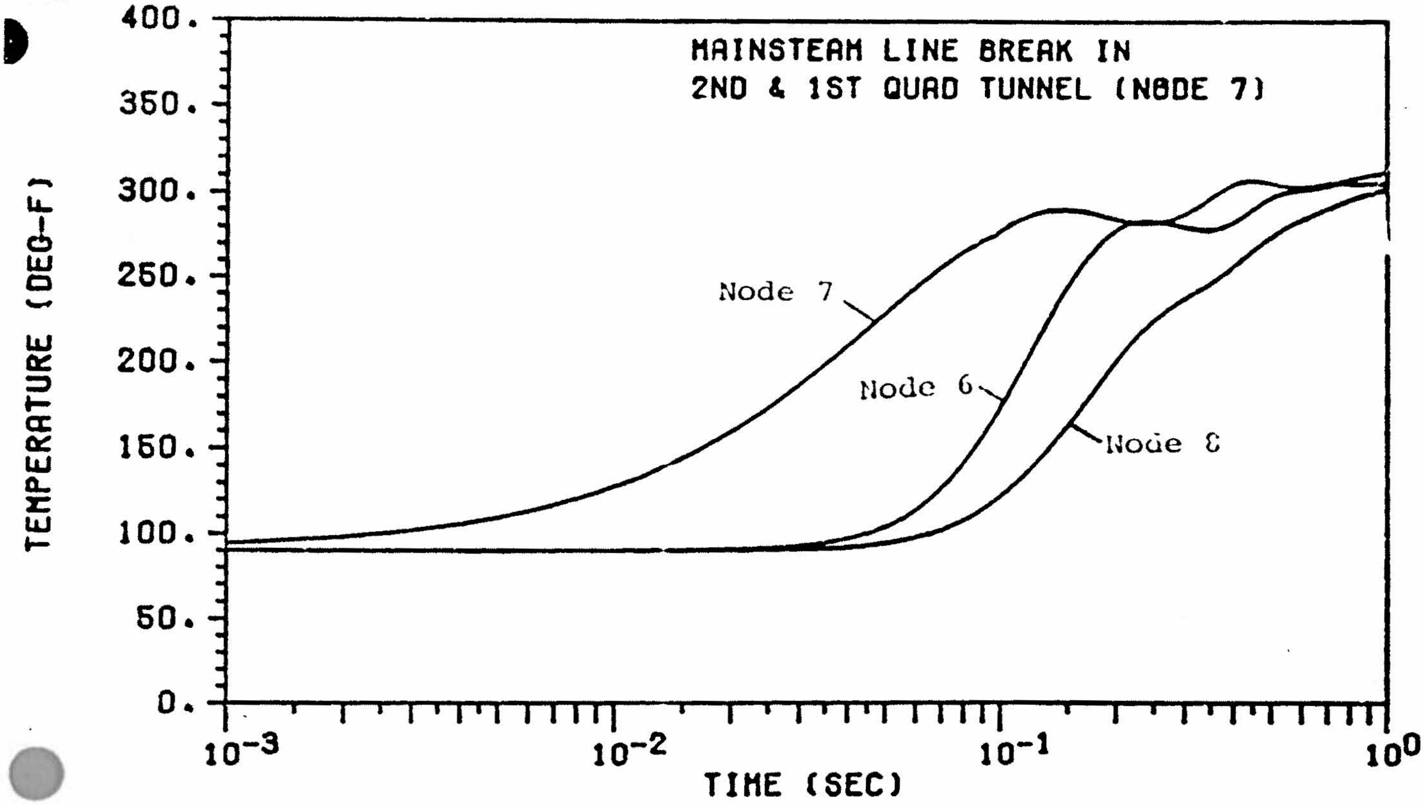


FIGURE 27:
TEMPERATURE TRANSIENT FOR NODES 2, 3, 4, & 5 | 2

07/23/82 PLT-FILE-018



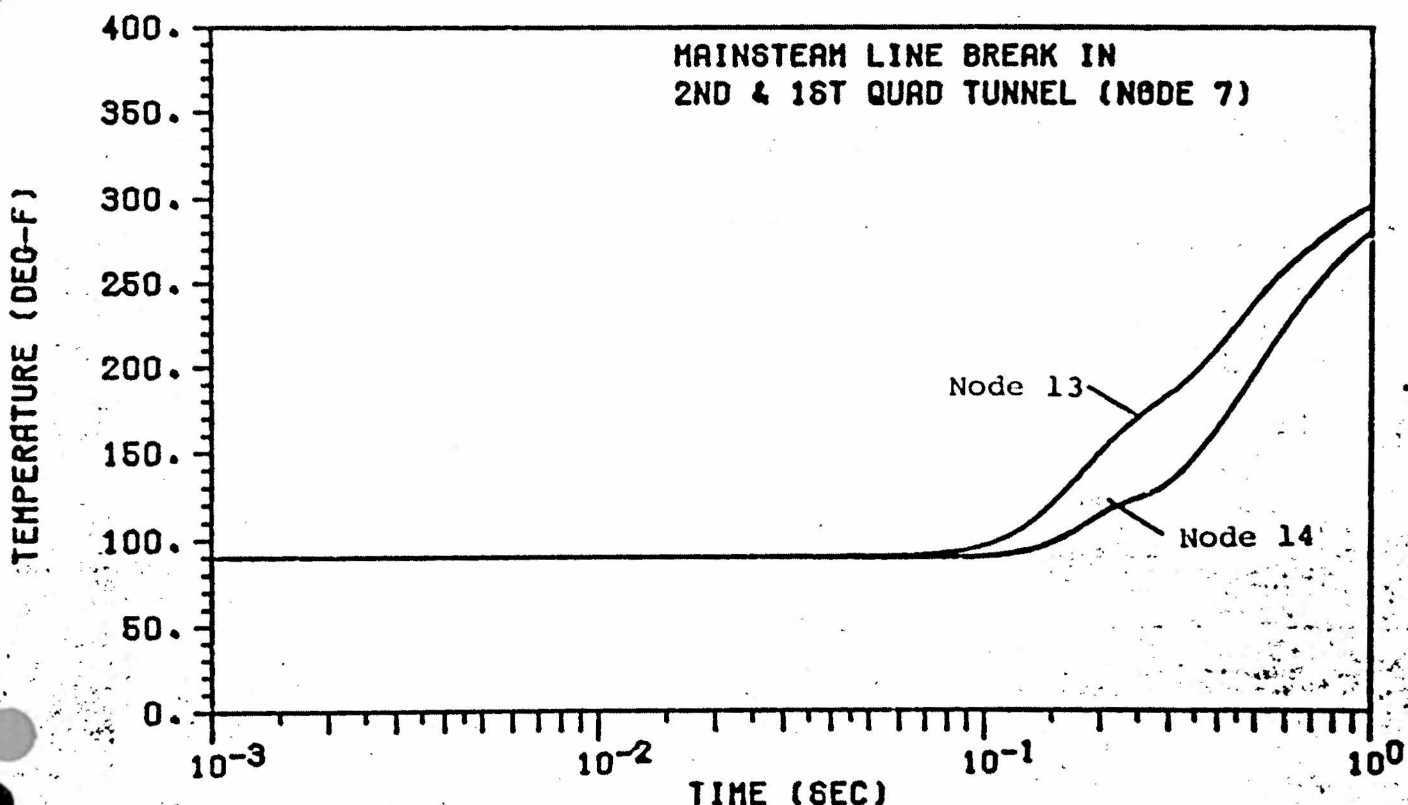
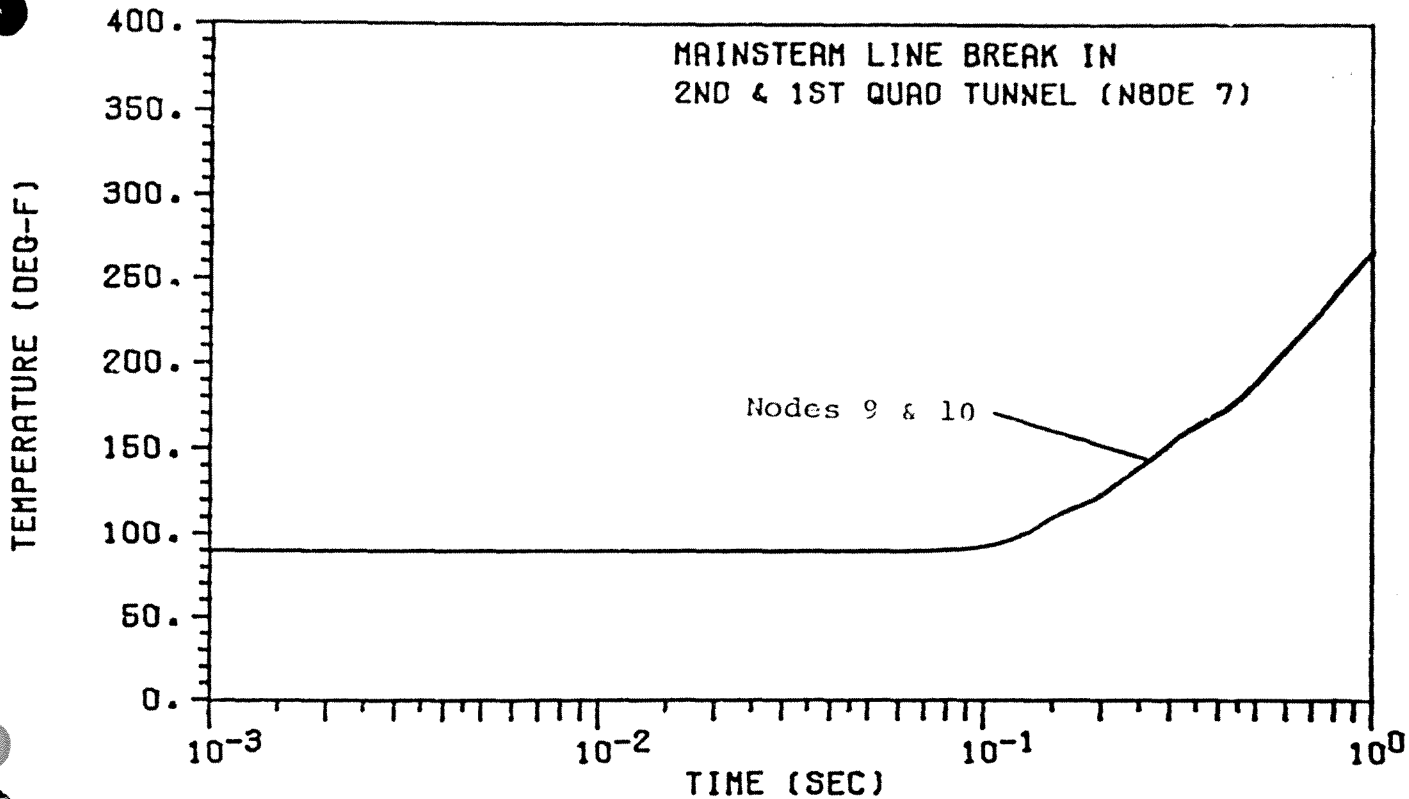


FIGURE 28:
TEMPERATURE TRANSIENT FOR NODES 6, 7, 8, 13, & 14 | 2

09/17/82 PLT-FILE-028



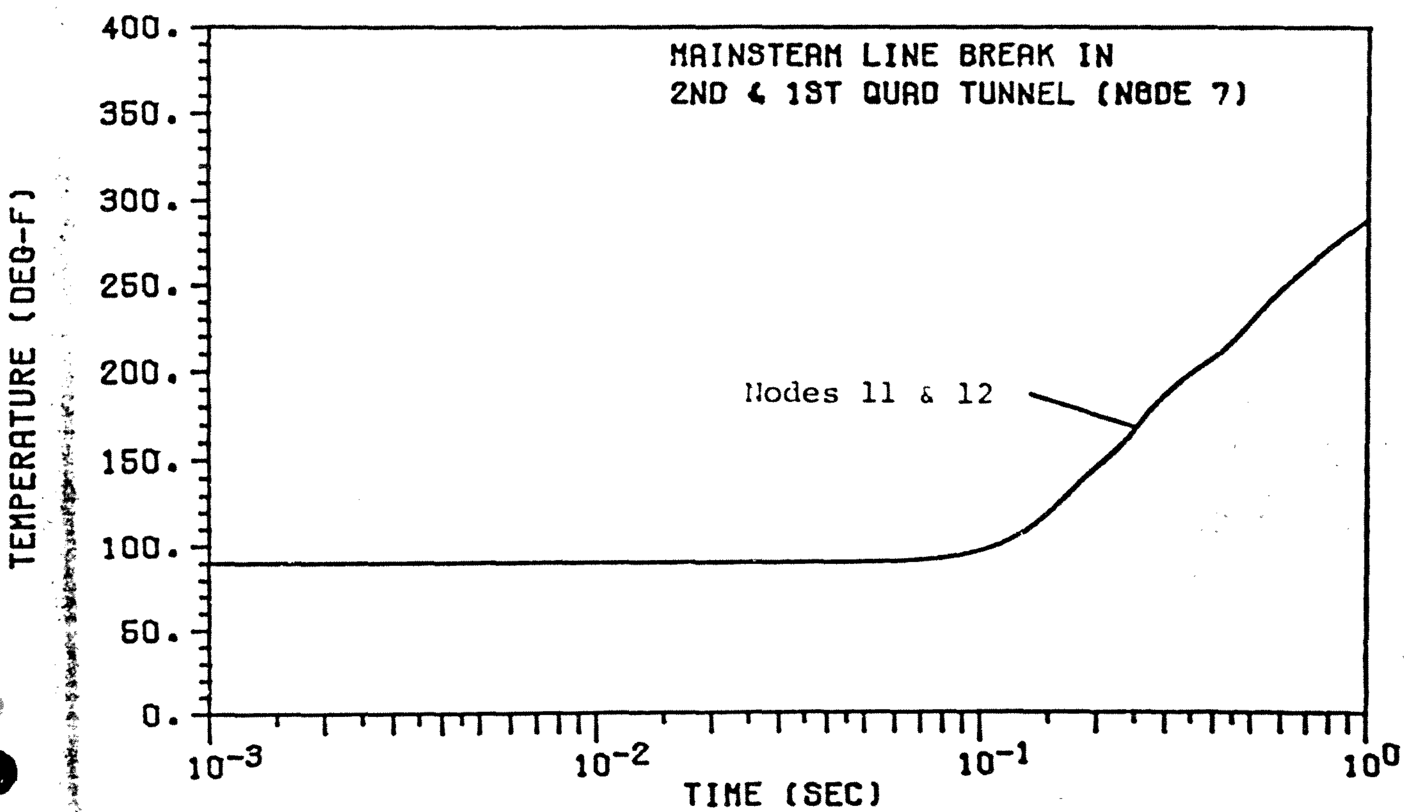
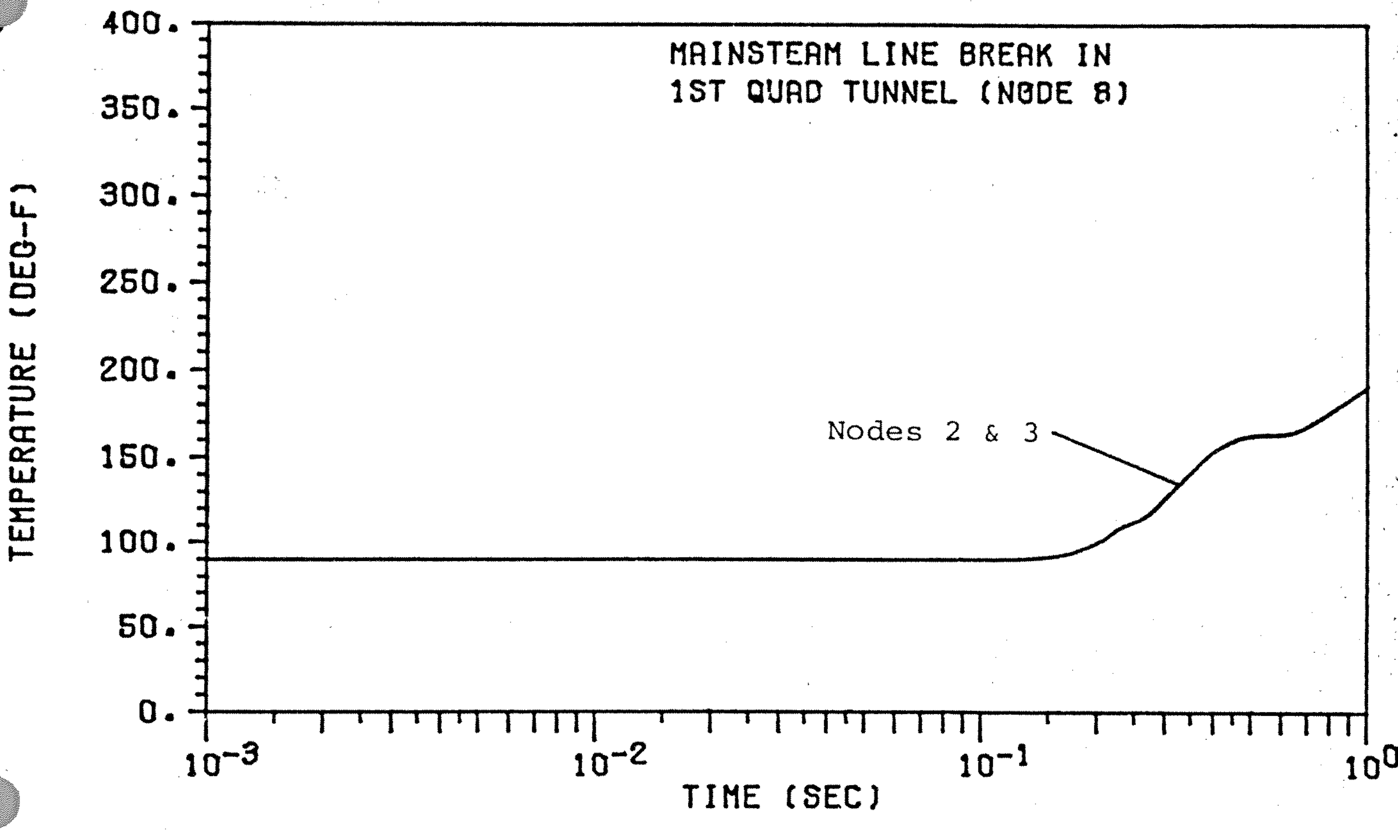


FIGURE 29:
TEMPERATURE TRANSIENT FOR NODES 9, 10, 11, & 12 | 2

09/17/82 PLT-FILE-032



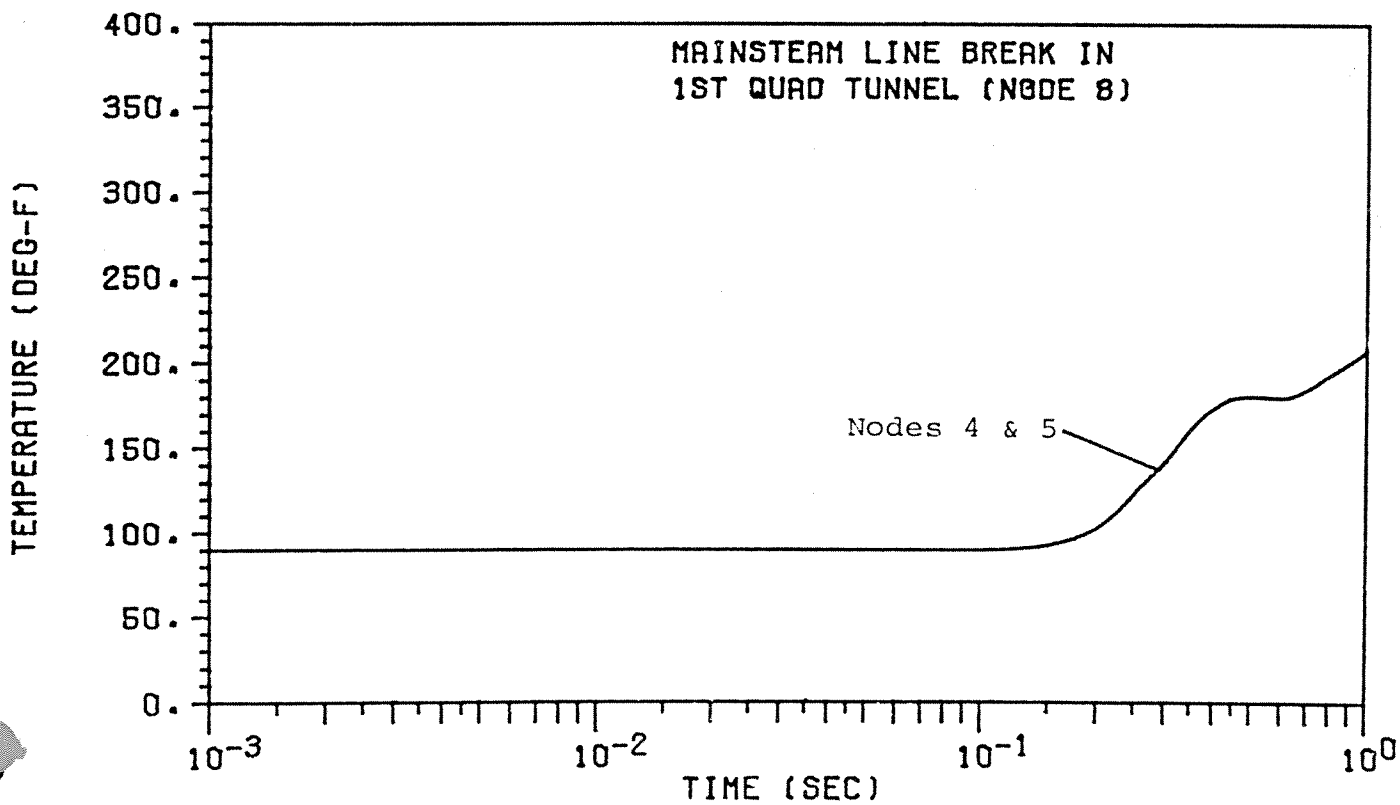
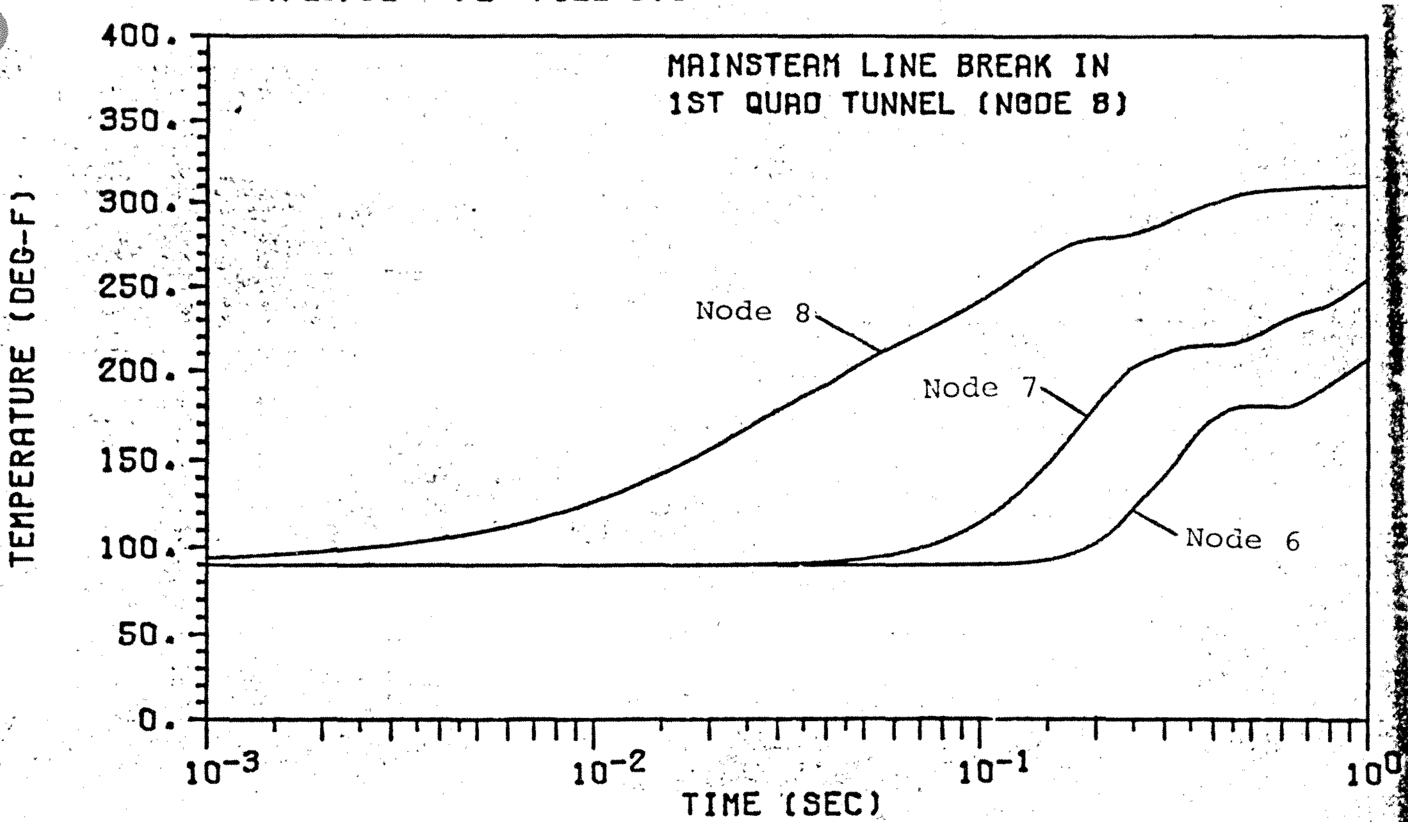


FIGURE 30:
TEMPERATURE TRANSIENT FOR NODES 2, 3, 4, & 5 | 2

07/23/82 PLT-FILE-970



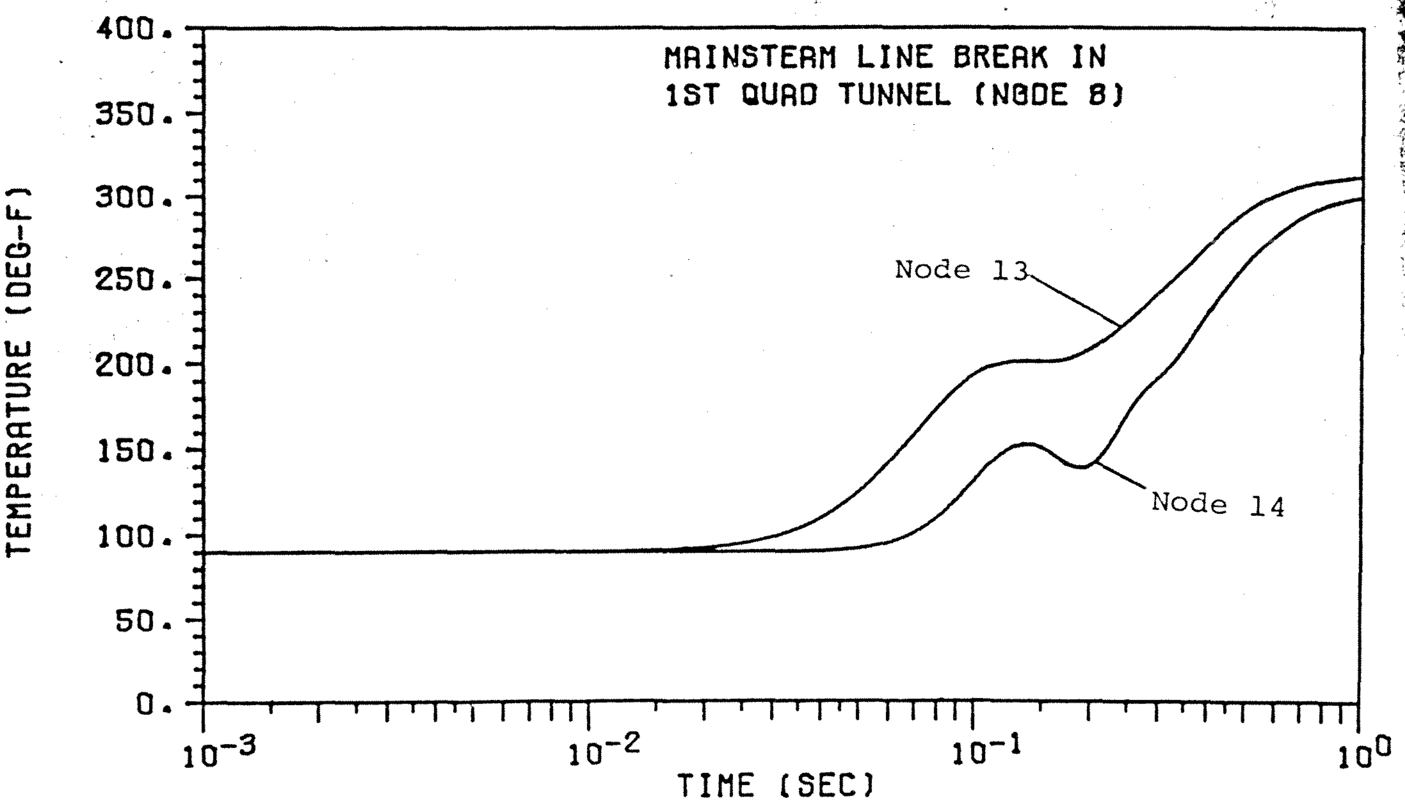


FIGURE 31:
TEMPERATURE TRANSIENT FOR NODES 6, 7, 8, 13, & 14 | 2

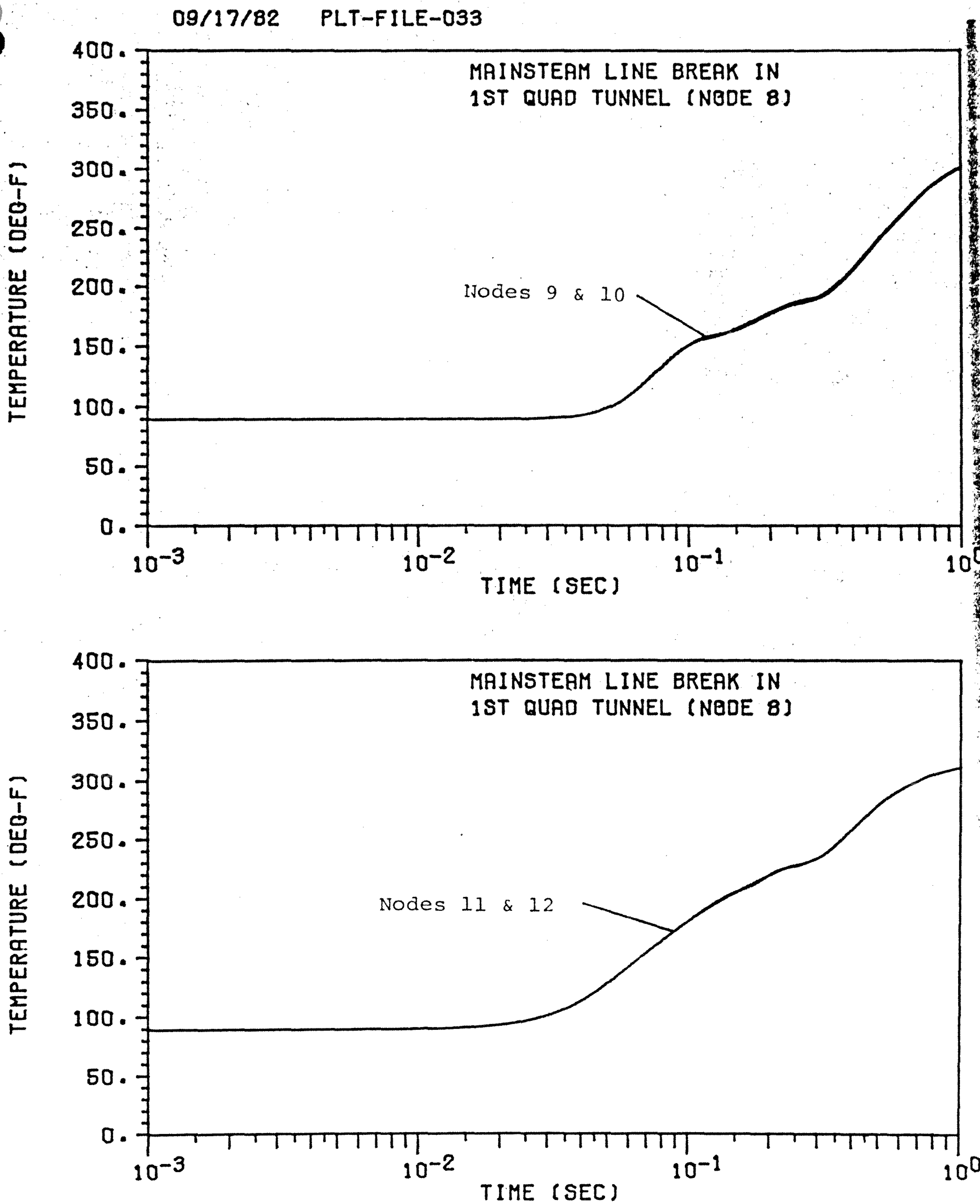
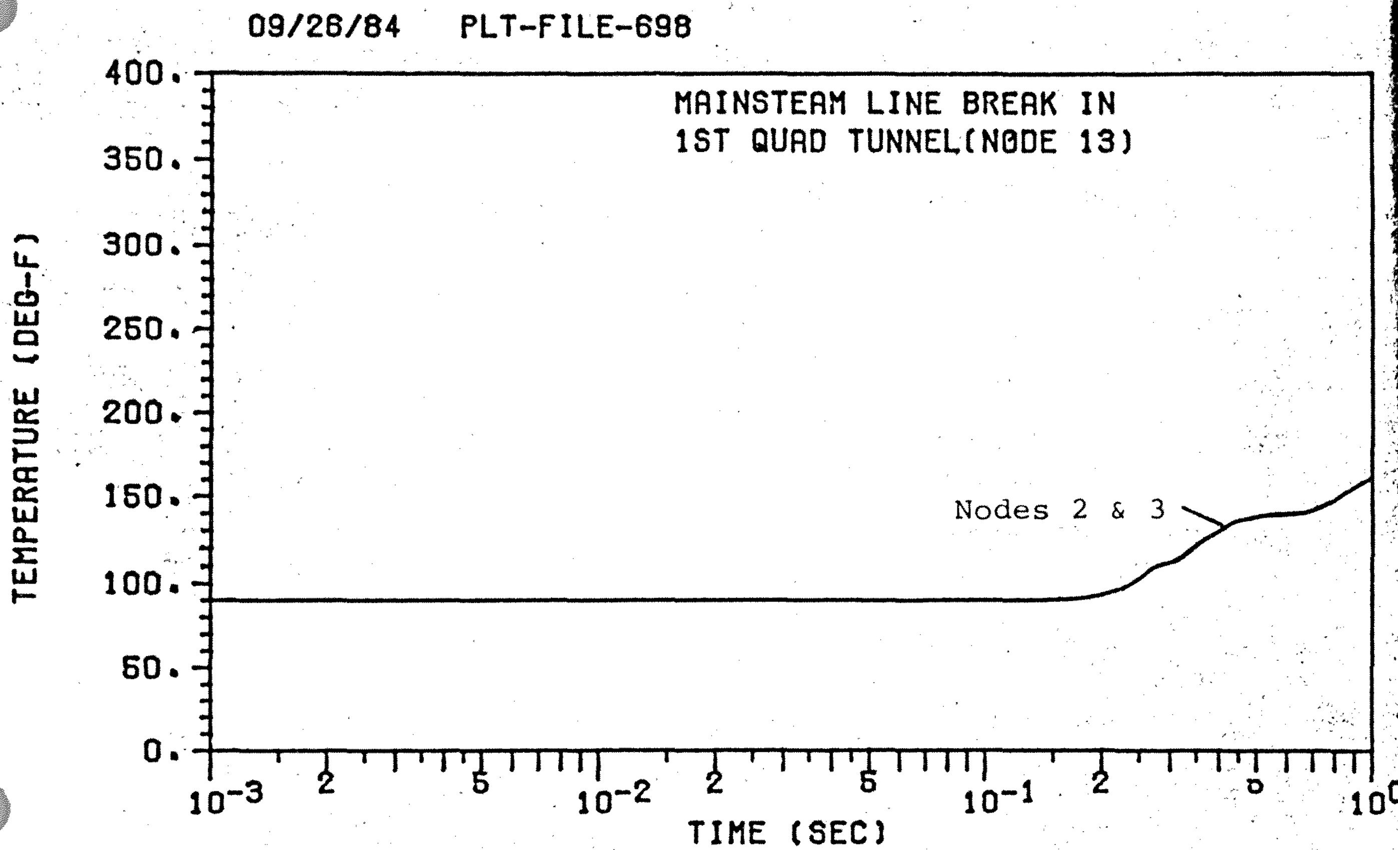
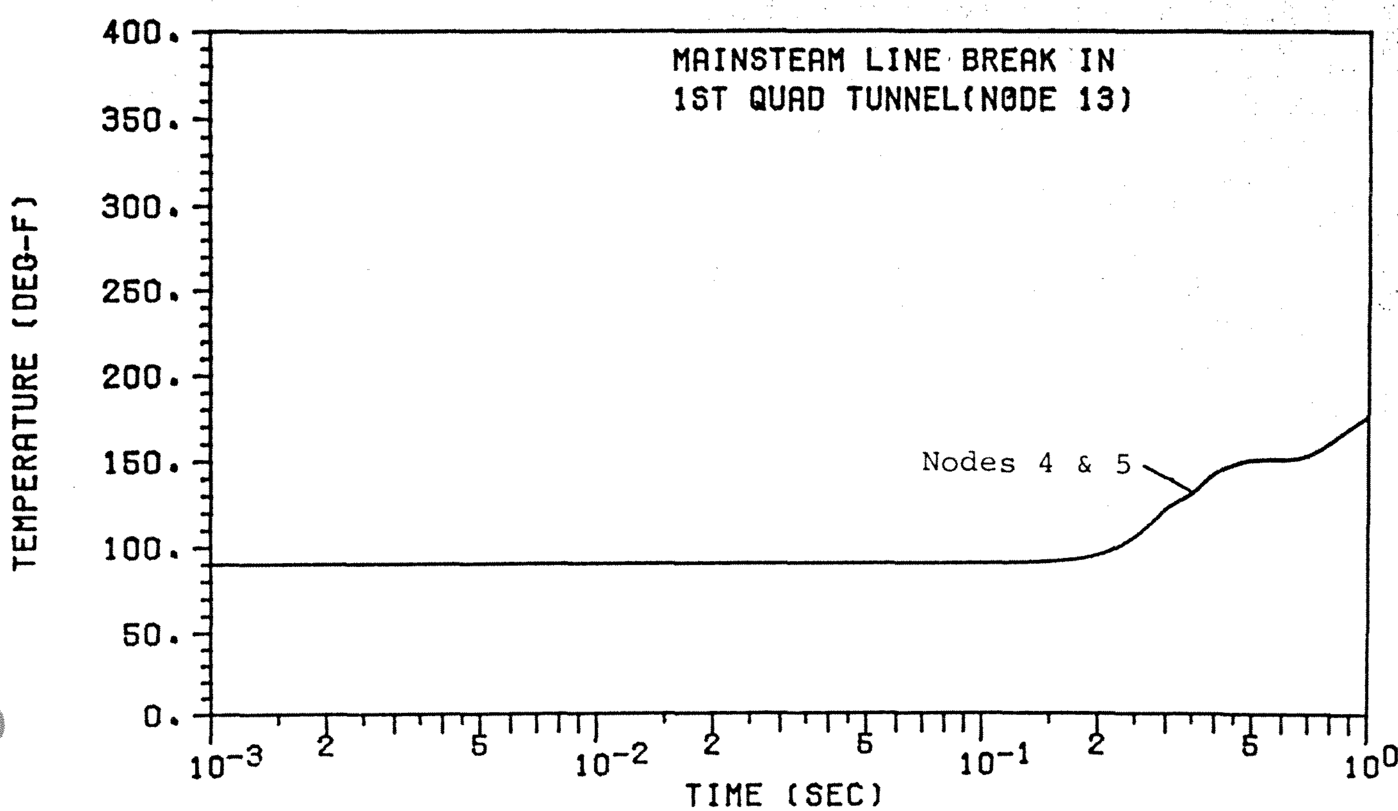


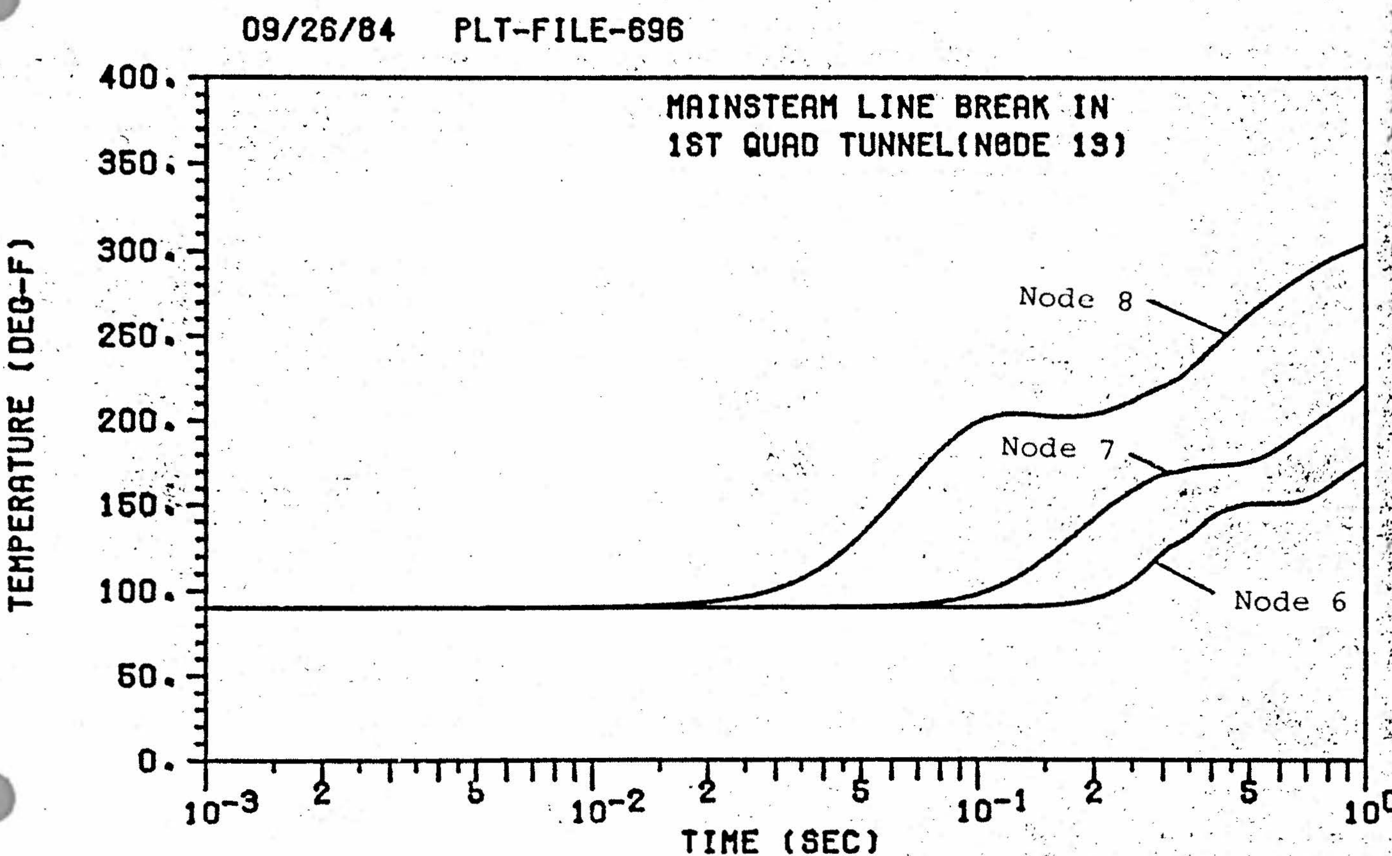
FIGURE 32:
TEMPERATURE TRANSIENT FOR NODES 9, 10, 11, & 12 | 2





2

FIGURE 33:
TEMPERATURE TRANSIENT FOR NODES 2, 3, 4, & 5



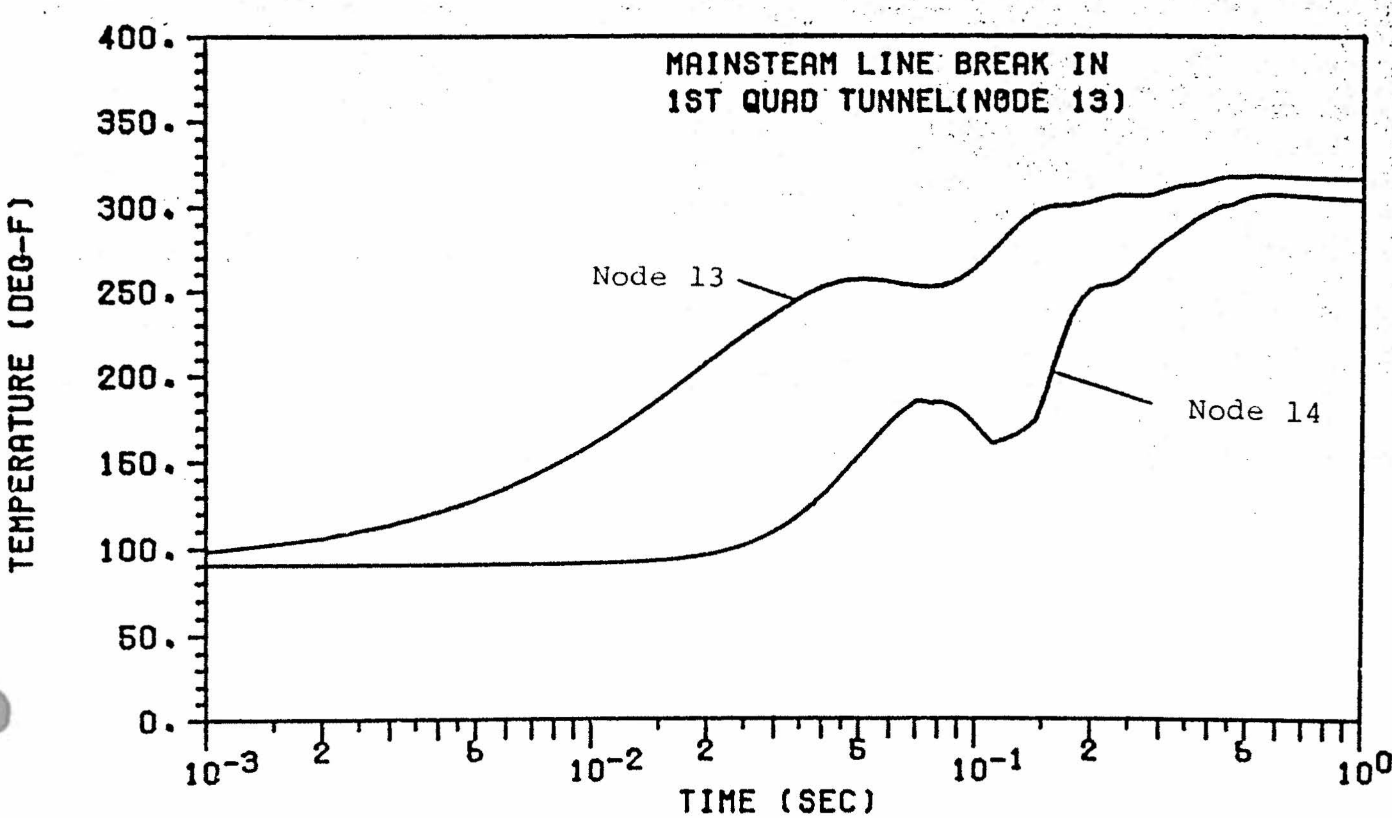
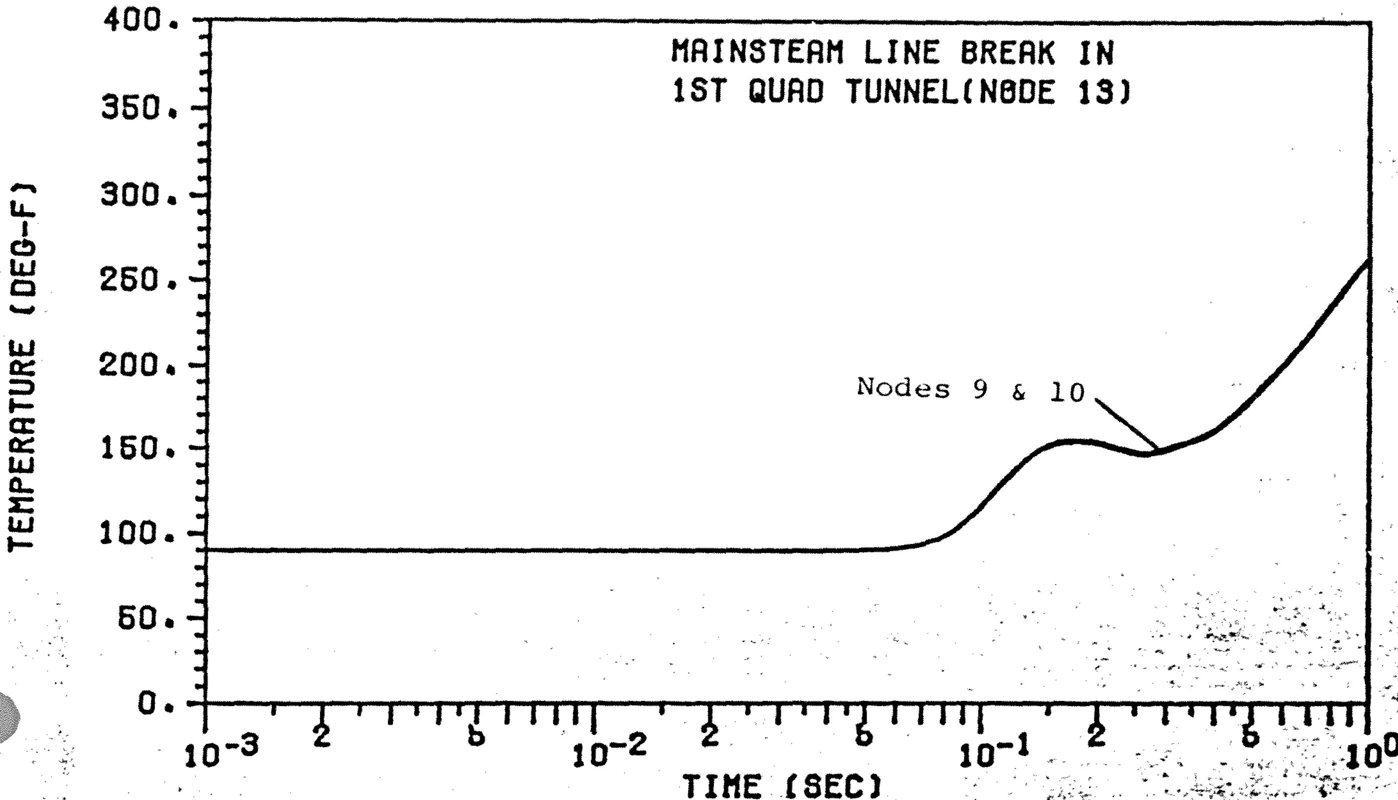


FIGURE 34:
TEMPERATURE TRANSIENT FOR NODES 6, 7, 8, 13, & 14

09/26/84 PLT-FILE-699



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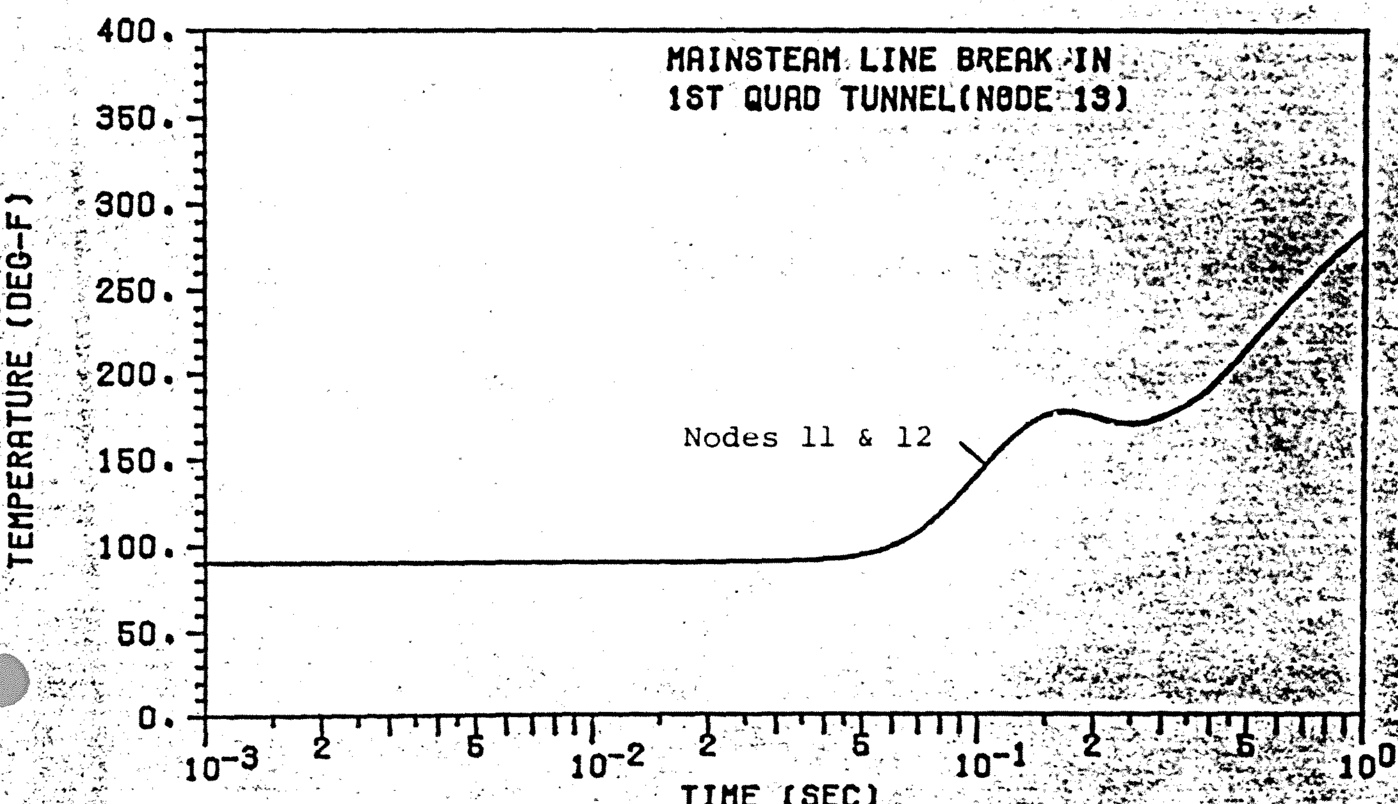
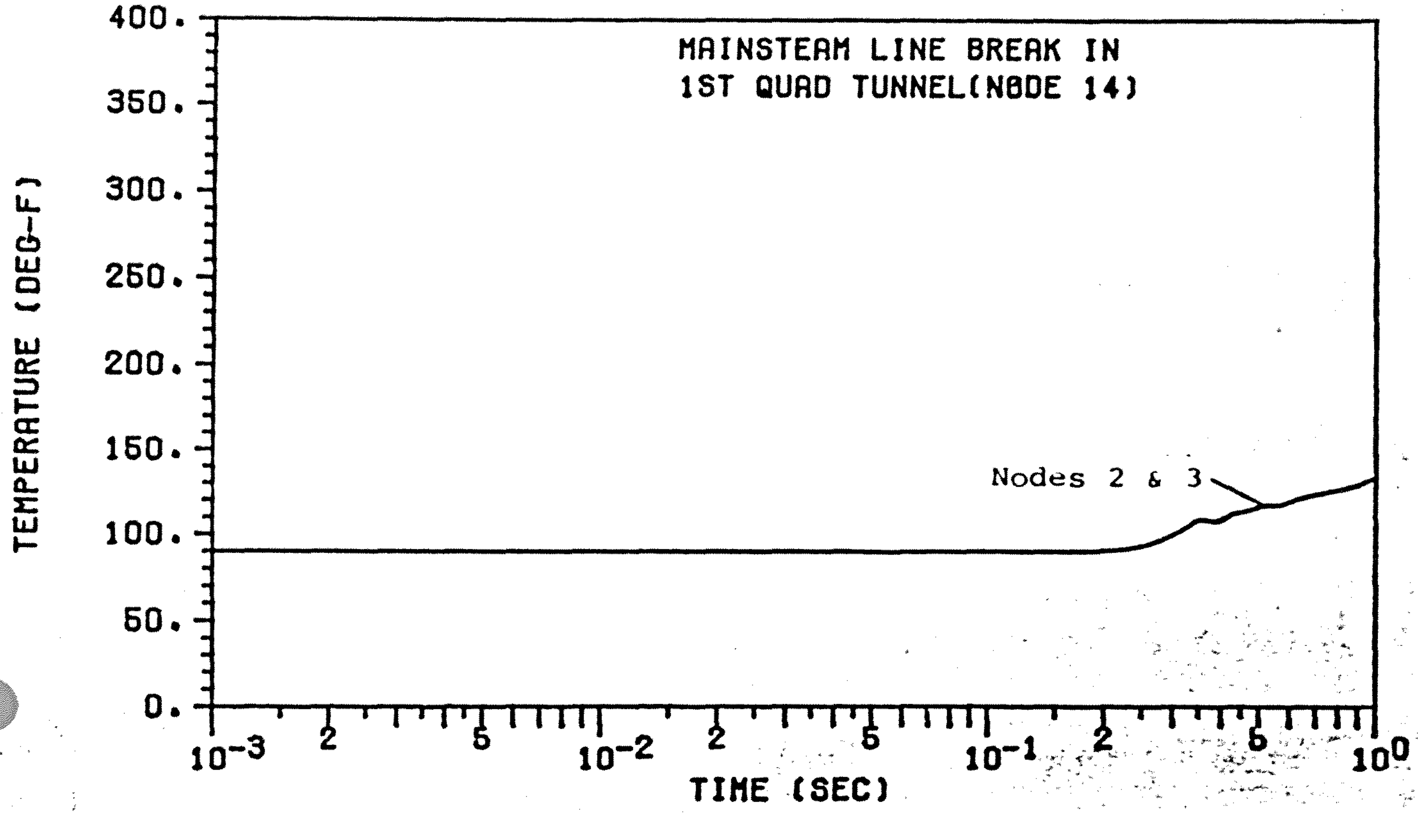


FIGURE 35:
TEMPERATURE TRANSIENT FOR NODES 9, 10, 11, & 12

09/26/84 PLT-FILE-701



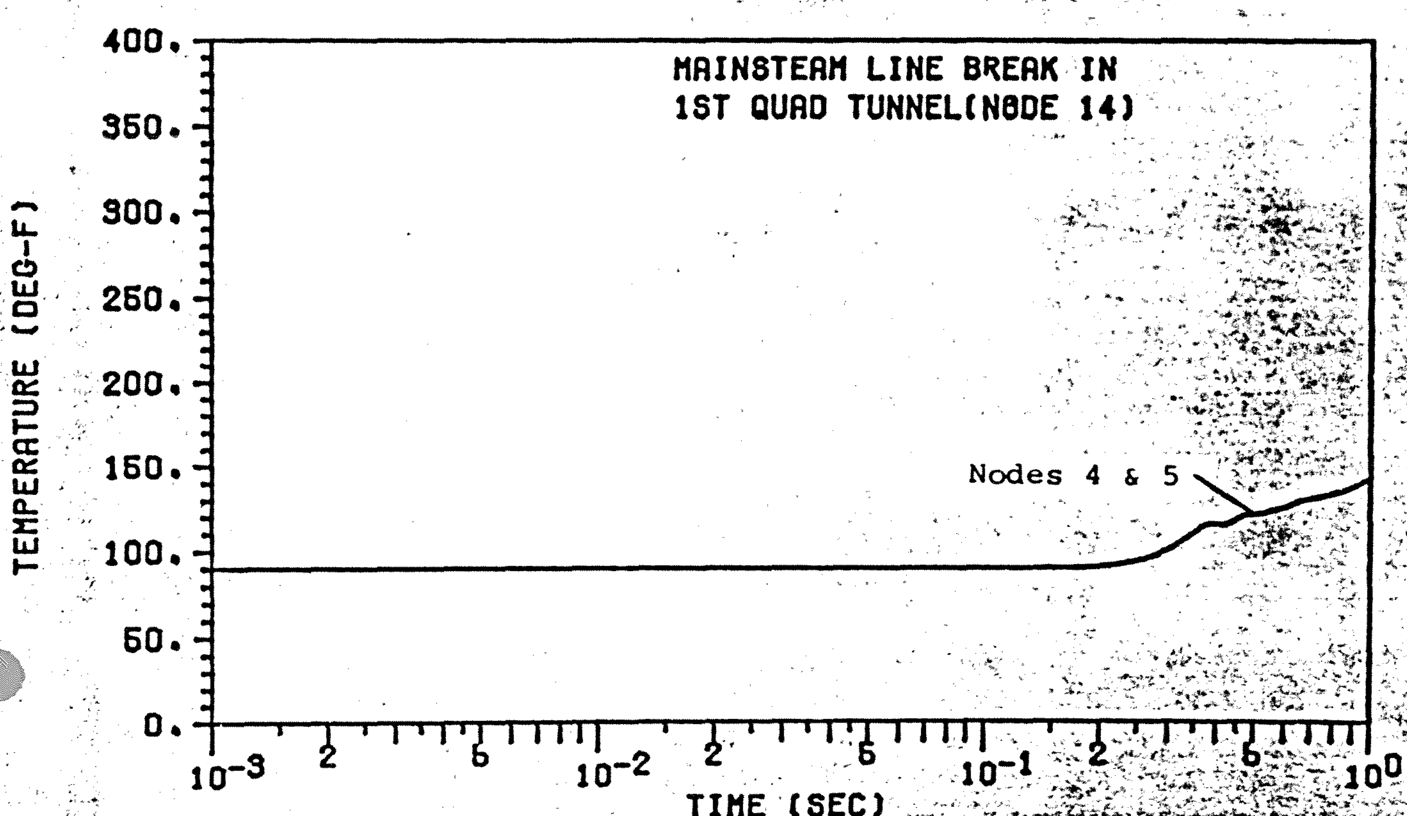
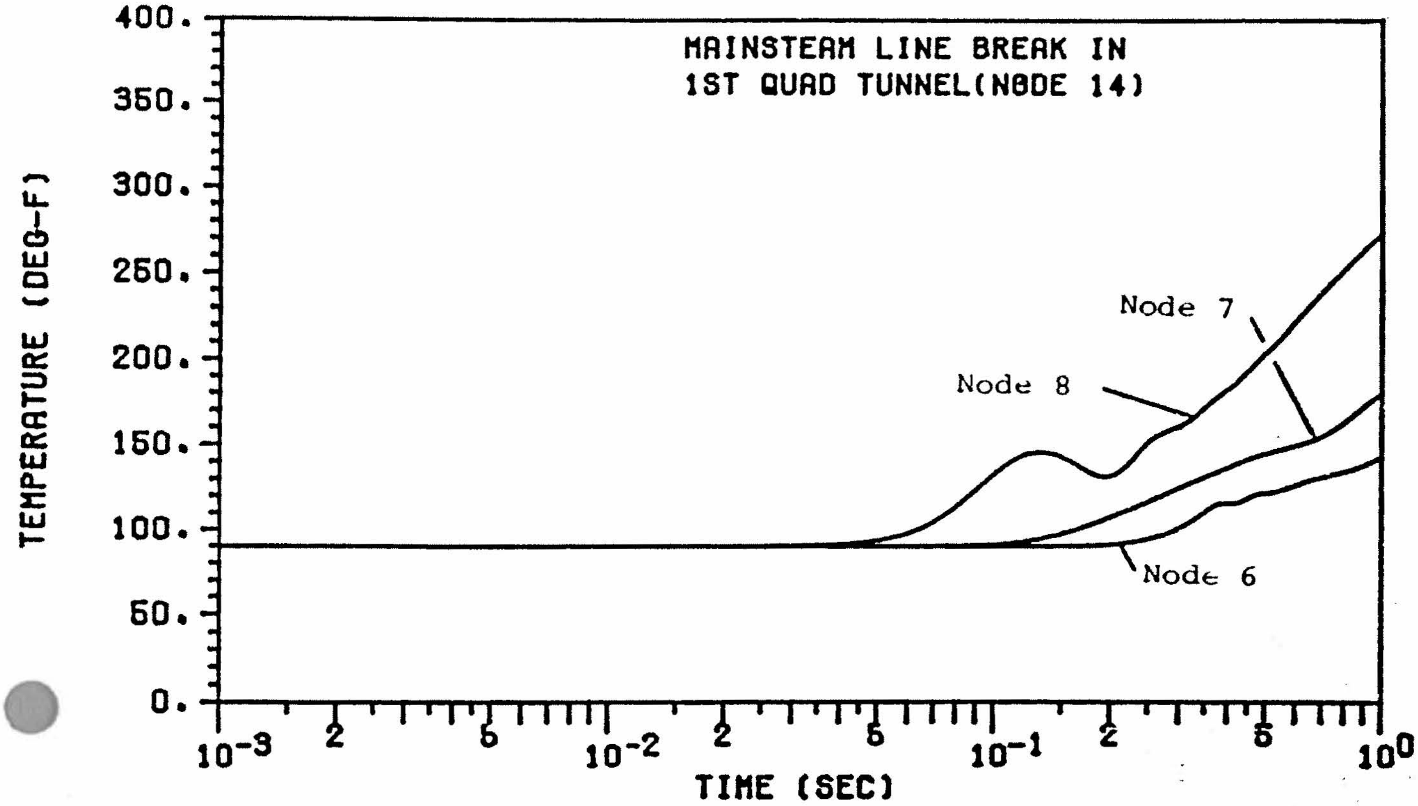


FIGURE 36:
TEMPERATURE TRANSIENT FOR NODES 2, 3, 4, & 5

09/26/84 PLT-FILE-700



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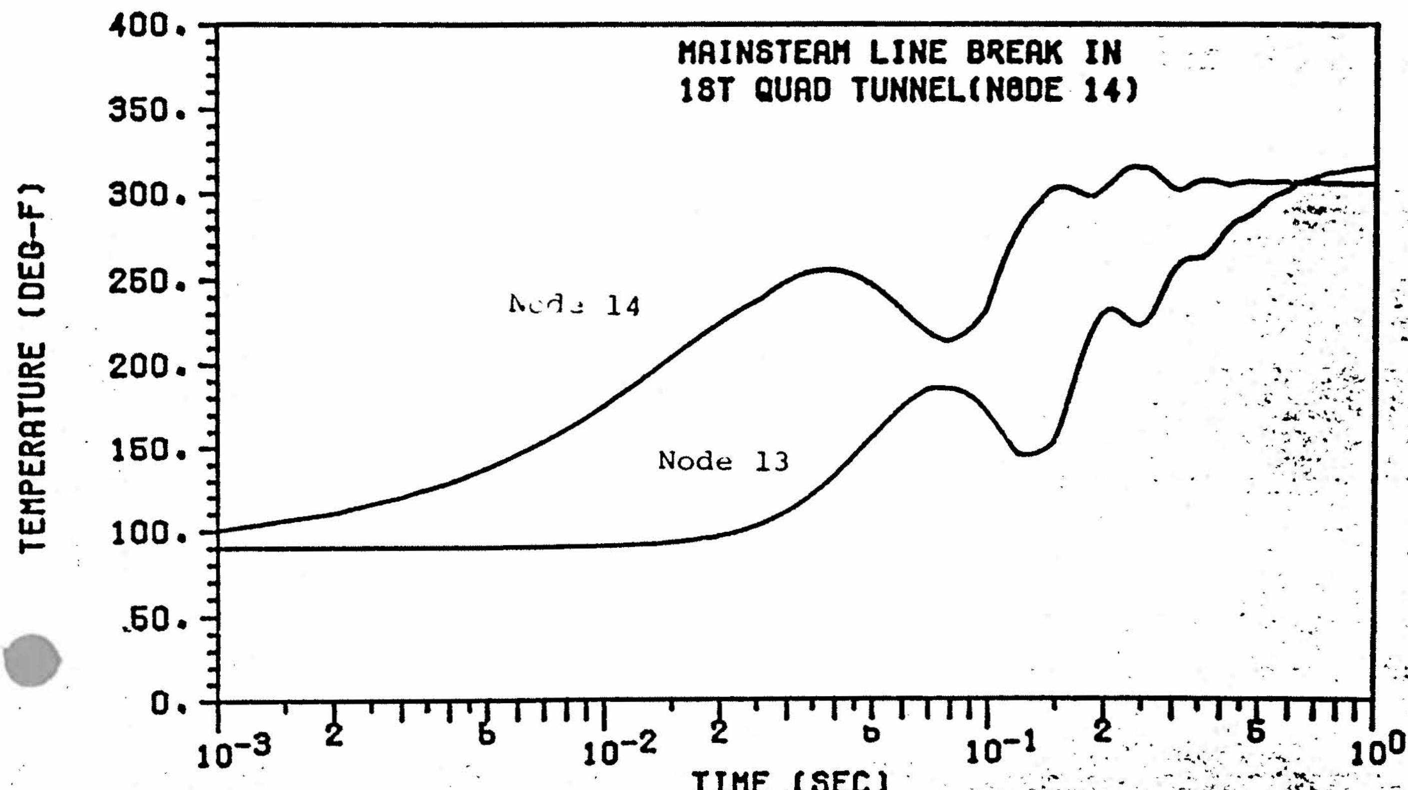
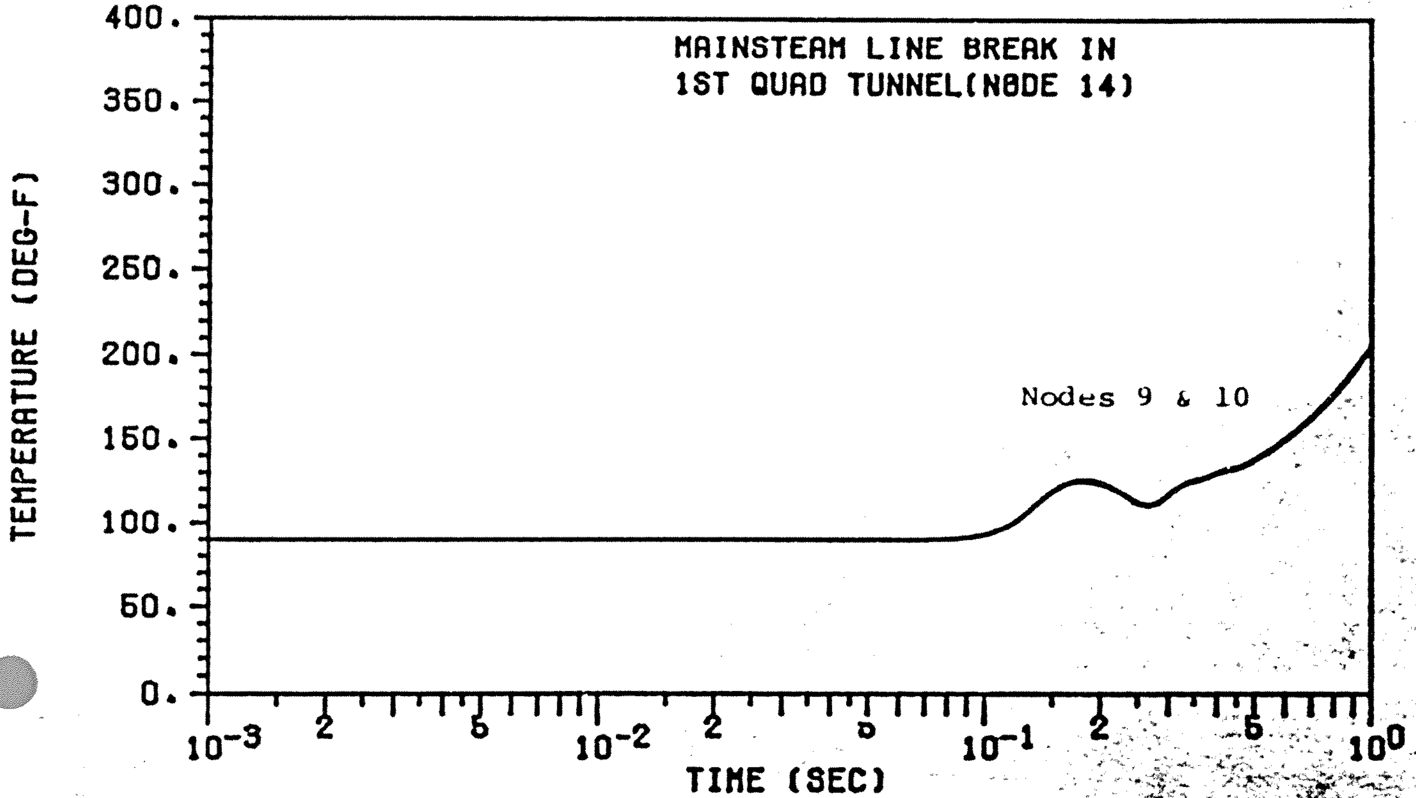


FIGURE 37:
TEMPERATURE TRANSIENT FOR NODES 6, 7, 8, 13, & 14

09/26/84 PLT-FILE-702



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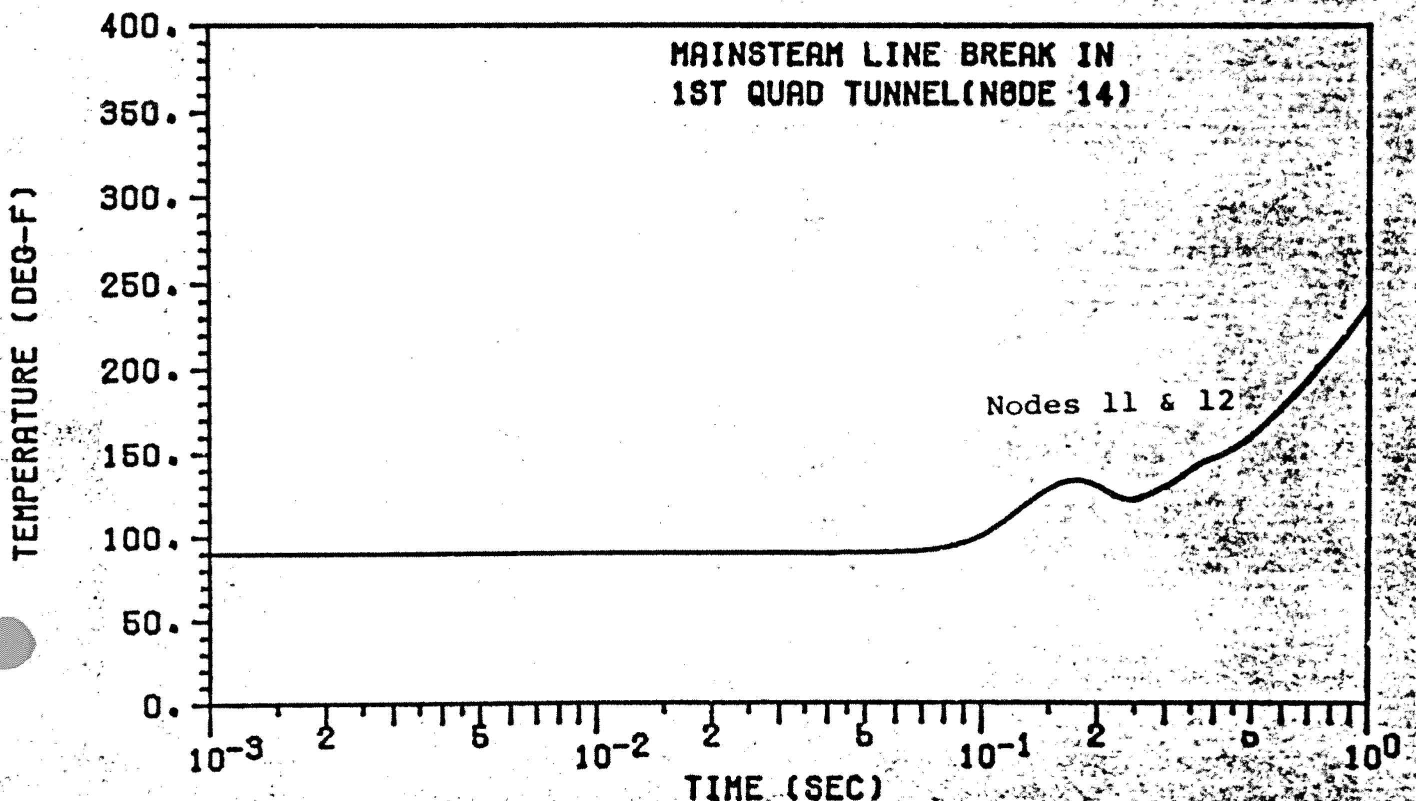

FIGURE 38:
TEMPERATURE TRANSIENT FOR NODES 9, 10, 11, & 12

TABLE OF CONTENTS OF COMPUTER OUTPUT

PART DESCRIPTION	PROGRAM	DATE TIME	PAGES SUPS	CALC.NO. SYM-FILE-NAME	REV.	RUN-ID
PART 1-0 MAINSTEAM BREAK IN NODE 5 (LOWER VALVE ROOM)	REL098026570	22 JUL 82 19:02 20:38	454 45.88	3C8-0282-001 GJS-BYR*SYM2(3).	0	GJS
PART 2-0 MAINSTEAM BREAK IN NODE 6 (2ND QUAD. SECT. OF TUNNEL)	REL098026570	22 JUL 82 21:47 22:42	457 45.96	3C8-0282-001 GJS-BYR*SYM2(6).	0	GJS
PART 3-0 MAINSTEAM BREAK IN NODE 7 (2ND & 1ST QUAD. SECT. OF TU	REL098026570	22 JUL 82 22:55 23:46	454 45.67	3C8-0282-001 GJS-BYR*SYM2(9).	0	GJS
PART 4-0 MAINSTEAM BREAK IN NODE 8 (1ST QUAD. SECT. OF TUNNEL)	REL098026570	22 JUL 82 23:59 00:50	454 44.14	3C8-0282-001 GJS-BYR*SYM2(12).	0	GJS
SECTION 1-1 FOR STEAM BREAK IN 2ND QUAD. DOGHOUSE (NODE 5)	PPP09809910I/L	22 JUL 82 20:39 20:46	9 4.19	3C8-0282-001 GJS-BYR*SYM2(4).	0	GJS
SECTION 2-1 FOR STEAM BREAK IN 2ND QUAD. TUNNEL (NODE 6)	PPP09809910I/L	22 JUL 82 22:43 22:49	9 4.18	3C8-0282-001 GJS-BYR*SYM2(7).	0	GJS
SECTION 3-1 FOR STEAM BREAK IN 2ND & 1ST QUAD TUNNEL (NODE 7)	PPP09809910I/L	22 JUL 82 23:47 23:56	9 4.19	3C8-0282-001 GJS-BYR*SYM2(10).	0	GJS
SECTION 4-1 FOR STEAM BREAK IN 1ST QUAD. TUNNEL (NODE 8)	PPP09809910I/L	23 JUL 82 00:51 00:59	9 4.19	3C8-0282-001 GJS-BYR*SYM2(13).	0	GJS
SECTION 5-1 FOR STEAM BREAK IN 2ND QUAD. DOGHOUSE (NODE 5)	PPP09809911I/S	22 JUL 82 20:46 20:53	8 4.19	3C8-0282-001 GJS-BYR*SYM2(5).	0	GJS
SECTION 6-1 FOR STEAM BREAK IN 2ND QUAD. TUNNEL (NODE 6)	PPP09809911I/S	22 JUL 82 22:50 22:54	9 4.18	3C8-0282-001 GJS-BYR*SYM2(8).	0	GJS

Calc. No. 3C8-0282-001
Revision: 2
Page: 65
Project No. 4391-00 | 2

SECTION 7-1 PPP09809911I/S FOR STEAM BREAK IN 2ND & 1ST QUAD TUNNEL (NODE 7)	23 JUL 82 13:10 13:15	9 4.18	3C8-0282-001 GJS-BYR*SYM2(15).	0	GJS
SECTION 8-1 PPP09809911I/S FOR STEAM BREAK IN 1ST QUAD. TUNNEL (NODE 8)	23 JUL 82 00:59 01:03	8 4.18	3C8-0282-001 GJS-BYR*SYM2(14).	0	GJS
SECTION 9-1 PPP09809911I/S FOR MAIN STEAM LINE BREAK	23 JUL 82 17:22 18:13	198 30.12	3C8-0282-001 GJS-BYR*SYM2(17).	0	GJS

***** IT IS NOTED FOR SECTIONS 1-1 THRU 4-1 THAT THE INCORRECT PROGRAM NUMBER IS INDICATED. THE NUMBER SHOULD BE PPP09809911/S.

***** MICROFICHE FOR REVISION 1 *****

SECTION 1-1 PPP09809910I/L FOR STEAM BREAK IN 2ND QUAD. DOGHOUSE (NODE 5)	16 SEP 82 08:43 08:47	8 2.79	3C8-0282-001 GJS-BYR*SYM2(26).	1	GJS
SECTION 2-1 PPP09809910I/S FOR STEAM BREAK IN 2ND QUAD. TUNNEL (NODE 6)	17 SEP 82 14:49 15:06	8 2.79	3C8-0282-001 GJS-BYR*SYM2(27).	1	GJS
SECTION 3-1 PPP09809910I/S FOR STEAM BREAK IN 2ND & 1ST QUAD TUNNEL (NODE 7)	17 SEP 82 15:10 15:16	8 2.79	3C8-0282-001 GJS-BYR*SYM2(28).	1	GJS
SECTION 4-1 PPP09809910I/S FOR STEAM BREAK IN 1ST QUAD. TUNNEL (NODE 8)	17 SEP 82 15:22 15:32	8 2.79	3C8-0282-001 GJS-BYR*SYM2(29).	1	GJS
SECTION 5-1 PPP09809911I/S FOR STEAM BREAK IN 2ND QUAD. DOGHOUSE (NODE 5)	17 SEP 82 15:51 15:57	8 2.80	3C8-0282-001 GJS-BYR*SYM2(30).	1	GJS
SECTION 6-1 PPP09809911I/S FOR STEAM BREAK IN 2ND QUAD. TUNNEL (NODE 6)	17 SEP 82 16:02 16:08	8 2.79	3C8-0282-001 GJS-BYR*SYM2(31).	1	GJS
SECTION 7-1 PPP09809911I/S FOR STEAM BREAK IN 2ND & 1ST QUAD TUNNEL (NODE 7)	17 SEP 82 16:15 16:20	8 2.80	3C8-0282-001 GJS-BYR*SYM2(32).	1	GJS
SECTION 8-1 PPP09809911I/S FOR STEAM BREAK IN 1ST QUAD. TUNNEL (NODE 8)	17 SEP 82 16:23 16:34	8 2.79	3C8-0282-001 GJS-BYR*SYM2(33).	1	GJS

***** IT IS NOTED FOR SECTIONS 1-1 THRU 4-1 (REV. 1) THAT THE INCORRECT PROGRAM NUMBER IS INDICATED. THE NUMBER SHOULD BE PPP09809911/S.

1

2

***** MICROFICHE FOR REVISION 2 *****

PART 5-0 REL098026570	26 JUN 84	454	3C8-0282-001 2	GJS
MAINSTEAM BREAK IN NODE 13 (1ST QUAD SECT OF TUNNEL)	16:57 17:50	32.92	GJS-BYR*SYM(3).	
PART 6-0 REL098026570	26 JUN 84	454	3C8-0282-001 2	GJS
MAINSTEAM BREAK IN NODE 14 (1ST QUAD SECT OF TUNNEL)	17:51 18:40	32.05	GJS-BYR*SYM(4).	
SECTION 10-1PPP09809912I/L	26 SEP 84	9	3C8-0282-001 2	GJS
FOR STEAM BREAK IN 1ST QUAD. TUNNEL (NODE 13)	14:48 14:51	1.85	GJS-BYR*SYM2(1).	
SECTION 11-1PPP09809912I/L	26 SEP 84	9	3C8-0282-001 2	GJS
FOR STEAM BREAK IN 1ST QUAD. TUNNEL (NODE 14)	14:53 14:56	1.84	GJS-BYR*SYM2(2).	
SECTION 12-1PPP09809912I/L	26 SEP 84	8	3C8-0282-001 2	GJS
FOR STEAM BREAK IN 1ST QUAD. TUNNEL (NODE 13)	14:57 15:01	1.84	GJS-BYR*SYM2(3).	
SECTION 13-1PPP09809912I/L	26 SEP 84	11	3C8-0282-001 2	GJS
FOR STEAM BREAK IN 1ST QUAD. TUNNEL (NODE 14)	15:03 15:11	1.84	GJS-BYR*SYM2(4).	

2

MICROFICHE*

*Microfiche from Revisions 0 and 1 are to be retained. 2

REVIEW METHOD SHEET

The NSLD Calc. No. 3C8-0282-001 Revision 2 has been reviewed by me according to the method(s) checked below:

Computer Aided Calculations:

- [ ] A review to determine if the input data as specified for program execution is consistent with the design input, correctly defines the problem for the computer algorithm, and is sufficiently accurate to produce results within any numerical limitation of the program.
- [x] Review of code input only since the computer program has sufficient history of use at Sargent & Lundy in similar calculations.
- [ ] Comparison of computer program's solution to test problem(s).
- [ ] Comparison of results of the computer calculation with the results of an independent hand calculation.
- [ ] Other. Explain: ______

Hand Prepared Design Calculations:

- [ ] Detailed review of the original calculations.
- [ ] Review by an alternate, simplified, or approximate method of calculation.
- [ ] Review of a representative sample of repetitive calculations.
- [ ] Review of the calculation against a similar calculation previously performed.

Revisions:

- [ ] Editorial changes only.
- [ ] Elimination of unapproved input data without altering calculation results.
- [x] Other. Explain: Detailed Review of the two additional cases analyzed in this calculation

- [ ] Other: ______

Reviewer: Vijay Kumar Sehgal Date: 10/18/84

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For Main Steam Tunnel Pressure Study For Main Steam Line Break	Calc. No. 3C8-0282-001
	[X] Safety-Related [ ] Non-Safety-Related	Rev. 0 Date 8/11/82
		Page A1 of

Client Commonwealth Edison Co.	Prepared by [signature] Date 8-6-82
Project Byron - Unit 1	Reviewed by Richard Cussy Date 8-6-82
Proj. No. 4391-00 Equip. No.	Approved by John W. Ahrens for R.T.H. Date 8-11-82

Appendix A

Hand Calculations

Form GO-3.08.1 Rev. 2

I recalulated volumes, flow areas, vent areas, inertia terms, and loss coefficients in this appendix. Having the previous values used in Reference 1 on hand, actual input used is as follows;

1.) Volumes

Will take 90% of recalculated gross volume for node 6. All other volumes used in reference 1 will be used.

2.) Vents

Even though there is very good agreement, I replaced values where recalulation is smaller.

3.) Inertia Terms

Larger of two values will be used.

4.) Loss Coefficients

Larger of two values will be used.

5.) Flow Areas

I used recalculated values when smaller than previously used.

SARGENT & LUNDY
ENGINEERS
CHICAGO

Calcs. For

X Safety-Related | Non-Safety-Related

Calc. No. 3C8-0282-001
Rev. 0 Date
Page A3 of

Client
Project
Proj. No. 4391-00 Equip. No.

Prepared by Date
Reviewed by Date
Approved by Date

Table A-1

Summary of Gross Volumes And Volumes Used in Analysis

Node(s)	Recalculated Gross Volume (ft^3)	Volume Used In Analysis (ft^3)	Difference (%)*
2,3,9,10	6360	4900	-23
4,5,11,12	6650	6005	-10
6	15,217	(13,695) 14,687	-3.5
7	39,192	34,865	-11
8	42,845	35,016	-18
13	21,956	17,388	-20
14	16,660	13,530	-19

* Used Recalculated Gross Volume as base.

Form GQ-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For	Calc. No. 3C8-0282-001
	X Safety—Related / Non—Safety—Related	Rev. 0 Date / Page A4 of

Client	Prepared by / Date
Project	Reviewed by / Date
Proj. No. 4391-00 Equip. No.	Approved by / Date

Table A-2

Summary of Vent Areas And Vent Areas Used IN Analysis

Vent No	Area Used IN Analysis	Recalculated Net Area	Difference (%)
1	271	298**	−9.0
2	125	121	+3.3
3	125	121	+3.3
4	75	73	+2.7
5	75	73	+2.7
6	100	100	0.0
7	200	202	−1.0
8	200	202	−1.0
9	125	121	+3.3
10	100	100	0.0
11	125	121	+3.3
12	100	100	0.0
13	374	422**	−11.4
14	271	298**	−9.1
15	75	73	+2.7
16	75	73	+2.7
17	100	100	0.0
18	51.3	53	−3.2
19	75.8	78.5	−3.4
20	51.3	53	−3.2
21	75.8	78.5	−3.4

* Is determined using Recalc. Net Area as base.

** Gross Vent Area minus Area equal to cross-sectional area of 4 MS Lines and 4 FW lines.

Form GQ-3.06.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For	Calc. No. 3C8-0282-001
	X Safety-Related / Non-Safety-Related	Rev. 0 Date
		Page A5 of

Client	Prepared by Date
Project	Reviewed by Date
Proj. No. 4391-00 Equip. No.	Approved by Date

Table A-3

Summary of Recalulated Inertia Values and Interia Values used in the analysis

Vent No.	Inertia (L/A) Used in Analysis	Recalulated Inertia
1	.1034	.0897
2	.0320	.1358
3	.0320	.1358
4	.0600	.2350
5	.0600	.2350
6	.0200	.1614
7	.5105	.446
8	.6306	.662
9	.0320	.1358
10	.0200	.1115
11	.0320	.1358
12	.0200	.1614
13	.1124	.099
14	.1551	.098
15	.0600	.2350
16	.0600	.2350
17	.0200	.1115
18	.2970	.2893
19	.3330	.1919
20	.2970	.2893
21	.3330	.1919

Form GQ-3.06.1 Rev. 2

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CHICAGO

Calcs. For		Calc. No. 3C8-0282-001
X Safety-Related	Non-Safety-Related	Rev. 0 Date
		Page A6 of
Client	Prepared by	Date
Project	Reviewed by	Date
Proj. No. 4391-00 Equip. No.	Approved by	Date

Table A-4

Summary of Recalculated Loss Coefficients (K) and Loss Coefficients Used in the Analysis

Vent No.	K Used in Analysis	Recalculated K
1	1.0271	1.0656
2	1.5150	1.5207
3	1.5150	1.5207
4	1.5040	1.5683
5	1.5040	1.5685
6	1.5043	1.5071
7	1.8315	2.186
8	2.0500	2.753
9	1.5150	1.5207
10	1.5043	1.512
11	1.5150	1.5207
12	1.5043	1.5071
13	1.0366	2.26
14	1.0543	2.26
15	1.5040	1.5685
16	1.5040	1.5685
17	1.5043	1.512
18	1.6930	2.9
19	2.90	2.9
20	1.6930	2.9
21	2.900	2.9

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For		Calc. No. 3C8-0282-001
	X Safety-Related	Non-Safety-Related	Rev. 0 Date
			Page A7 of

Client	Prepared by	Date
Project	Reviewed by	Date
Proj. No. 4391-00 Equip. No.	Approved by	Date

Check for Reynolds Number

Will select Junction 2 (ξ 3, 9, 11)

This junction consists of 3 openings.

Max. Mass Flow = 620 lbm/sec (Computer Output 1-0) (t = .015 seconds)

Opening # 1

$4 \times 5.5 = 22\ ft^2$ Perimeter = 19 ft

$\therefore D_H = 4 \frac{Area}{Perimeter} = 4.63$

Prorating Mass Flow => $\frac{22}{125} = .176\,(620) = 109.1\ \frac{lbm}{sec}$

At t = .015 seconds,

$v = 12.9578\ \frac{ft^3}{lbm}$

$\therefore \rho = .0771736\ \frac{lbm}{ft^3}$

$$V = \frac{109.1\ \frac{lbm}{sec}}{.0771736\ \frac{lbm}{ft^3}\,(22\,ft^2)} = 64.2\ ft/sec$$

$$\text{Rey No.} = \frac{\rho D_H V}{\mu} = \frac{.0771736\,(4.63)\,64.2\ \frac{ft}{sec}\ \frac{lbm}{ft^3}}{(.005\ \text{centipoises}).000672}$$

(μ = .005 centipoises, Marks, Page 4-50 Fig. 17)

Rey No. = 6.8×10^6

Turbulent Flow

$\therefore \nu = 4.36 \times 10^{-5} = \frac{ft^2}{sec}$

Form GQ-3.08.1 Rev. 2

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CHICAGO

Calcs. For		Calc. No. 3C5-0282-001
X Safety-Related	Non-Safety-Related	Rev. 0 Date
		Page A8 of

Client	Prepared by [signature]	Date
Project	Reviewed by	Date
Proj. No. 4391-00 Equip. No.	Approved by	Date

Volume Computation

1. Nodes 2, 3, 9, 10

Upper Valve Rooms

See Drawing Nos. S-900 ; S 1056 ; S-899 ; S1057

3 Sections

1. Volume Between Els 401'0" ; 413'4"

Length = 27.3 ft
Width = 13.3 ft
Ht = 12.3 ft
Vol = 4466 ft^3

2. Volume Between Els. 413'4" ; 416'4"

Length = 20.5 ft
Width = 6.5 ft
Ht = 3.0 ft

Vol = 399.75 ft^3

3. Volume Between El. 416'4" ; 421'8"
Length = 21'2"
Width = 13.3 ft
Ht = 5.3 ft
Volume = 1492 ft^3

Total Gross Volume = 6357.8 ft^3

Form GQ-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For X Safety–Related / Non–Safety–Related	Calc. No. 38-0282-001 Rev. 0 Date Page A9 of
Client Project Proj. No. 4391-00 Equip. No.	Prepared by Reviewed by Approved by	Date Date Date

2. Nodes 4, 5, 11, 12

Lower Valve Room:

See Drawings S-896 ; S-1056

Length = 25 ft (See S-896)
Width = 13.3 ft (See S-896)
Ht = 20 ft (See S-1056)
Gross Volume = 6650 ft^3

To subtract pipe volume, see Drawing Nos. M-160, Sht. 3, and M-188, Sht. 1.

Main Steam piping Dia. = 32 3/4

$$\text{Volume}_{\text{thru room}} = \left(\frac{32.0625}{12}\right)^2 \frac{\pi}{4}(25) = 140\ ft^3$$

Feedwater piping Dia = 16"

$$\text{Volume}_{\text{thru room}} = \left(\frac{16}{12}\right)^2 \frac{\pi}{4}\, 25 = 34.9\ ft^3$$

The following calculations are estimates;

Approximately 8 → 3 inch lines. Dia = 3.5 in

$$\text{Total Volume (8 pipes)} = \left(\frac{3.5}{12}\right)^2 \frac{\pi}{4}(25)8 = 13.4\ ft^3$$

Approximately 8 → 6 inch lines

$$\text{Total Volume (8 pipes)} = \left(\frac{6}{12}\right) \pi/4 (25)8 = 39.2\ ft^3$$

SARGENT & LUNDY ENGINEERS CHICAGO

Calcs. For		Calc. No. 3C8-0282-001
X Safety–Related	Non–Safety–Related	Rev. 0 Date
		Page A10 of

Client	Prepared by	Date
Project	Reviewed by	Date
Proj. No. 4391-00 Equip. No.	Approved by	Date

Total piping Volume = 228 ft^3

Therefore,

Volume minus piping = 6422 ft^3

Form GQ-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO

Calcs. For		Calc. No. 3C8-0282-001
X Safety-Related	Non-Safety-Related	Rev. 0 Date
		Page A11 of

Client	Prepared by	Date
Project	Reviewed by	Date
Proj. No. 4391-00 Equip. No.	Approved by	Date

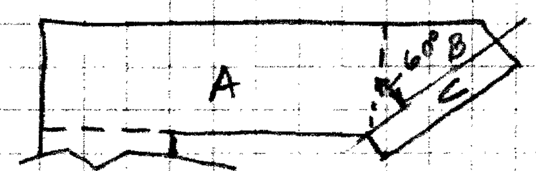
Form GQ-3.06.1 Rev. 2

3. Node 6

Main Steam Tunnel – 2nd Quadrant

See Drawings Nos. S-896 & S-1056

Section is shaped as



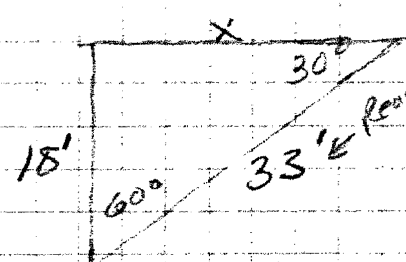
A) Width = 18 ft

Length ≅ 28 ft (See S-896)

Ht = 19 ft

Volume = 9576 ft^3

B)



read off of drawing

Cos 30° , X

X ≅ 28.6'

Ht = 19' (See S-1056)

Volume ≅ 4891 ft^3

C) Volumn in vents

3 Vents

(See No. S-1056) 1. (5'10") × 6.5' × 6 = 227.5 ft^3

× 2 = 455 ft^3

3. 7' × 7' × 6 = 294 ft^3

750 ft^3

Gross Total Vol. ≅ 15,217 ft^3

SARGENT & LUNDY
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CHICAGO

Calcs. For		Calc. No 3C8-0282-001
X Safety–Related	Non–Safety–Related	Rev. 0 Date
		Page A12 of

Client	Prepared by	Date
Project	Reviewed by	Date
Proj. No. 4391-00 Equip. No.	Approved by	Date

Will Subtract Volume for 2 main steam lines and 2 FW lines

Approximate Length = 58'
(I simply added the lengths for A & B of previous page for conservative estimate)

$MS \Rightarrow \left(\frac{32}{12}\right)^2 \frac{\pi}{4}\, 58(2) = 647.9\ ft^3$ see No. M-160 Sht. 1

$FW \Rightarrow \left(\frac{16}{12}\right)^2 \frac{\pi}{4}\, 58(2) = 162\ ft^3$

$810\ ft^3$

Net Volume = 14,407 ft^3

810 ft^3 is 5.6% of Gross Volume

I will use 90% of gross in analysis

$\therefore$

Volume = 12966 ft^3

Form GQ-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO

Calcs. For

X Safety–Related | Non–Safety–Related

Calc. No. 3C8-0282-001
Rev. 0 Date
Page A13 of

Client
Project
Proj. No. 4391-00 Equip. No.

Prepared by Date
Reviewed by Date
Approved by Date

4. Node 7

Main Steam Tunnel
Connecting 2nd & 1st Quadrants
See Drawing Nos. S-895 ; S-896 ; S-1060

Length = (31' 1 3/4" − 2 2) + 47'0" + 23'3" + 28'4" + 45'8" + 18'6" = 171.9 ft

Width = 12 ft

Ht = 19 ft

Gross Volume = 39,192 ft^3

Volumn to be Subtracted

2 Main Steam lines

$$\left(\frac{32}{12}\right)^2 \frac{\pi}{4} (172) 2 = 1921 \text{ ft}^3$$

2 FW lines

$$\left(\frac{16}{12}\right)^2 \frac{\pi}{4} (172) 2 = 480 \text{ ft}^3$$

Total = 2401 ft^3

Net Volumn = 36,791 ft^3

Form GQ-3.05.1 Rev. 2

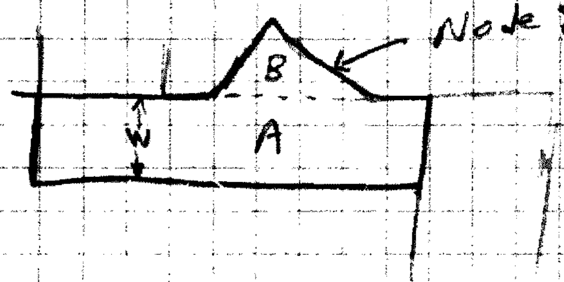
SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For	Calc. No. 365-0282-001
	X Safety–Related / Non–Safety–Related	Rev. 0 Date
		Page A14 of

Client	Prepared by Date
Project	Reviewed by Date
Proj. No. 4391-00 Equip. No.	Approved by Date

5. Node 8

1st Quadrant Main Steam Tunnel

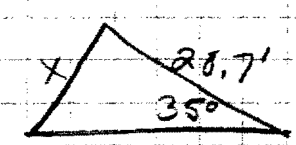
See Drawings S-688 ; S-1555 ; S-765 ; S-1062



A. W = 23.75 ft
Ht = 26.0
Length = 76.0 ft

Volume = 36,100 ft³

B.



X = 28.7 Cos 35° measured from drawing

X = 23.5 ft

Ht = 20 ft (See S-1062)

Volume = 6745 ft³

Gross Volume = 42 845 ft³

SARGENT & LUNDY ENGINEERS CHICAGO

Calcs. For		Calc. No. 3C8-0282-001
X Safety–Related	Non–Safety–Related	Rev. 0 Date
		Page A15 of

Client	Prepared by	Date
Project	Reviewed by	Date
Proj. No. 4391-00 Equip. No.	Approved by	Date

4 MS Lines in Node 8

$$\left(\frac{32}{12}\right)^2 \frac{\pi}{4} (76)\, 4 = 1700 ft^3$$

4 FW Lines in Node 8

$$\left(\frac{16}{12}\right)^2 \frac{\pi}{4} (76)\, 4 = 424 ft^3$$

$$\text{Total} \rightarrow 2125 ft^3$$

This volume represents about 5% of the gross volume in Node 8

Form GQ-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO

Calc. For	
X Safety–Related	Non–Safety–Related

Calc. No. 3C8-0282-001
Rev. 0 Date
Page A16 of

Client	Prepared by Date
Project	Reviewed by Date
Proj. No. 4391-00 Equip. No.	Approved by Date

6. Node 13

1st Quadrant Main Steam Tunnel (Node 13)
(Section where floor drops while making 90° turn) (P-Q) & (8-10)

Length - 25.5'
Width - 28.7'
height - 30.0'

Gross Volume = 21,956 ft^3

Form GQ-3.08.1 Rev. 2

SARGENT & LUNDY
ENGINEERS
CHICAGO

Calcs. For		Calc. No. 3C8-0282-001	
X Safety-Related	Non-Safety-Related	Rev. 0	Date
		Page A17	of

Client		Prepared by	Date
Project		Reviewed by	Date
Proj. No. 4391-00	Equip. No.	Approved by	Date

7. Node 14

Last Leg of Main Steam Tunnel
(L-P) & (8-10)

See drawing No. S-688 & S-762

Length = 52 ft
Width = 26.7 ft
Height = 12.0 ft

Gross Volume = 16,660.8

Form GO-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO

Calcs. For		Calc. No. 3C8-0282-001
		Rev. 0 Date
X Safety—Related	Non—Safety—Related	Page A18 of

Client	Prepared by	Date
Project	Reviewed by	Date
Proj. No. 4391-00 Equip. No.	Approved by	Date

Vent Computation

1. Junctions 2, 3, 9, 11

(Vents between Upper & Lower Valve Rooms)

See Drawings S-899 & S-900.

There are 3 openings.

			Area	Perimeter (ft)	R_H
1.	4 × 5.5	=	22 ft²	19	4.63
2.	6 × 10.5	=	63 ft²	33	7.63
3.	3 × 13.333	=	40 ft²	32.666	4.90
			125 ft²	84.7	

The only obstruction is a 28" pipe leading from the MS line to the S/RV's. (See M-159 Sht 1 & M-187 Sht 1)

$$\text{Area } (28") = \left(\frac{28}{12}\right)^2 \frac{\pi}{4} = 4.3 \text{ ft}^2$$

Net Area = 120.7

$$\text{Hydraulic Radius} = \frac{\text{Area}}{\text{wetted Perimeter}}$$

$$D = 4R = \frac{4\,(121.)}{84.7} = 5.7$$

Form GO-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For		Calc. No. 308-0232-001	
	X Safety–Related	Non–Safety–Related	Rev. 0	Date
			Page A19	of

Client	Prepared by — Date
Project	Reviewed by — Date
Proj. No. 4391-00 Equip. No.	Approved by — Date

2. Junctions 4, 5, 15, 16

(Lower Valve Chambers to Main Steam Tunnels)

See Drawing No. S-1056 & S-1061

4 Openings

	Area (ft^2)	Perimeter (ft)	D
1. 3.5 × 2	7.0	11.0	2.54
2. 3.0 × 2.75	8.25	11.5	2.87
3. 6.5 × 5.83 − 2	35.9	23.5	6.11
4. 3.5 × 7 − 2.5	22	19.5	4.63
	73.15	65.5	

Hydraulic Diameter = $\frac{4\,(73)}{65.5} = 4.5$

Form GO-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO

Calcs. For		Calc. No. 3C8-0282-001
X Safety–Related	Non–Safety–Related	Rev. 0 Date
		Page A20 of
Client	Prepared by	Date
Project	Reviewed by	Date
Proj. No. 4391-00 Equip. No.	Approved by	Date

3. Junctions 6 and 12 (Between Lower Valve Chambers)

See Drawing Nos. S-895, S-896, S-1056, and S-1057

2 openings

		Area	Perimeter	R_H
1.	$6 \times 7 =$	42	26	6.46
2.	$8.33 \times 7 =$	58.33	30.67	7.61
		100 ft^2	56.7	

Hydraulic Diameter $= 4 \frac{(100)}{56.7} = \underline{\underline{7.1}}$

Form GO-3.06.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For		Calc. No 3C8-0282-001
	X Safety-Related	Non-Safety-Related	Rev. 0 Date
			Page A21 of

Client	Prepared by Date
Project	Reviewed by Date
Proj. No. 4391-00 Equip. No.	Approved by Date

4. Junctions 7 & 8 See Drawing Nos. S-896 & S-1060 and S-899 & 6-688

(Between Nodes 6 & 7 and 7 & 8)

Width = 11 ft

Height = 19 ft

Area 209 ft

Perimeter ↓ 60 ft

Subtract Area for 2 MS Lines and 2 FW lines

$2\ MS \Rightarrow \left(\frac{32}{12}\right)^2 \frac{\pi}{4} = 11.2\ ft^2$

$2\ FL \Rightarrow \left(\frac{16}{12}\right)^2 \frac{\pi}{4} = \frac{2.8}{14.0\ ft^2}$

Net Area = $195\ ft^2$

Hydraulic Diameter = $\frac{4(200)}{60} = 13.3$

Form GQ-3.08.1 Rev. 2

5. Junctions 10 and 17
(Vents between Upper Valve Chambers)

See S-899, S-900, S-1056, S-1057

3 openings

		Area (ft^2)	Perimeter	R_H
1.	2.5 x 12.333	30.83	29.67	4.16
2.	2.75 x 12.333	33.92	28.17	4.82
3.	3.0 x 12.333	37.00	30.666	4.83
		101.75 ft^2	88.5	
Subtract	$\frac{(3 \times 1)}{2} = 1.5$	-1.50		
		100.25 ft^2		

Hydraulic Diameter = $4 \left(\frac{100.25}{88.5} \right) = \underline{\underline{4.5}}$

SARGENT & LUNDY
ENGINEERS
CHICAGO

Calcs. For		Calc. No. 3C8-0282-001
		Rev. 0 Date
X Safety–Related	Non–Safety–Related	Page A23 of

Client	Prepared by Date
Project	Reviewed by Date
Proj. No. 4391-00 Equip. No.	Approved by Date

6. Junction 13
(Between Nodes 8 and 13)
See Drawings S-688 ;' S-762

Area = 22.5 × 20 = 450 ft²
Perimeter = 85 ft

Area 4 ms = $\left(\frac{32}{12}\right)^2 \frac{\pi}{4}(4) = 22.3 \text{ ft}^2$

Area 4 FW = $\left(\frac{16}{12}\right)^2 \frac{\pi}{4}(4) = \frac{5.6}{28 \text{ ft}^2}$

Net Area = 422 ft²

(373 ft² was used in calculation)

Hydraulic Diameter = $4 \frac{(373)}{85} = 17.6$

Form GQ-3.08.1 Rev. 2

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ENGINEERS
CHICAGO

Calcs. For		Calc. No. 308-0282-601
		Rev. 0 Date
X Safety–Related	Non–Safety–Related	Page A24 of
Client	Prepared by	Date
Project	Reviewed by	Date
Proj. No. 4391-00 Equip. No.	Approved by	Date

7. Junctions 1 and 14

(Vents between Nodes 13 & 14 and 14 & 1)
Junctions 1 and 14.

Area = 27.17 X 12 = 326 ft^2
Perimeter = 78.3 ft
Area of 4 MS & 4 FW lines equal to 28 ft^2

(271 ft^2 was used in calculation)

Hydraulic Diameter = $\frac{4(271)}{78}$ = 13.9

Form GQ-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For	Calc. No. 3C8-0282-001
	X Safety-Related / Non-Safety-Related	Rev. 0 Date
		Page A25 of

Client	Prepared by / Date
Project	Reviewed by / Date
Proj. No. 4391-00 Equip. No.	Approved by / Date

8. <u>Junctions 18 and 20</u>
(Upper Valve Chamber not containing Door)
See Drawing Nos. S-899, S-900
S-1056, S-1057

Area HVAC Openings (Blow open - 1.5 psid)
(See S-1056)

Area = 13'4" × 4 = 53.3 ft^2
Perimeter = 34.7 ft

(51.3 ft^2 was used in calculation)

Hydraulic Diameter = $4\frac{(51.3)}{34.7}$ = $\underline{\underline{5.9}}$

Form GQ-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For		Calc. No. 368-0282-001	
	X Safety-Related	Non-Safety-Related	Rev. 0	Date
			Page A26 of	

Client		Prepared by	Date
Project		Reviewed by	Date
Proj. No. 4391-00	Equip. No.	Approved by	Date

9. Junctions 19 & 21
(Upper Valve Chambers containing Door)

See Drawing Nos. S-899, S-900, S-1056, & S-1057

2 Openings (Blow open - 1.5 psid)

Door - 3.5 × 7'2½" (See S-1061) — R_h 3.40

HVAC - 53.3 ft^2 (See Previous page)

Total Area = 78.5 ft^2

Perimeter = 56.1

Used 75.83 ft^2 in the Analysis

Hydraulic Diameter = $\frac{4(75.83)}{56.1}$ = 5.4

Form GQ-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For		Calc. No. 3C8-0282-001
	X Safety–Related	Non–Safety–Related	Rev. 0 Date
			Page A27 of

Client	Prepared by	Date
Project	Reviewed by	Date
Proj. No. 4391-00 Equip. No.	Approved by	Date

Inertia Values

1. Junctions 2, 3, 9, 11 (Vents between upper & lower Valve rooms)

This junction consists of 3 parallel vents (See Drawing Numbers S-1056 & S-1057)

Path #1) $$\sum \frac{L}{A} = \frac{L_1 - D_H}{A_1} + \frac{L_v + 2D_H}{A_v} + \frac{L_2 - D_H}{A_2}$$

L_1 (Upper Valve Room) $= 20.6/2 = 10.3$ ft
A_1 " $= 363$ ft^2
L_v (Vent) $= 4$ ft
A_v " $= 22$ ft^2
L_2 (Lower Valve Room) $= 20/2 = 10$ ft
A_2 " $= 332.5$ ft^2

$D_H = 4.63$ ft

$$\sum \frac{L}{A} = \frac{10.3 - 4.63}{363} + \frac{4 + 2(4.63)}{22} + \frac{10 - 4.63}{332.5}$$

$$\sum L/A = .0156 + .6027 + .0162$$

$$\sum L/A = .6345$$

Path #2) $A_v = 63$ ft^2
$D_H = 7.63$ ft

$$\sum \frac{L}{A} = \frac{10.3 - 7.63}{363} + \frac{4 + 2(7.63)}{63} + \frac{10 - 7.63}{332.5}$$

$$\sum \frac{L}{A} = .0074 + .3057 + .0071$$

$$\sum \frac{L}{A} = .3202$$

Form GQ-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For	Calc. No. 3C8-0282-001
		Rev. 0 — Date
	X Safety-Related — Non-Safety-Related	Page A28 of

Client	Prepared by	Date
Project	Reviewed by	Date
Proj. No. 4391-00 — Equip. No.	Approved by	Date

Path # 3)

$$A_V = 40\ ft^2$$
$$D_H = 4.90$$

$$\sum \frac{L}{A} = \frac{10.3-4.90}{363} + \frac{4+2(4.9)}{40} + \frac{10-4.9}{332.5}$$

$$\sum \frac{L}{A} = .0149 + .345 + .0153$$

$$\sum \frac{L}{A} = .3752$$

$$\sum \frac{L}{A} = \frac{1}{\left(\frac{1}{.6345} + \frac{1}{.3202} + \frac{1}{.3752}\right)} = \frac{1}{7.36}$$

$$\sum \frac{L}{A} = \underline{\underline{.1358}}$$

Form GQ-3.06.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For		Calc. No. 3C8-0282-001
			Rev. 0 Date
	X Safety-Related	Non-Safety-Related	Page A29 of

Client		Prepared by	Date
Project		Reviewed by	Date
Proj. No. 4391-00	Equip. No.	Approved by	Date

2. Junctions 4, 5, 15, 16

(Vents between Lower Valve rooms and main steam Tunnel)

See Drawings 5-895 & 5-896

Junction consists of 4 parallel paths

Path #1) $\sum \frac{L}{A} = \frac{L_1 - D_H}{A_1} + \frac{L_V + 2D_H}{A_V} + \frac{L_2 - D_H}{A_2}$

L_1 (Valve Room) $= 25/2 = 12.5$ ft

A_1 " $= 266$ ft^2

L_V (Path) $= 6$ ft

$A_V = 7$ ft^2

L_2 (Main Steam) $= 28(\frac{2}{3}) + 28/2 = 23.5$ ft

A_2 " $= 342$ ft^2

$R_H = 2.54$

$$\sum \frac{L}{A} = \frac{12.5 - 2.54}{266} + \frac{6 + 2(2.54)}{7} + \frac{23.5 - 2.54}{342}$$

$$\sum \frac{L}{A} = .0374 + 1.5829 + .06129$$

$$\sum \frac{L}{A} = 1.6816$$

Path #2) $A_V = 8.25$ ft^2

$D_H = 2.87$

$$\sum \frac{L}{A} = \frac{12.5 - 2.87}{266} + \frac{6 + 2(2.87)}{8.25} + \frac{23.5 - 2.87}{342}$$

$$\sum \frac{L}{A} = .0362 + 1.423 + .0603$$

$$\sum \frac{L}{A} = 1.5195$$

Form GQ-3.06.1 Rev. 2

Path #3) $A_V = 35.9\ ft^2$
$D_H = 6.11\ ft$

$$\Sigma \frac{L}{A} = \frac{12.5-6.11}{266} + \frac{6+2(6.11)}{35.9} + \frac{23.5-6.11}{342}$$

$$\Sigma \frac{L}{A} = .02402 + .5075 + .05085$$

$$\Sigma \frac{L}{A} = .5824$$

Path #4) $A_V = 22\ ft^2$
$D_H = 4.63$

$$\Sigma \frac{L}{A} = \frac{12.5-4.63}{266} + \frac{6+2(4.63)}{22} + \frac{23.5-4.63}{342}$$

$$\Sigma \frac{L}{A} = .0296 + .6936 + .0552$$

$$\Sigma \frac{L}{A} = .7784$$

Total

$$\Sigma \frac{L}{A} = \frac{1}{\frac{1}{1.6816} + \frac{1}{1.5195} + \frac{1}{.5824} + \frac{1}{.7784}} = \frac{1}{4.25}$$

$$\Sigma \frac{L}{A} = .2350$$

SARGENT & LUNDY ENGINEERS CHICAGO

Calcs. For		Calc. No 3C8-0282-001
X Safety–Related	Non–Safety–Related	Rev. 0 Date
		Page A31 of

Client	Prepared by	Date
Project	Reviewed by	Date
Proj. No. 4391-00 Equip. No.	Approved by	Date

3. Junctions 6 & 12

(Between Lower Valve Chambers)

See Drawings S-895 and S-896

Junction consists of 2 parallel paths

$$\Sigma \frac{L}{A} = \frac{L_1 - D_H}{A_1} + \frac{L_V + 2D_H}{A_V} + \frac{L_2 - D_H}{A_2}$$

Path #1)

L_1 (Valve Room) $= L_2 = 13.3/2 = 6.7'$

A_1 " $= A_2 = 500\ ft^2$

$L_V = 2\ ft$

$A_V = 42\ ft^2$

$D_H = 6.46$

$$\Sigma \frac{L}{A} = \frac{6.7 - 6.46}{500} + \frac{2 + 2(6.46)}{42} + \frac{6.7 - 6.46}{500}$$

$$\Sigma \frac{L}{A} = .3562$$

Path #2)

$A_V = 58.33\ ft^3$

$D_H = 7.61$

$$\Sigma \frac{L}{A} = 0 + \frac{2 + 2(7.61)}{58.33} + 0$$

$$\Sigma \frac{L}{A} = .2952$$

Total

$$\Sigma \frac{L}{A} = \frac{1}{\frac{1}{.3562} + \frac{1}{.2952}} = \frac{1}{6.195}$$

$$\Sigma \frac{L}{A} = \underline{\underline{.1614}}$$

Form GQ-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For	Calc. No. 308-0282-001
	X Safety–Related / Non–Safety–Related	Rev. 0 Date
		Page A32 of

Client	Prepared by	Date
Project	Reviewed by	Date
Proj. No. 4391-00 Equip. No.	Approved by	Date

4. Junction 7

(Between nodes 6 & 7)

See Drawings S-895 & S-896

$L \text{ (Node 6)} = 28 + 28.6\left(\frac{2}{3}\right)/2 = 23.5'$

$L \text{ (Node 7)} = 171.9/2 = 86 \text{ ft}$

Area (Node 6) = 342 ft^2

Area (Node 7) = 228 ft^2

$$\Sigma \frac{L}{A} = \frac{23.5}{342} + \frac{86}{228} = \underline{\underline{.446}}$$

5. Junction 8

(Area between nodes 7 & 8)

Going into 2nd 90° Turn in Tunnel

$L_1 \text{ (Node 7)} = 171/2 = 86 \text{ ft}$

A_1 " = 342 ft^2

$L_2 \text{ (Node 8)} = 76/2 = 38 \text{ ft}$

A_2 " = 475 ft^2

$$\Sigma \frac{L}{A} = \frac{86}{342} + \frac{38}{475} = .331$$

To account for 90° turn will double L/A

$$\therefore \frac{L}{A} = \underline{\underline{.662}}$$

Form GO-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For		Calc. No. 3C8-0282-001
	X Safety-Related	Non-Safety-Related	Rev. 0 Date
			Page A33 of

Client	Prepared by	Date
Project	Reviewed by	Date
Proj. No. 4391-00 Equip. No.	Approved by	Date

6. Junctions 10 & 17

(Vent areas between Upper Valve rooms)

See Drawings S-899 & S-900

This junction consists of 3 parallel paths

$L_1 = L_2$ (Upper Valve Room) $= 13.2/2 = 6.7$ ft

$A_1 = A_2$ " $= 336$ ft^2

Path #1) $\sum \frac{L}{A} = \frac{L_1 - D_H}{A_1} + \frac{L_V + 2D_H}{A_V} + \frac{L_2 - D_H}{A_2}$

$L_V = 2$ ft

$A_V = 30.83$ ft^2

$D_H = 4.16$

$$\sum \frac{L}{A} = 2\left(\frac{6.7 - 4.16}{336}\right) + \frac{2 + 2(4.16)}{30.83}$$

$$\sum \frac{L}{A} = .3347$$

Path #2) $A_V = 33.92$ ft^2

$D_H = 4.82$

$$\sum \frac{L}{A} = 2\left(\frac{6.7 - 4.82}{336}\right) + \frac{2 + 2(4.82)}{33.92}$$

$$\sum \frac{L}{A} = .3432$$

Form GQ-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For		Calc. No. 3C8-0282-001
	X Safety-Related	Non-Safety-Related	Rev. 0 Date
			Page A34 of

Client	Prepared by Date
Project	Reviewed by Date
Proj. No. 4391-00 Equip. No.	Approved by Date

Path #3) $A_V = 37 \text{ ft}^2$
$D_H = 4.83$

$$\Sigma \frac{L}{A} = 2\left(\frac{6.7-4.83}{336}\right) + \frac{2+2(4.83)}{37}$$

$$\Sigma \frac{L}{A} = .3263$$

Total

$$\Sigma \frac{L}{A} = \frac{1}{\frac{1}{.3347} + \frac{1}{.3432} + \frac{1}{.3263}} = \frac{1}{8.97}$$

$$\Sigma \frac{L}{A} = \underline{\underline{.1115}}$$

Form GO-3.08.1 Rev. 2

SARGENT & LUNDY
ENGINEERS
CHICAGO

Calcs. For

X Safety-Related | Non-Safety-Related

Calc. No. 3C8-0282-001
Rev. 0 Date
Page A35 of

Client		Prepared by	Date
Project		Reviewed by	Date
Proj. No. 4391-00	Equip. No.	Approved by	Date

7. Junction 13
(Between Nodes 8 & 13)
See Drawing No. S-688

L_1 (Node 8) = 76/2 = 38 ft, Area = 475 ft^2
L_2 (Node 13) = 28.7/2 = 14.4, Area = 765 ft^2

$$\sum \frac{L}{A} = \frac{38}{475} + \frac{14.4}{765} = .099$$

8. Junction 14

(Between Nodes 13 & 14)
See Drawing No. S-688

L_1 (Node 13) = 28/2 = 14.4, Area = 861 ft^2
L_2 (Node 14) = 52/2 = 26, Area = 320 ft^2

$$\sum \frac{L}{A} = \frac{14.4}{861} + \frac{26}{320} = .098$$

Form GO-3.08.1 Rev. 2

9. Junction 1

(Between Node 14 and 1)
– Opening from MS tunnel to Turbine building –

Will use

$$\Sigma \frac{L}{A} = \frac{L_1}{A_1} + \frac{6 D_H}{31 A_1}$$

L_1 (Node 14) = 52/2 = 26 ft
A_1 = 320 ft.
D_H = 13.9

$$\Sigma \frac{L}{A} = \frac{26}{320} + \frac{6(13.9)}{31(320)}$$

$$\Sigma \frac{L}{A} = .0897$$

10. Junctions 18 and 20
(HVAC opening in upper valve chamber)

Will use $\Sigma \frac{L}{A}$ equation per Junction 1

L_1 (Upper Valve room) = 27.3/2 = 13.7 ft
A_1 " = 51.3 ft^2
D_H = 5.9

$$\Sigma \frac{L}{A} = \frac{13.7}{51.3} + \frac{6(5.9)}{31(51.3)} = .2893$$

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For		Calc. No. 3C8-0282-001	
	X Safety-Related	Non-Safety-Related	Rev. 0	Date
			Page A37 of	

Client		Prepared by	Date
Project		Reviewed by	Date
Proj. No. 4391-00	Equip. No.	Approved by	Date

11. Junctions 19 & 21

(Between Upper Valve Rooms and atmosphere - HVAC and door)

This junction consists of 2 parallel paths

Path #1) HVAC - already calculated for junctions 18 and 20

$L/A = .2893$

Path #2) Door

$$A_V = 25.2 \text{ ft}^2$$
$$D_H = 3.4 \text{ ft}$$

$$\Sigma \frac{L}{A} = \frac{13.7}{25.2} + \frac{6(3.4)}{31(25.2)} = .5698$$

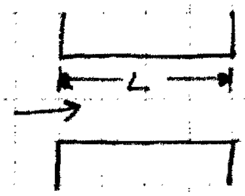
Total

$$\Sigma \frac{L}{A} = \frac{1}{\frac{1}{.2893} + \frac{1}{.5698}} = \frac{1}{5.21}$$

$$\Sigma \frac{L}{A} = .1919$$

Loss Coefficients

1. Junctions 2, 3, 9, 11 (Vents Between Upper & Lower Valve Rooms)



$L_v = 4\ ft$ (Floor thickness)

This junction consists of 3 parallel vents.

Reference: I.E. Idel'chik, AEC-TR-6630, 1960

Common to each of 3 vents { Entrance loss = .5 (See Page 100)
Exit Loss = 1.0 (See Page 128)

To determine conservative friction factor, I will calculate conserative relative roughness by using largest ϵ_n (for concrete) and smallest D_H of vents.

$\therefore$ For concrete $\epsilon_{max} = .01 \Rightarrow \frac{\epsilon_{max}}{D_{H_{min}}} = \frac{.01}{4.63} = .0022 \Rightarrow f_{max} \cong .024$ *

$$K_v = f_{max} \frac{L_v}{D_{H_{min}}} = .024 \frac{(4 ft)}{4.63} = .0207$$

$\therefore$

$$K = 1 + .5 + .0207$$

Conservatively, it will be assumed this K is applicable to all 3 vents,

$\therefore$ $K_T = 1.5207$

This is applicable to either flow direction

* Friction factor curves being used can be found in most any fluids book. The book being used in this analysis is, "Fluid Mechanics with Engineering Applications", by Daugherty & Franzini, McGrall-Hill, Inc, 1977 (Seventh Edition). The curves are on Page 214.

Form GQ-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO

Calcs. For	
X Safety–Related	Non–Safety–Related
Calc. No. 38-0282-001	
Rev. 0	Date
Page A39 of	
Client	
Project	
Proj. No. 4391-00	Equip. No.
Prepared by	Date
Reviewed by	Date
Approved by	Date

2. Junctions 4, 5, 15, 16

(Vents between Lower Valve Rooms and Main Steam Tunnel)

These junctions consist of 4 parallel vents

Common to each of 4 vents {
Entrance Loss = .5 (page 100, idel'chik)
Exit Loss = 1.0 (page 128, idel'chik)

$$\frac{\epsilon_{comm}}{D_{H_{min}}} = \frac{.01}{2.54} = .004$$

$$\therefore\ f_{max} = .029 \qquad K_v = f_{max}\frac{L_v}{D_{H_{min}}} \qquad L_v(\text{vent}) = 6\text{ft}$$

$$K = K_v + K_{EN} + K_{ex} = \frac{.029\ (6.0)}{2.54} + 1.0 + .5$$

Conservatively, it will be assumed this K is applicable to all 4 vents,

$$\therefore\ K_T = 1.5685$$

This applicable for both flow directions

Form GQ-3.06.1 Rev. 2

3. Junctions 6 and 12
(Between Lower Valve Rooms)

This junction consists of 2 parallel vents

Applicable to both vents { Entrance Loss = .5 (See page 100, Idel'chik)
Exit Loss = 1.0 (See page 128, Idel'chik)

$$\frac{\epsilon_{MAX}}{D_{H_{MIN}}} = \frac{.01}{6.46} = .00155 \quad \therefore f_{MAX} = .023$$

$$L_{vent} = 2\,ft \Rightarrow \frac{f_{max} L_v}{D_{H_{min}}} = K_v = \frac{.023\,(2)}{6.46} = .0071$$

$$K = 1.5071$$

Conservatively, it will be assumed this K is applicable to both vents, therefore,

$$\underline{\underline{K_T = 1.5071}}$$

This applicable to both flow directions

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For	Calc. No. 3C8-0282-001
	X Safety–Related / Non–Safety–Related	Rev. 0 Date
		Page A41 of

Client	Prepared by	Date
Project	Reviewed by	Date
Proj. No. 4391-00 Equip. No.	Approved by	Date

4.) Junction 7 – (Vent Between Nodes 6 & 7)

Distance Between Nodes (centroids)

$$= \frac{42.3 + 172}{2} = 107.1 \text{ ft}$$

$$\frac{\epsilon_{MIN}}{D_H} = \frac{.01}{13.3} = .00075 \therefore f = .018$$

$$K_V = f \frac{L}{D_H} = \frac{.018\,(107.1)}{13.3} = .145$$

For Turning Loss –

See Page 214 of Idel'Chik, AEC-TR-6630, Handbook of Hydraulic Resistance, Coefficients of Local Resistance and of Friction, 1960.
(Diagram 6-6)

For roughwalls $\Rightarrow \xi_T = \xi_1 \, k_{RE} \, k_\Delta$

$\xi_1 = f\left(\frac{b_1}{b_0}\right) \Rightarrow b_0 = 18 \text{ ft (node 6)} \quad a_0 = 19 \text{ ft}$

$b_1 = 12 \text{ ft (Node 7)}$

$\frac{b_1}{b_0} = \frac{12}{18} = .67 \qquad \frac{a_0}{b_0} = \frac{19}{18} \approx 1.0$

$\xi_1 = 1.59$

Form GO-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For	Calc. No. 3C8-0282-001
	X Safety–Related / Non–Safety–Related	Rev. 0 Date
		Page A42 of

Client	Prepared by / Date
Project	Reviewed by / Date
Proj. No. 4391-00 Equip. No.	Approved by / Date

To determine k_{RE} & k_{Δ}, see Table 6-11, Page 215 of Idel'chik.

It is assumed Reynolds Number $\geq 4 \times 10^4$

Since $\bar{\Delta} = \frac{\epsilon}{D_H} = .00075$

$\therefore \quad k_{RE} = 1.0$

$K_{\Delta} = 1 + 500(.00075) = .375$

$K_T = 1.59(1.0)(1.375)$

$\underline{\underline{K_T = 2.186}}$

It is evident from page 214, that by reversing the flow, K_T would be less. Both the b_1/b_0 and a_0/b_0 ratios would be greater than 1 driving down ζ_1.

For conservatism, the above K will be applicable for both flow directions

Form GQ-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For	Calc. No. 3C8-0282-001
	X Safety-Related / Non-Safety-Related	Rev. 0 Date
		Page A43 of

Client	Prepared by	Date
Project	Reviewed by	Date
Proj. No. 4391-00 Equip. No.	Approved by	Date

5. Junction 8 (Between nodes 7 & 8)

Distance Between Centroids

L_8 (Node 8) = 76 ft and L_7 (Node 7) = 172 ft

$$L_v = \frac{172 + 76}{2} = 124 \text{ ft}$$

$$\frac{\epsilon_{MAX}}{D_H} = \frac{.01}{13.3} = .00075 \quad \therefore \quad f = .018$$

$$K_v = f\frac{L_v}{D_H} = .018 \frac{(124 \text{ ft})}{13.3}$$

$$K = .168$$

For flow from Node 7 to 8

See Page 214

$b_0 = 12$ ft $\quad a_0 = 19$ ft

$b_1 = 23.75$ ft $\quad a_1 = 20$ ft

$$b_1/b_0 = \frac{23.75}{12} \simeq 2.0 \qquad a_0/b_0 = 19/12 = 1.58$$

$$\xi_1 = .805$$

As for Junction 7

$K_{Re} = 1.0$

$K_\Delta = 1.375$

$$K_{TOTAL} = (.805)(1.0)(1.375) + .168$$

$$\underset{7\to8}{K_{TOTAL}} = 1.275$$

Form GQ-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For		Calc. No. 3C8-0282-001
	X Safety–Related	Non–Safety–Related	Rev. 0 Date
			Page A44 of

Client	Prepared by	Date
Project	Reviewed by	Date
Proj. No. 4391-00 Equip. No.	Approved by	Date

<u>For flow from Node 8 to 7</u>

See Page 214, Idel'chik

$b_1/b_0 = \frac{12}{23.75} = .51$

$\frac{a_0}{b_0} = \frac{20}{23.75} = .84$

Interpolation to determine ζ_1

	.5	.6	.8
.25		1.76	1.43
.84	1.88	1.71	1.38
1.00		1.70	1.36

$\zeta_1 = 1.88$

$K_{RE} = 1.0$

$K = 1.375$

$K_{TOTAL} = (1.88)(1.0)1.375 \quad .168$

$\underline{K_T = 2.753}$

For conservatism, the above K will be applicable for both flow directions

Form GQ-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For	Calc. No. 3C8-0282-001
	X Safety-Related / Non-Safety-Related	Rev. 0 Date
		Page A45 of

Client	Prepared by	Date
Project	Reviewed by	Date
Proj. No. 4391-00 Equip. No.	Approved by	Date

6) Junctions 10 and 17
(Vents between Upper Valve Rooms)

This junction consists of 3 Parallel vents

Applicable to all vents $\left\{ \begin{array}{l} K_{ENTRANCE} = .5 \\ K_{exit} = 1.0 \end{array} \right.$ $\frac{\epsilon_{max}}{D_{H_{MIN}}} \frac{.01}{4.16} = .0024 \therefore f_{MAX} = .025$

$L_v = 2 ft$ $K_v = f_m \frac{L_v}{D_{H_{min}}} = .025 \frac{(2 ft)}{4.16}$

$K = .012$

$K_{TOTAL} = 1.512$

This K value will be applicable to both flow directions

7) Junctions 13 and 14
(Between Nodes 8 & 13 and 13 & 14)

See Page 229 in idel'chek

$b_0 = 23.75 ft$ $a_0 = 20 ft$

$\frac{a_0}{b_0} = \frac{20}{23.75} = .84$ $l'_0 = 14 ft$ (difference between Centerlines of nodes 8 and 14)

$l'_0/b_0 = \frac{14}{23.75} = .59 \simeq .6 \therefore \xi_1 = 2.9$

Rough walls

$\xi = k_\Delta C_1 \xi_1 + \xi_{fe}$

See Page 230
$\xi_{fe} = f(1 + \frac{l_0}{b_0})$
$\xi_{fr} = .025(1 + .6)$
$\xi_{fr} = .04$

$Re_y \geq 4 \times 10^4 \therefore k_\Delta = 1.5$
$a_0/b_0 = .84 \therefore C_1 = 1.03$ (See Page 230 Table B)

$K = (1.5)(1.03)2.9 + .04$
$K = 4.52$

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For	Calc. No. 3C8-0282-001
	X Safety–Related / Non–Safety–Related	Rev. 0 Date / Page A46 of

Client	Prepared by / Date
Project	Reviewed by / Date
Proj. No. 4391-00 Equip. No.	Approved by / Date

The loss coefficient is for both junctions 13 and 14, therefore, 1/2 of the coefficient will used for each junction.

$$\therefore \quad \underline{\underline{K_{T_{13}} = K_{T_{14}} = 2.26}}$$

For reverse flow, r_0/b_0 would be smaller resulting in a smaller ξ_1. Also, a_0/b_0 would also be smaller resulting in a smaller C_1. Therefore, the above K will be applicable to both flow directions

8. **Junction 1**

(From main steam tunnel to Turbine Building (atmosphere))

L_{14} (Node 14) $= 52$ ft $\quad L_{ATM} = 44$ ft

$$L_V = \frac{44+52}{2} = 48 \text{ ft}$$

$$\frac{\epsilon_{MAX}}{D_H} = \frac{.01}{13.9} = .00072 \quad \therefore f = .019$$

$$K = f\frac{L_V}{D_H} = .019\frac{(48)}{13.9} = .0656$$

$$K_{exit} = 1.0$$

$$\underline{\underline{K_T = 1.0656}}$$

Entrance to the tunnel results in a lower K, therefore the above K will be applicable to either flow direction

Form GQ-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For		Calc. No. 3L8-0282-001
	X Safety-Related	Non-Safety-Related	Rev. 0 Date
			Page A47 of

Client	Prepared by	Date
Project	Reviewed by	Date
Proj. No. 4391-00 Equip. No.	Approved by	Date

9.) Junctions 18 and 20

(Upper HVAC openings in Upper Valve chambers of safety valve room)

Will treat opening as an orifice.
Therefore, see page 135 of Idel'chick

K is a function of the ratio of the projected areas of the nodes. Since atmosphere is represented as a very large node, the ratio goes to zero.
Therefore, from the tables,

$$\underline{\underline{K_T = 2.9}}$$ (Applicable to both flow directions)

10.) Junctions 19 and 21

(Upper HVAC openings and doors in Upper Valve chambers of safety valve room)

I will treat door as an orifice
Therefore, as explained for junctions 18 & 20,

$$\underline{\underline{K_T = 2.9}}$$ (Applicable to both flow directions)

Form GQ-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For	Calc. No. 3C8-0282-001
	X Safety-Related / Non-Safety-Related	Rev. 0 Date
		Page A48 of

Client	Prepared by	Date
Project	Reviewed by	Date
Proj. No. 4391-00 Equip. No.	Approved by	Date

Determination of Node Flow Areas

1. Nodes 2 and 9

Flow will be vertical

Flow area to HVAC opening at top of volume is dictated by dimensions at El. 413'4" and 416'4".

$$F.A. = 20\text{ ft} \times 6.5\text{ ft} = \underline{\underline{133.25\text{ ft}^2}}$$

2. Nodes 3 and 10

Flow will be both vertical and horizontal

Will use flow area equal to that determined for Nodes 2 and 9 plus twice the area of the door.

$$F.A. = 133.25 + (25.2)2 = \underline{\underline{183.7\text{ ft}^2}}$$

3. Node 6

Flow is horizontal

$$F.A = 18 \times 19 = 342\text{ ft}^2$$

Projected area of 2 MS lines (33") and 2 FW lines (16") is equal to 15 ft^2.
I will subtract 25 ft^2 to account for piping.
$\therefore$ $FA = \underline{\underline{317\text{ ft}^2}}$

SARGENT & LUNDY ENGINEERS CHICAGO	Calcs. For		Calc. No. 3C8-0282-001
	X Safety–Related	Non–Safety–Related	Rev. 0 Date
			Page A49 of

Client	Prepared by	Date
Project	Reviewed by	Date
Proj. No. 4391-00 Equip. No.	Approved by	Date

4.) Node 7

Flow is horizontal

$FA = 12 \times 19 = 228\ ft^2$

minus $25\ ft^2$ for piping ($15\ ft^2$

$F.A. = \underline{203\ ft^2}$

5.) Node 8

Flow is horizontal

$F.A. = 20 \times 23.75 = 475\ ft^2$

minus $40\ ft^2$ for piping

$F.A. = \underline{\underline{435\ ft^2}}$

6.) Node 13

Flow is directed both vertically and horizontally

Will set flow capacity equal to Node 8 to which it connects.

$FA. = \underline{\underline{435}}\ ft^2$

7.) Node 14

Flow is directed horizontally

$\therefore$ $F.A. = 26.7 \times 12 = 320\ ft^2$

minus $40\ ft^2$ for piping

$F.A. = \underline{\underline{280\ ft^2}}$

Form GQ-3.08.1 Rev. 2

SARGENT & LUNDY ENGINEERS CHICAGO

Calcs. For		Calc. No. 3C8-0282-001
X Safety–Related	Non-Safety–Related	Rev. 0 Date
		Page A50 of FINAL

Client		Prepared by	Date
Project		Reviewed by	Date
Proj. No. 4391-00	Equip. No.	Approved by	Date

8.) Notes 4, 5, 11, 12

Flow will be both vertical and horizontal, therefore, the smaller of the two will be used.

$20 \times 13.3 = 266\ ft^2 \times .8 = 213\ ft^2$

Form GQ-3.08.1 Rev. 2

APPENDIX B

Revised Main Steam Tunnel Pressure For Byron/Braidwood Unit 1

Based On Mass And Energy Release From

FTI 32-1258100-00 (Reference B1)

For Replacement Steam Generator (RSG)

Table of Contents

List of Tables

List of Figures

1.0 PURPOSE AND SCOPE

The purpose of this appendix is to recalculate the peak differential pressures for the Byron and Braidwood Unit 1 main steam tunnels and valve rooms using the mass and energy releases of Reference B1 for the break locations defined in Section II of the main report. Reference B2 drawings will be reviewed to verify that there are no changes that would significantly affect the node and junction parameters calculated in Appendix A. Except for the use of the Reference B1 mass and energy releases, the RELAP4/MOD5 (Reference B3) computer models will be those used in previous revisions of the calculation.

2.0 DESIGN INPUT

2.1 The Reference B1 mass and energy release rates for the postulated main steam line rupture.

2.2 The Reference B2 mechanical and structural drawings.

3.0 ASSUMPTIONS

Assumptions and information used in this calculation are as noted in Section IV and V of the main report, except the mass and energy release rates for the postulated steam line rupture were taken from Reference B1.

4.0 APPROACH

The approach to this calculation is the same as that described in Section V. (Method of Analysis) of the main report except:

4.1 The Sargent & Lundy drawings listed in Reference 5 of the main report were updated to include the Reference B2 drawings of this appendix as the basis for the computer model. The Reference B2 drawings were reviewed to verify that there are no changes that would significantly affect the node and junction geometrical and flow parameters listed in Tables 1 and 2, respectively, of the main report.

4.2 The Reference B3 version of RELAP4/MOD5 was used to determine the pressure transients for the six cases, each having a different break location in the main steam tunnel.

4.3 The blowdown rates and average enthalpies are based on the mass and energy flows of Reference B1 and are presented in Table B1.

5.0 CALCULATIONS

5.1 Mass Energy Release

The Reference B1 mass and energy releases are presented in that reference as mass flows (lbm/sec) and energy flows (Btu/sec) for the single and triple loop. Per Reference B1, the single loop rates represents the mass and energy flows from the broken steam generator and the triple loop rates represent the mass and energy flows from the intact steam generator into the containment (prior to isolation). Per Reference B1, these rates should be combined for any subcompartment analysis. Therefore, in this calculation the break mass flow rate was set equal to the total of the single and triple loop values and an average enthalpy was used as input to the RELAP4 model as shown in Table B1. The average enthalpy was determined by summing the single and triple loop energy flow rates and dividing by the total mass flow rate.

5.2 Computer Runs

Six RELAP4/MOD5 (Reference B3) computer runs were made corresponding to the break locations described in Section II of the main report and shown schematically in Figures 1 and 2 of the main report. As in the main report Table of Contents of Computer Output (page 65), the computer run part numbers used in this appendix correspond to the same break locations:

5.2 Computer Runs (contd.)

Part No.	Break Location
1	Node 5
2	Node 6
3	Node 7
4	Node 8
5	Node 13
6	Node 14

The same computer model was used for each case, but the break node location was changed to correspond to Figure 2 of the main report.

5.3 Nodal Differential Pressures

For each node in the computer model the maximum nodal pressure was determined for each computer run. These maximum pressures were then compared as shown in Table B2 to determine the overall maximum pressure for each node. The maximum nodal differential pressures with respect to the areas surrounding the main steam tunnel and valve rooms were then obtained by subtracting atmospheric pressure (or the minimum transient node pressure) from the overall maximum pressure for each node (See Table B2).

These overall maximum nodal differential pressures along with the symmetry of the main steam tunnel areas was then used to determine the peak nodal differential pressures for this calculation.

5.4 Differential Pressure Across Internal Walls

For each wall/floor internal to the valve rooms and those separating the valve rooms from the main steam tunnel areas, the maximum differential pressure across these walls was calculated for each break location. These maximum wall differential pressures were then compared as shown in Table B3 to determine the overall maximum differential pressure across each wall.

These overall maximum wall/floor differential pressures along with the symmetry of the main steam tunnel areas was then used to determine the peak nodal differential pressures for this calculation.

6.0 RESULTS

The peak nodal differential pressures which represent the difference between steam tunnel/valve room nodes and the surrounding areas are presented in Table B4 and Figures B1 through B7 . From this table and the figures it is seen that the highest peak nodal differential pressure of 17.7 psid occurs in the lower valve chambers.

The peak differential pressures across internal walls/floors are shown in Table B5 and Figures B8 through B11. From this table and the figures it is seen that the highest peak differential pressure of 14.4 psid is for the vertical wall separating the lower valve rooms from the main steam tunnel.

The results presented above for the main steam tunnel conservatively do not consider a path to the auxiliary feedwater (AFW) tunnel. The AFW tunnel lies beneath the main steam tunnel. If one or more hatches covering the four approximately 15 square foot ladder openings in the lower valve rooms are left open, however, flow paths from the main steam tunnel to the AFW tunnel do exist. Based on a review of drawing M-159, the largest high-energy lines in the AFW tunnel are 4-inch AFW system lines. The estimated mass flow from a double-ended guillotine break of these 4-inch lines is on the order of 50 to 60% of that from the MSLB as shown in Table B6. From that same table, it is also seen, however, that the enthalpy of

6.0 RESULTS (contd.)

the water in these 4-inch lines is quite small, so that the resulting total energy release is less than 4% of that from the MSLB. Because of this, nodal pressure differentials for the AFW tunnel would be bounded by those for the main steam tunnel.

In general the nodal differential pressures for Byron and Braidwood Unit1 determined in this Appendix are less than the Revision 2 results. The only exception is the nodal differential pressure for node 14 (the last segment of the MST that opens into the turbine building) which is 0.2 psid higher (less than 2%) than the Revision 2 results.

7.0 REFERENCES

B1. NDIT No. 960136, "Steam Generator Replacement Project: Transmittal of SLB M&E for Steam Tunnel Pressure Analysis," Dated 9/16/96. (Attached)

B2. Sargent and Lundy Drawings:

Drawing No.	Sheet No.	Byron Braidwood Revision	Byron Revision	Braidwood Revision
M-159	1	M	-	-
M-159	2	D	-	-
M-159	3	J	-	-
M-160	1	L	-	-
M-187	1	L	-	-
M-188	1	L	-	-
S-688	1	-	AE	-
S-688	1	-	-	AE
S-758	1	-	J	-
S-758	1	-	-	K
S-762	1	-	W	-
S-762	1	-	-	W
S-765	1	-	K	-
S-765	1	-	-	K
S-895	1	-	AA	
S-895	1	-	-	AD
S-896	1	-	U	-
S-896	1	-	-	W
S-899	1	-	W	-
S-899	1	-	-	W
S-900	1	-	W	-
S-900	1	-	-	Y
S-1056	1	-	Y	-
S-1056	1	-	-	AB

B2. Sargent and Lundy Drawings:(contd.)

Drawing No.	Sheet No.	Byron Braidwood Revision	Byron Revision	Braidwoo Revision
S-1057	1	-	AK	-
S-1057	1	-	-	AS
S-1060	1	-	U	-
S-1060	1	-	-	Z
S-1061	1	-	Y	-
S-1061	1	-	-	AB
S-1062	1	-	U	-
S-1062	1	-	-	W

B3. User's Manual for RELAP4, "Nuclear Plant Transients," Sargent & Lundy Program Number 03.7.407-1.0, April 14, 1993.

B4. Piping Line List from Sargrent & Lindy PDIS.

B5. Byron/Braidwood Stations Piping Design Table "907BB" Carbon Steel, Rev. C, 12-31-84

B6. Crane Technical Paper No. 410, 1976.

B7. User's Manual for FLS, "Flood Level Simulator," Sargent & Lundy Program Number 03.7.195-1.3, January 13,1992.

B8. ASME Steam Tables.

8.0 ATTACHMENTS Pages B_

1. NDIT No. 960136 32 40

Table B1 : Blowdown Rate and Enthalpy

For Ruptured Main Steam Line (Per Reference B1)

Time (sec)	Flow (lbm/sec)	Enthalpy (Average) (Btu/lbm)
0	14189	1024.9
0.02	14189	1024.9
0.04	13883	1116.4
0.06	12901	1119.3
0.08	12479	1124.6
0.1	12342	1133
0.12	12250	1134
0.14	12093	1128.3
0.16	11827	1119.4
0.18	11434	1111.2
0.2	11022	1107.3
0.22	10642	1105.7
0.24	10315	1105.5
0.26	10041	1105.9
0.28	9810	1106.3
0.3	9608	1106.4
0.32	9424	1106.4
0.34	9255	1106.3
0.36	9097	1106.4
0.38	8954	1106.8
0.4	8827	1107.7
0.42	8728	1110.1
0.44	8633	1109.1
0.46	8558	1112.7
0.48	8522	1116.4
0.5	8512	1119.5
0.52	8523	1122.7
0.54	8553	1125.9
0.56	8598	1128.8
0.58	8652	1131.3
0.6	8709	1133.3
0.62	8765	1134.8
0.64	8813	1135.8
0.66	8852	1136.5
0.68	8879	1136.9
0.7	8894	1137.2
0.72	8898	1137.3
0.74	8892	1137.4
0.76	8878	1137.5
0.78	8875	1138.5

Table B1 (contd.): Blowdown Rate and Enthalpy

For Ruptured Main Steam Line (Per Reference B1)

Time (sec)	Flow (lbm/sec)	Enthalpy (Average) (Btu/lbm)
0.8	8846	1137.5
0.82	8816	1137.9
0.84	8788	1138.3
0.86	8761	1138.5
0.88	8733	1138.7
0.9	8705	1138.9
0.92	8679	1139.1
0.94	8655	1139.3
0.96	8632	1139.5
0.98	8611	1139.6
1	8591	1139.8
1.02	8573	1139.9
1.04	8557	1140.1
1.06	8542	1140.2
1.08	8529	1140.3
1.1	8518	1140.4
1.12	8508	1140.5
1.14	8499	1140.5
1.16	8492	1140.5
1.18	8486	1140.4
1.2	8481	1140.3
1.22	8477	1140.2
1.24	8473	1140
1.26	8471	1139.7
1.28	8468	1139.4
1.3	8466	1139
1.32	8465	1138.6
1.34	8463	1138.1
1.36	8462	1137.5
1.38	8462	1136.9
1.4	8461	1136.2

Table B2: Comparison of Maximum Calculated Node Pressures and Nodal Differential Pressures

PART No. (Break Location)		Volume 2 Average Pressure (psia)	Volume 3 Average Pressure (psia)	Volume 4 Average Pressure (psia)	Volume 5 Average Pressure (psia)	Volume 6 Average Pressure (psia)	Volume 7 Average Pressure (psia)	Volume 8 Average Pressure (psia)	Volume 9 Average Pressure (psia)	Volume 10 Average Pressure (psia)	Volume 11 Average Pressure (psia)	Volume 12 Average Pressure (psia)	Volume 13 Average Pressure (psia)	Volume 14 Average Pressure (psia)	
PART 1	MIN	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.69	14.69	14.69	14.69	14.66	14.63	
(Node 5)	MAX	29.89	28.95	29.51	32.30	27.99	25.54	19.11	17.83	17.78	18.11	18.13	18.25	16.19	
PART 2	MIN	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.69	14.69	14.70	14.70	14.68	14.63	
(Node 6)	MAX	25.89	25.52	26.68	26.86	30.63	27.98	20.16	18.55	18.50	18.99	18.97	19.02	16.48	
PART 3	MIN	14.69	14.69	14.70	14.70	14.70	14.70	14.70	14.69	14.69	14.70	14.70	14.70	14.64	
(Node 7)	MAX	24.14	24.05	25.14	25.17	28.22	29.83	21.12	19.24	19.17	19.67	19.70	19.89	16.84	
PART 4	MIN	14.69	14.69	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.69	
(Node 8)	MAX	19.34	19.30	19.90	19.88	21.33	22.33	22.97	20.77	20.74	21.51	21.62	23.20	19.47	
PART 5	MIN	14.69	14.69	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	
(Node 13)	MAX	18.12	18.07	18.48	18.49	19.59	20.33	22.73	20.55	20.36	20.97	21.08	25.32	21.91	
PART 6	MIN	14.69	14.69	14.70	14.70	14.70	14.70	14.70	14.69	14.69	14.70	14.70	14.70	14.70	
(Node 14)	MAX	16.78	16.76	17.08	17.06	17.94	18.05	19.46	18.36	18.18	18.67	18.68	21.76	25.88	MIN
	MIN	14.69	14.69	14.70	14.70	14.70	14.70	14.70	14.69	14.69	14.69	14.69	14.66	14.63	14.63
	MAX	29.89	28.95	29.51	32.30	30.63	29.83	22.97	20.77	20.74	21.51	21.62	25.32	25.88	
DELTA P		15.3	14.3	14.9	17.7	16.0	15.2	8.3	6.1	6.1	6.9	7.0	10.7	11.3	

Table B3: Comparison of Calculated Maximum Internal Wall Differential Pressures

	Junction 17	Junction 10	Junction 3	Junction 11	Junction 6	Junction 12	Junction 2	Junction 9	Junction 4	Junction 5	Junction 15	Junction 16
Between Nodes	2-3	9-10	3-4	10-11	4-5	11-12	2-5	9-12	4-6	5-6	11-8	12-8
PART 1	1.63	0.02	3.51	0.00	0.00	0.04	12.50	0.00	4.88	14.40	0.01	0.01
(NODE 5)*	5.48	0.12	2.11	0.83	13.20	0.06	0.00	0.75	0.00	0.00	1.42	1.37
PART 2	0.03	0.03	3.80	0.00	0.17	0.04	3.82	0.00	0.00	0.00	0.00	0.00
(NODE 6)*	0.46	0.13	0.00	0.91	0.17	0.07	0.00	0.83	10.41	10.41	1.68	1.63
PART 3	0.02	0.03	1.71	0.00	0.06	0.04	1.54	0.00	0.00	0.00	0.00	0.00
(NODE 7)*	0.23	0.15	0.00	1.03	0.10	0.08	0.00	0.92	4.33	4.25	2.01	1.95
PART 4	0.02	0.03	0.98	0.00	0.03	0.11	0.90	0.00	0.00	0.00	0.00	0.00
(NODE 8)*	0.12	0.30	0.00	1.87	0.06	0.13	0.00	1.88	2.18	2.13	4.84	4.84
PART 5	0.02	0.03	0.87	0.00	0.03	0.10	0.80	0.00	0.00	0.00	0.00	0.00
(NODE 13)*	0.12	0.28	0.00	1.36	0.06	0.12	0.00	1.37	1.65	1.59	4.24	4.24
PART 6	0.02	0.03	0.72	0.11	0.03	0.09	0.66	0.09	0.00	0.00	0.65	0.71
(NODE 14)*	0.10	0.21	0.00	0.83	0.05	0.10	0.00	0.83	1.09	1.04	2.57	2.57
MAX Delta P	5.48	0.30	3.80	1.87	13.20	0.13	12.50	1.88	10.41	14.40	4.84	4.84

(   )* - Break Node

Table B4: Peak Pressure Differentials - Main Steam Line Breaks in Main Steam Tunnel or Valve Rooms

Volume No.	Description	Break Location Volume No.	Calc. Peak Press. Diff. (psid)
1	Atmosphere	-	-
2	2nd Quadrant Upper Valve Chamber	5	15.3
3	2nd Quadrant Upper Valve Chamber	5	15.3
4	2nd Quadrant Lower Valve Chamber	5	17.7
5	2nd Quadrant Lower Valve Chamber	5	17.7
6	2nd Quadrant Main Steam Tunnel	6	16.0
7	Main Steam Tunnel	7	15.2
8	1st Quadrant Main Steam Tunnel	8	8.3
9	1st Quadrant Upper Valve Chamber	5**	15.3
10	1st Quadrant Upper Valve Chamber	5**	15.3
11	1st Quadrant Lower Valve Chamber	5**	17.7
12	1st Quadrant Lower Valve Chamber	5**	17.7
13	1st Quadrant Main Steam Tunnel	13	10.7
14	1st Quadrant Main Steam Tunnel	14	11.3

** Differential pressures calculated for 1st Quadrant valve chambers are also applicable to corresponding 2nd Quadrant valve chambers

TABLE B5: SUMMARY OF PEAK PRESSURES BETWEEN VALVE ROOMS AND MAIN STEAM TUNNEL

WALL LOCATION BETWEEN NODES		DELTA P ACROSS	PEAK PRESSURE (PSID)
2-3	9-10	VERT'L WALL	5.48
3-4	10-11	HORZ'L FLOOR	12.50
4-5	11-12	VERT'L WALL	13.20
2-5	9-12	HORZ'L FLOOR	12.50
4-6	5-6	MST VERT'L	14.40
11-8	12-8	WALL	

TABLE B6: Comparison of MSLB in MST with 4" AFW Break in Auxilary Feedwater Tunnel

Line Break Location	System	Nominal Diameter (Ref. B2, M-159)	Inside Diameter (Refs. B4, B5 & B6)	Inside Area (Ref. B6)	Operating Temp. (Ref. B4)	Operating Pressure (Ref. B4)	Approx. Mass Flux (Ref. B3 & B7)		Enthalpy (Ref. B8)	Mass Flow	Energy Flow	% of MST Break Energy Flow
			(in)	(ft^2)	(°F)	(psia)	(lbm/ft^2-sec)		(Btu/lbm)	(lbm/sec)	(Btu/sec)	(—)
MST (Ref B1)	MS	-	-	-	-	-	-	Maximum	1140.5	14189	1.55E+07	100
								Minimum	1024.9	8461	9.51E+06	100
AF Tunnel	AFW	4	3.624	0.07163	100	2080	34000	Maximum	73.5	4871	3.58E+05	2.31
								Minimum	73.5	4871	3.58E+05	3.76

FIGURE B1: MAIN STEAM LINE BREAK IN LOWER SECOND QUADRANT VALVE ROOM (NODE 5)

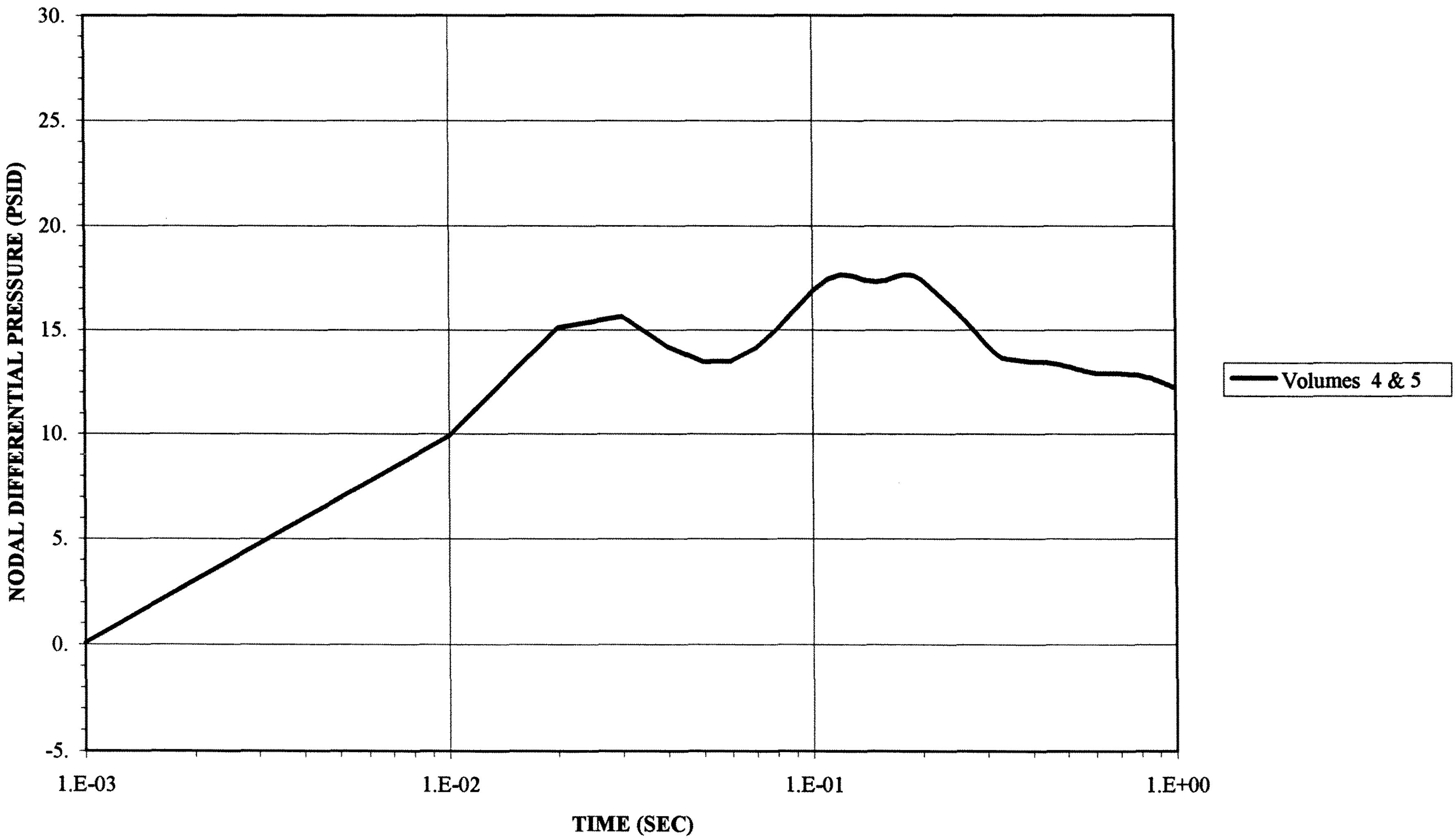


FIGURE B2: MAIN STEAM LINE BREAK IN 2ND QUADRANT TUNNEL (NODE 6)

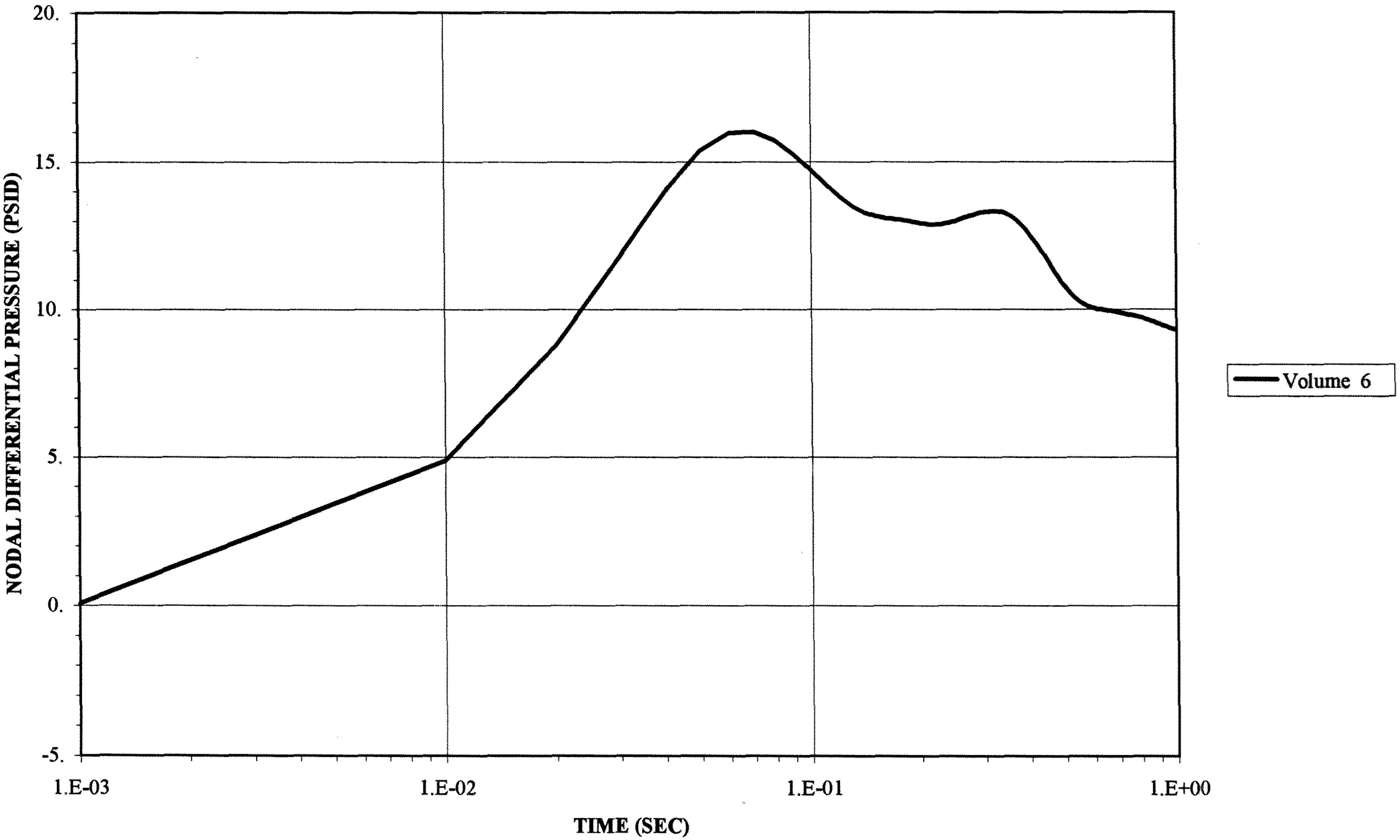


FIGURE B3: MAIN STEAMLINE BREAK IN 2ND & 1ST QUADRANT TUNNEL (NODE 7)

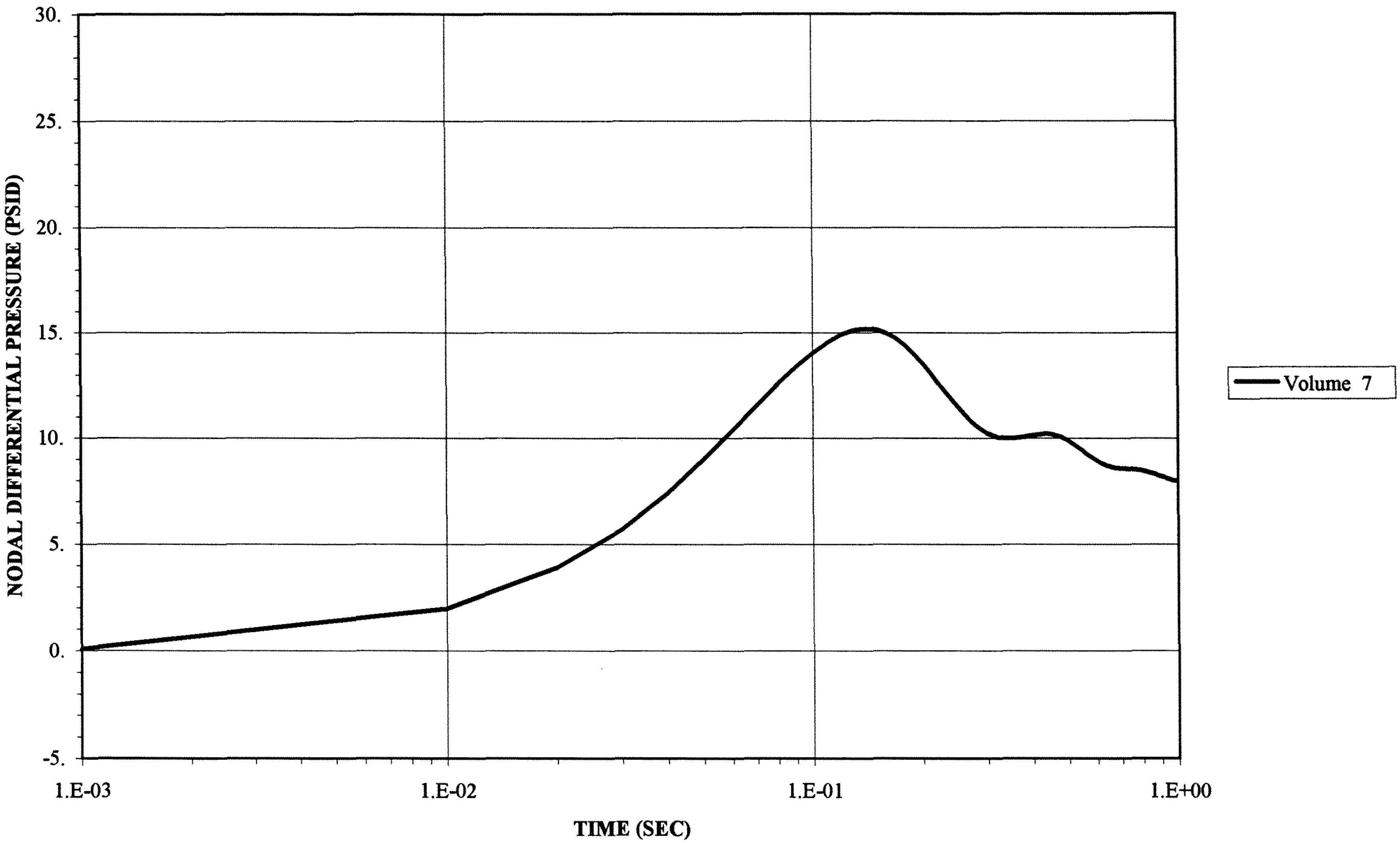


FIGURE B4: MAIN STEAM LINE BREAK IN 1ST QUADRANT OF TUNNEL (NODE 8)

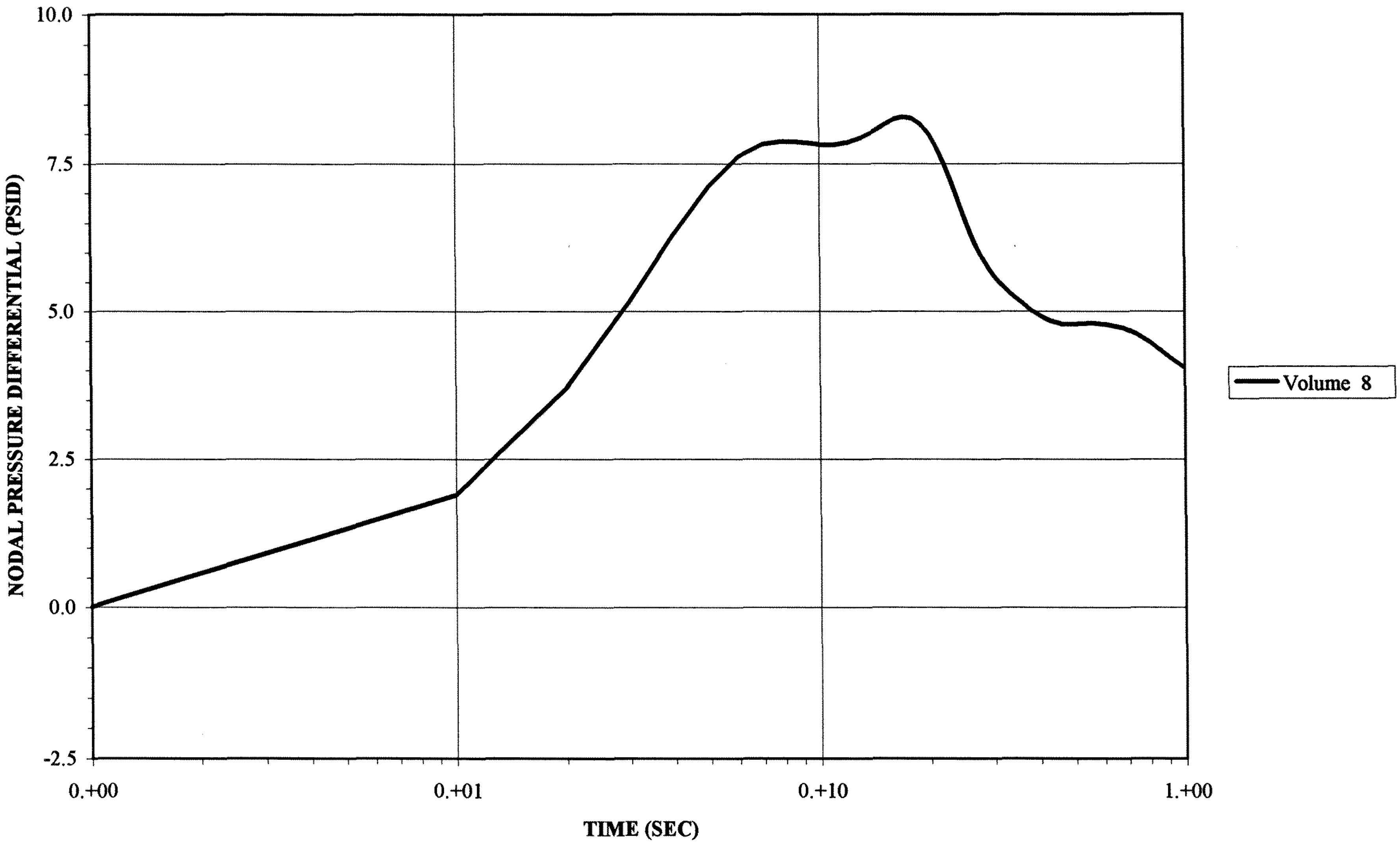


FIGURE B5 : MAINSTEAM LINE BREAK IN 1ST QUADRANT TUNNEL (NODE 13)

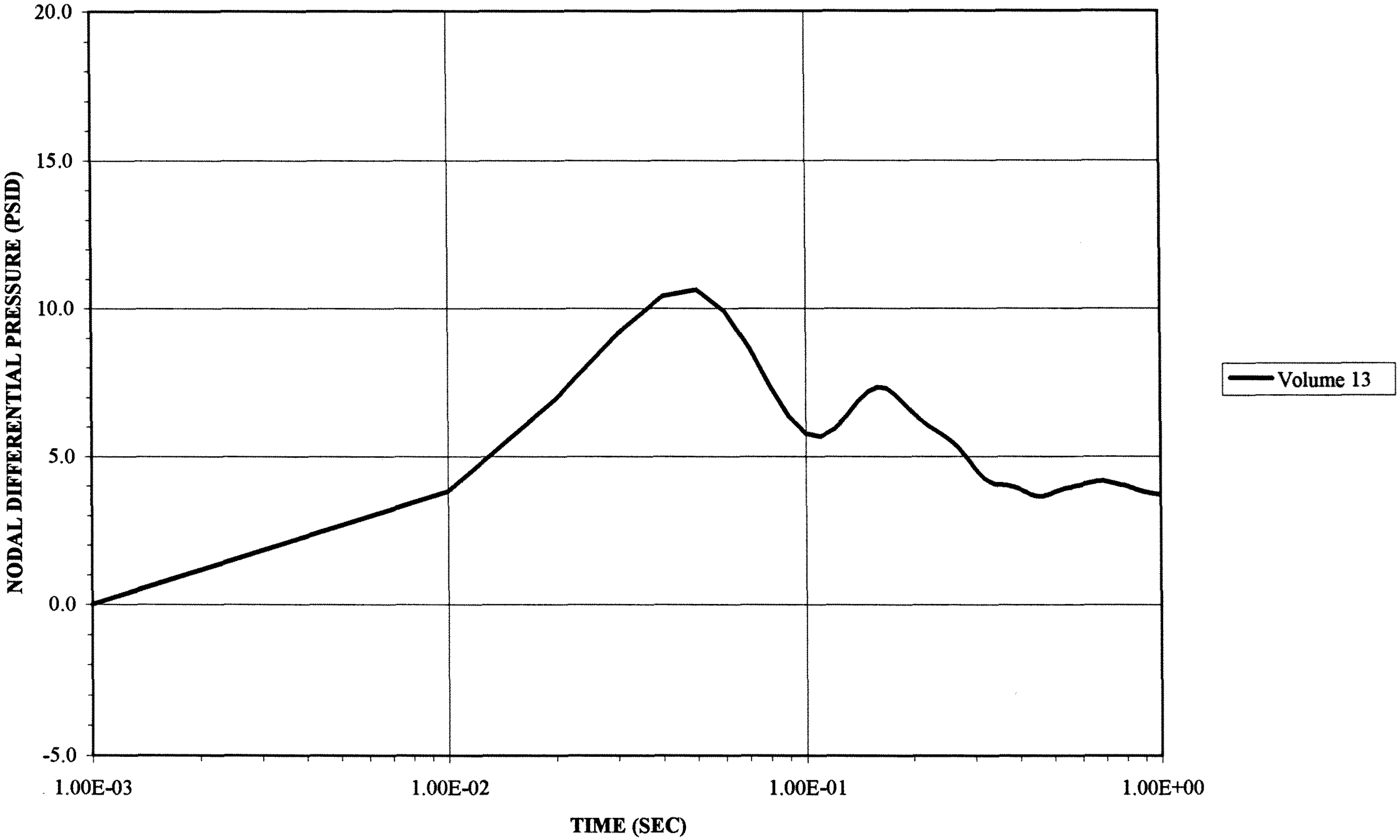


Figure B6 : Main Steam Line Break in 1st Quadrant of Main Steam Tunnel (Node 14)

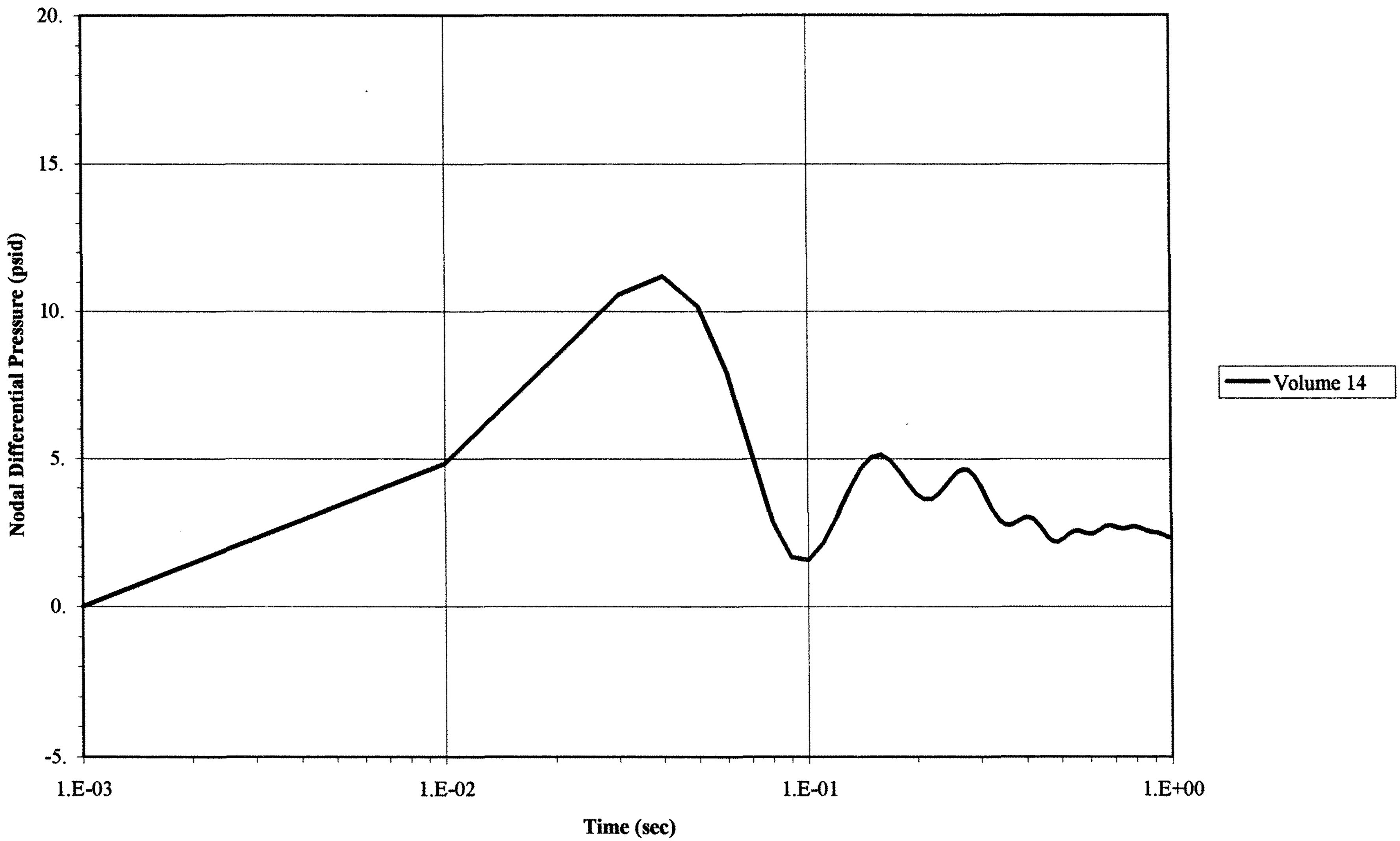


FIGURE B7: MAIN STEAM LINE BREAK IN LOWER 2ND QUADRANT VALVE ROOM (NODE 5)

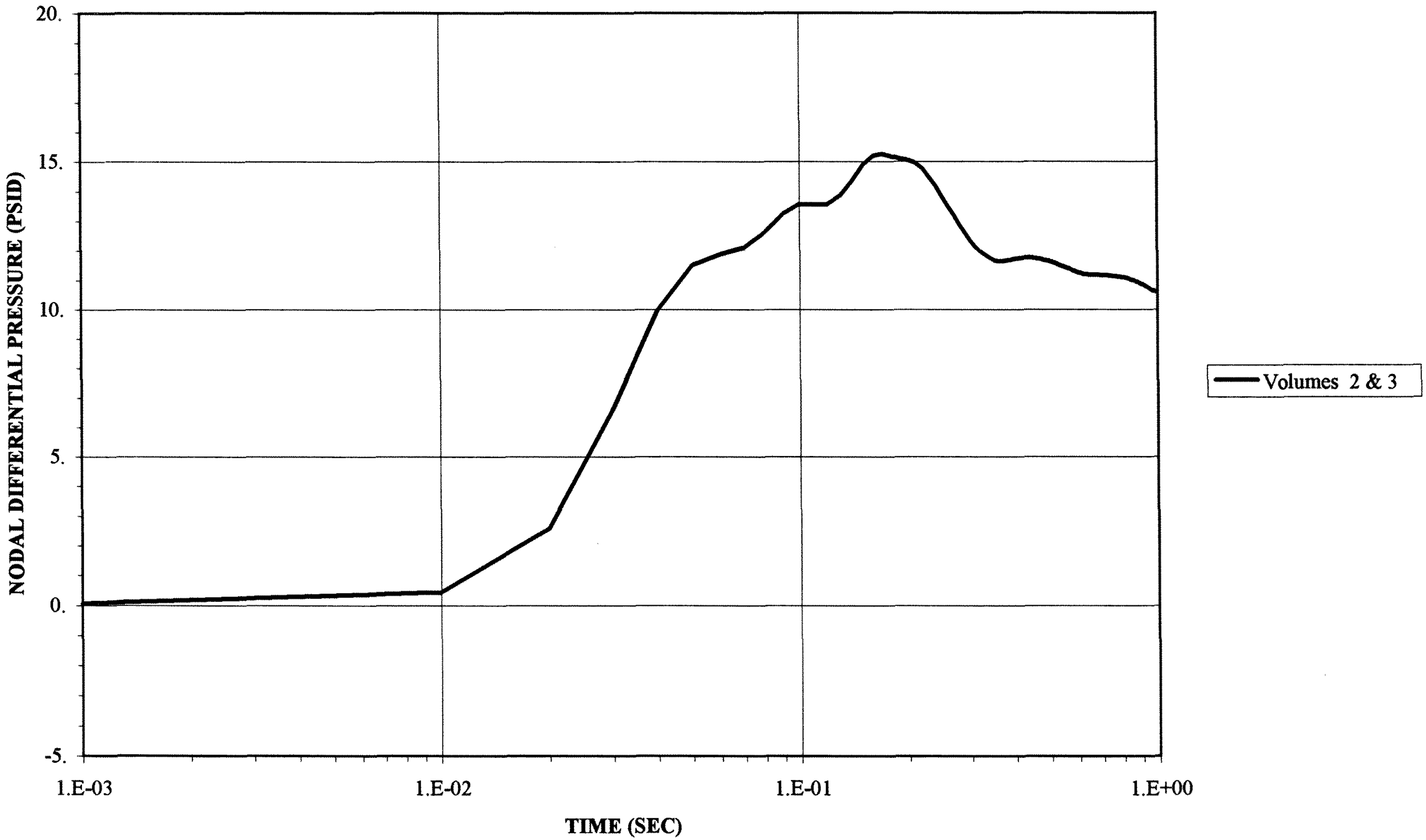


FIGURE B8: PEAK DIFFERENTIAL PRESSURES BETWEEN VALVE ROOMS AND MAINSTEAM TUNNEL (BETWEEN NODES 2 & 3, 9 &10)

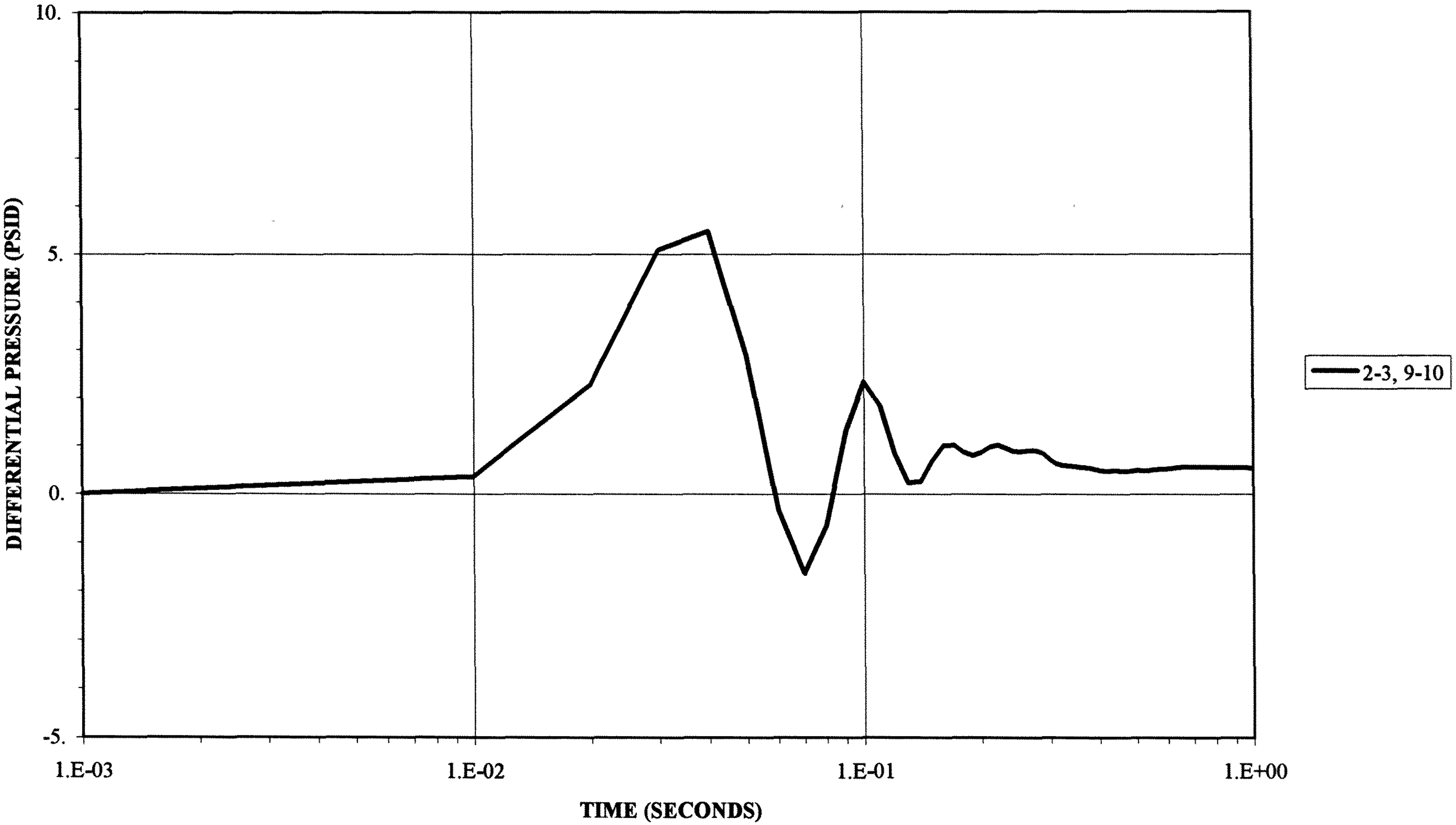


FIGURE B9: PEAK DIFFERENTIAL PRESSURES BETWEEN VALVE ROOMS AND MAIN STEAM TUNNEL (BETWEEN NODES 3 & 4, 10 & 11, 2 & 5, 9 & 12)

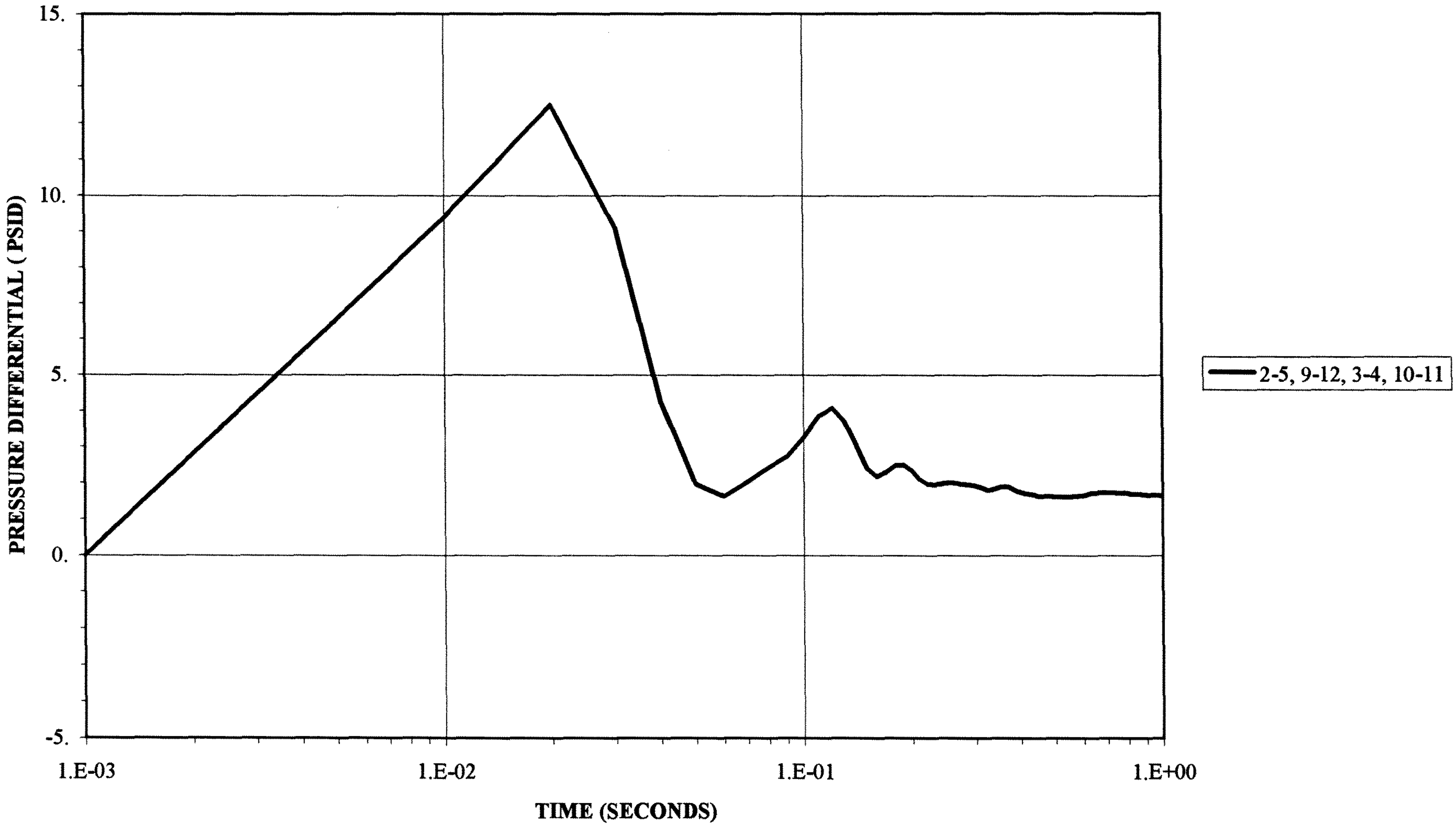


FIGURE B10: PEAKDIFFERENTIAL PRESURES BETWEEN VALVE ROOMS AND MAIN STEAM TUNNEL (BETWEE NODES 4 & 5, 11 & 12)

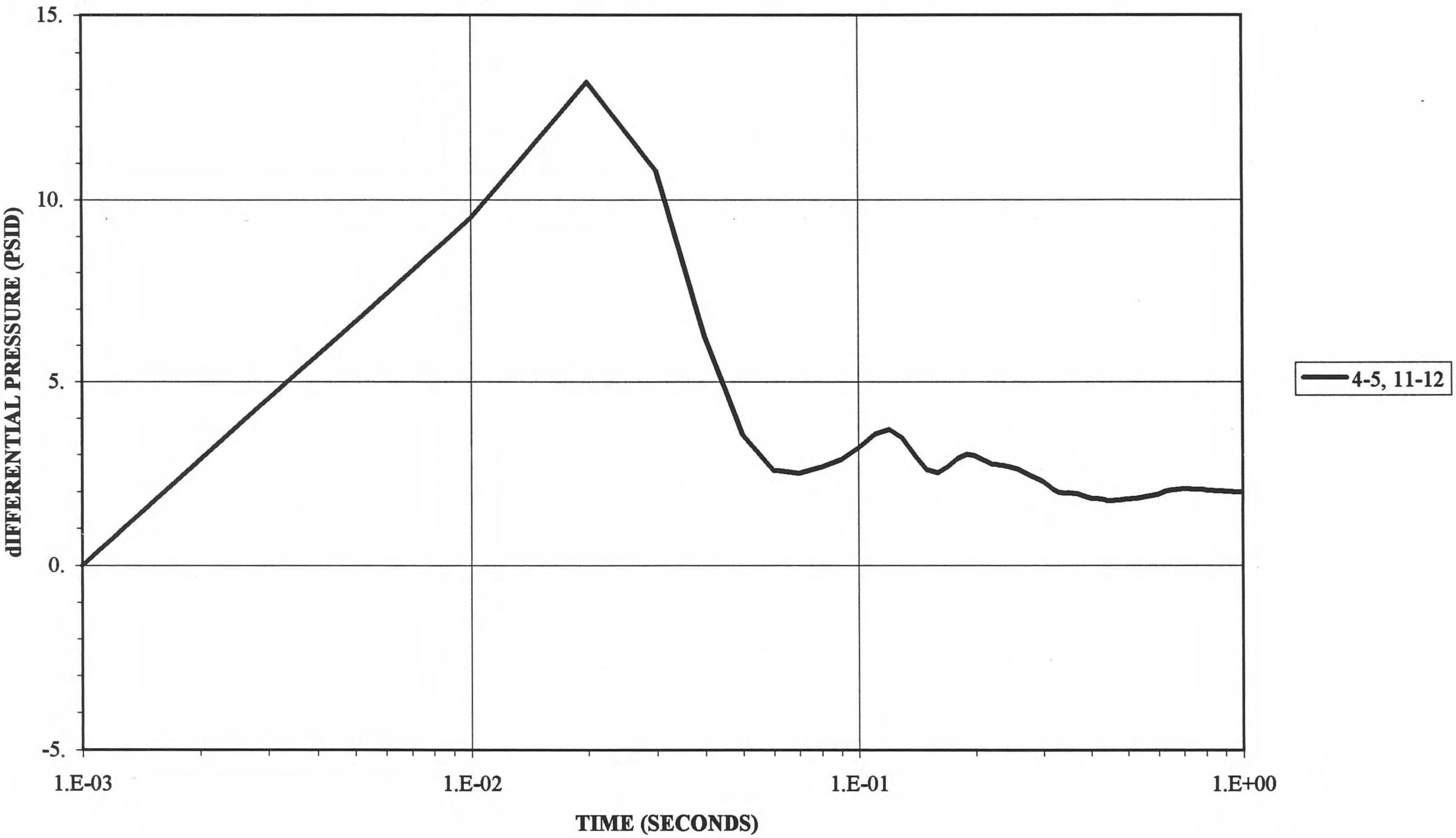
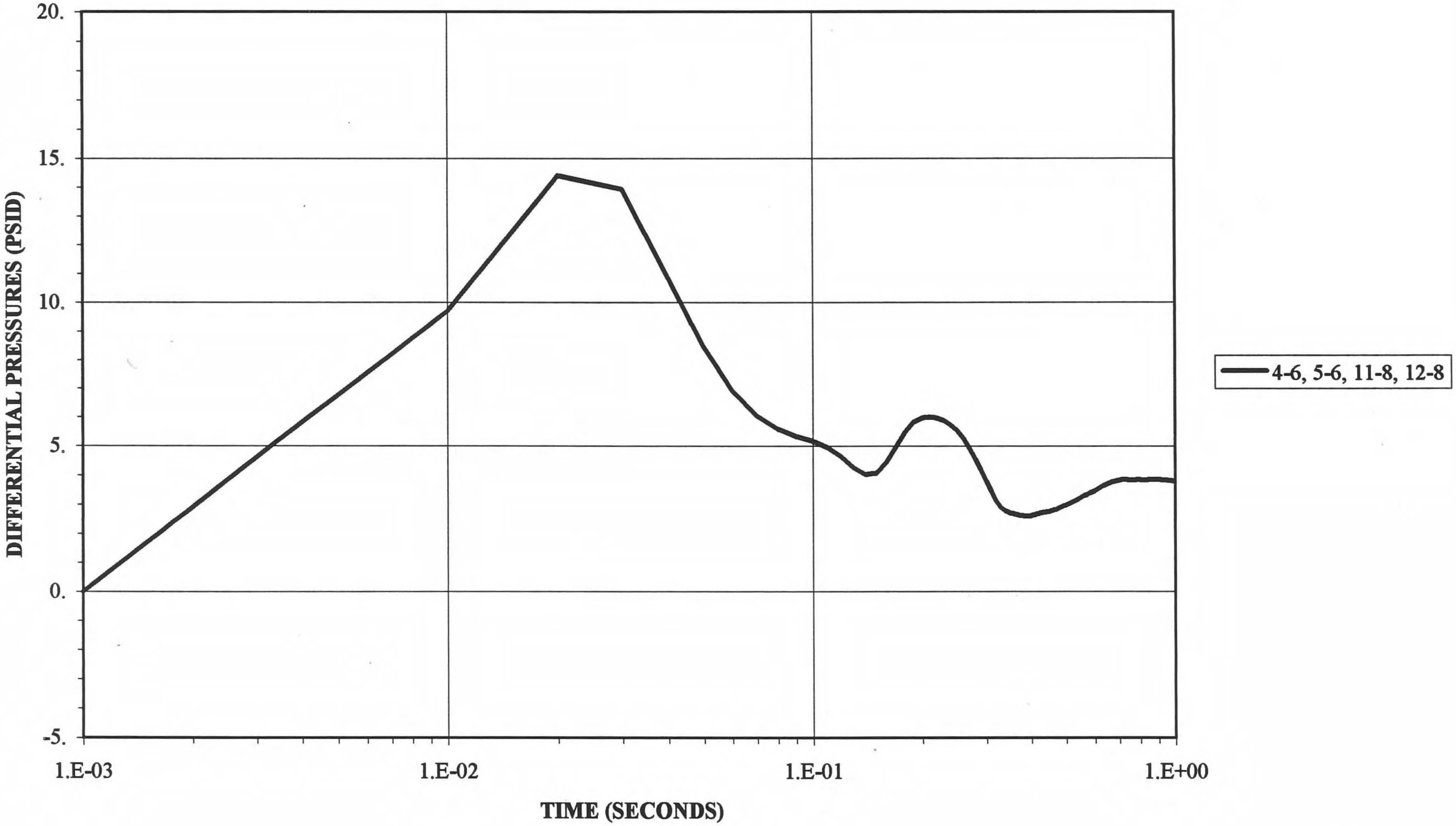


FIGURE B11: PEAK DIFFERENTIAL PRESSURES BETWEEN VALVE ROOMS AND MAIN STEAM TUNNEL (BETWEEN NODES 4 & 6, 5 & 6, 11 & 8, 12 & 8)



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Station Byron/Braidwood Unit 1 Cycle 9/8 Generic

To: Bob Peterson (S&L)

Subject Steam Generator Replacement Project: Transmittal of SLB M&E for Steam Tunnel Pressure Analysis

Amy Jo Patterson Preparer	Amy Jo Patterson Preparer's Signature	9/16/96 Date
Candice Y. Chou Reviewer	Candice Y. Chou Reviewer's Signature	9/16/96 Date
Kenneth N. Kovar NFS Supervisor	Kenneth N. Kovar NFS Supervisor's Signature	9/16/96 Date

Status of Information: ☒ Verified
☐ Unverified
☐ Engineering Judgement

Method and Schedule of Verification for Unverified NDITs:

Description of Information: Mass & Energy Release Rates following a postulated MSLB in the Main Steam Tunnel are provided.

Purpose of Information: For use by S&L in the Main Steam Tunnel Pressure analysis to determining functional integrity of the steam tunnel following a postulated MSLB.

Source of Information FTI Document 32-1258100-00, "SLB Subcompartment M&E."

Supplemental Distribution:
NFS NDIT File
DG Central File
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14	32-1258100-00	SLB M&E for Subcompartment	S	N	Y

Calc. No. 3C8-0282-001
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DOCUMENT IDENTIFIER 32-1258100-00

TITLE SLB Subcompartment M&E

PREPARED BY:				REVIEWED BY:			
NAME	M.D. Ripley			NAME	M.V. Parece		
SIGNATURE	[signature]			SIGNATURE	M V Parece		
TITLE	Engineer III	DATE	8/15/96	TITLE	Supervisory Engr I	DATE	8/16/96
COST CENTER	41010	REF. PAGE(S)	3	TM STATEMENT: REVIEWER INDEPENDENCE	[signature]		

PURPOSE AND SUMMARY OF RESULTS:

Commonwealth Edison is replacing the original steam generators (OSGs) at the Byron-1 and Braidwood-1 nuclear power plants with BWI replacement steam generators (RSGs). Part of this effort involves subcompartment analysis following high energy line breaks.

The purpose of this document is to determine and transmit the steam line break mass and energy release rates to be used by Sargent and Lundy for subcompartment analysis.

Calc. No. 3C8-0282-001
Revision : 3
Page No. B34 of
Project Nos. 4391-00

THE FOLLOWING COMPUTER CODES HAVE BEEN USED IN THIS DOCUMENT:

CODE/VERSION/REV	CODE/VERSION/REV
	RELAP5/MOD2/20/0HP

THIS DOCUMENT CONTAINS ASSUMPTIONS THAT MUST BE VERIFIED PRIOR TO USE ON SAFETY-RELATED WORK

○ YES ☑ NO

Purpose

The purpose of this document is to produce mass and energy release rates for the first 2-seconds following a steam line break for design input for Sargent and Lundy subcompartment analyses.

Method

The steam line break was performed in Reference 1 for the evaluation of mass and energy release rates to the containment building. The 102% power, MSIV failure case, double ended rupture case of Reference 1 was reproduced with increased minor edit frequency.

Evaluation

Case "SLBC1_1" from reference 1 was reproduced with a more frequent minor edit request and the end time set to 2.0 seconds:

```
203  152.0  1.0E-6  0.01  03   2   50  10000
*
*  Minor Edits
301  MFLOWJ   856000000   * break A flow
302  MFLOWJ   858000000   * break B flow
303  UFLOWJ   856000000   * break A total enthalpy rate
304  UFLOWJ   858000000   * break B total enthalpy rate
```

With these changes, the case was renamed "SLBME" and executed using RELAP5/MOD2 Version 20.0HP. This case is a restart case, with the restart file documented in Reference 1 as case "SLBIC2" (HASH = FOQX).

Due to the initial high SG level of the base deck, the liquid quality out the break was plotted with time to assure that the swell from the SG does not cause liquid entrainment and a corresponding non-conservative reduction in mixture enthalpy from the break. From plots of the volume enthalpy of the steam dome and steam piping enthalpy shows the quality not decreasing significantly out the break until approximately 1.4 seconds. To provide a conservatively high energy rate, only values until 1.4 seconds should be used for subcompartment analysis, with the values at 1.4 seconds used for all later times if necessary.

Conclusion

The mass and energy release rates from a double-ended steam break at 102% power were generated for design input for subcompartment analysis. Only values prior to 1.4 seconds should be applied due to a possible non-conservatism due to the high initial water level of the steam generators. The mass and energy release rates are provided in the following table. The single loop rates represent the mass and energy flows from the broken steam generator. The triple loop rates represent the mass and energy flows from the intact steam generator into the containment (prior to steam line isolation). These rates should be combined for any subcompartment analyses.

Reference

1. FTI Document 32-1239267-00, "Byron/Braidwood SLB for Containment".

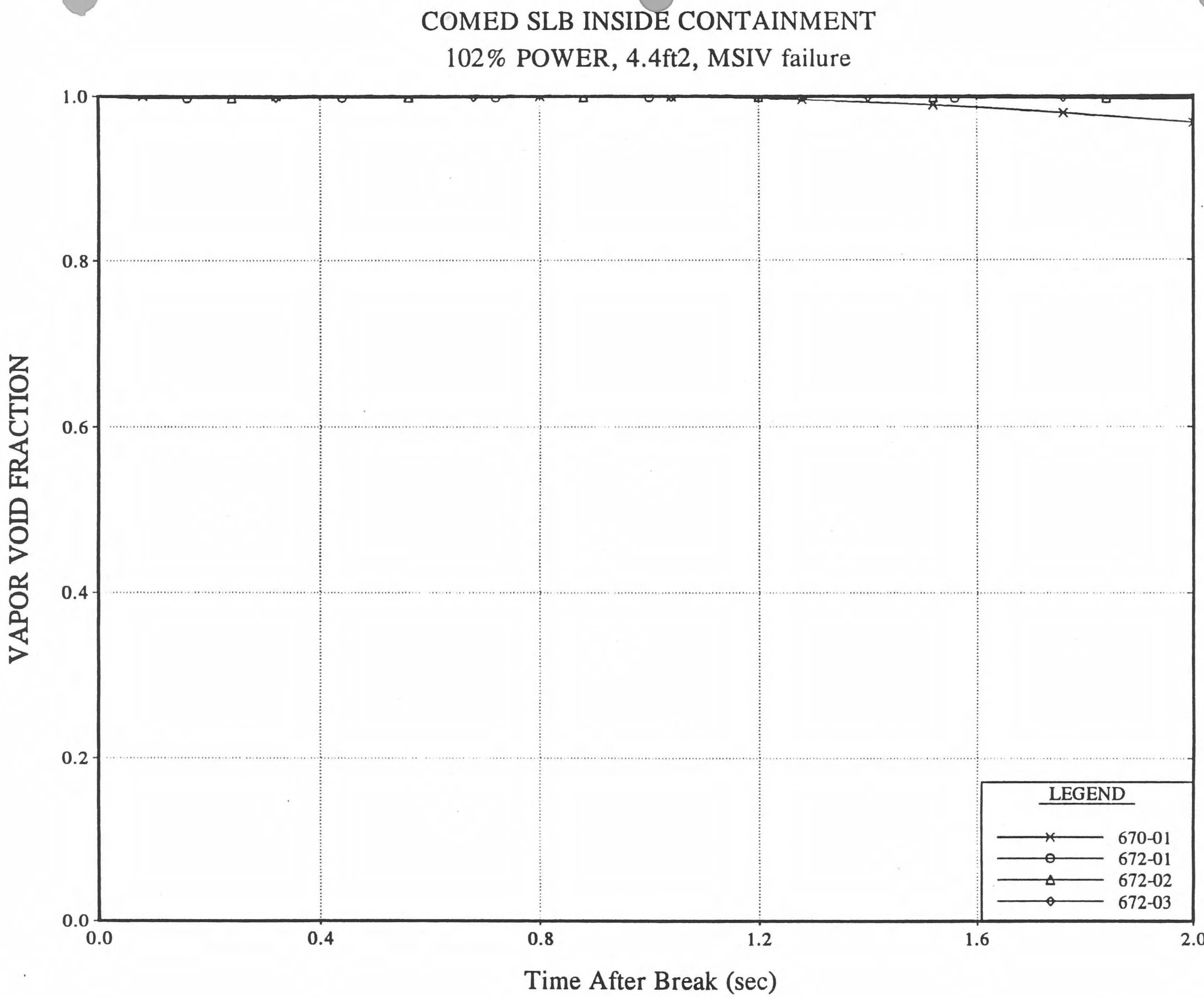
Microfiche Listing

Title	HASH	Description
SLBME	VNDG	Double-Ended SLB for Subcompartment M&E

Mass and Energy Release Rates
Double-Ended SLAB at 100% Power

TIME (SEC)	Single Loop Mass Flow (LB/SEC)	Triple Loop Mass Flow (LB/SEC)	Single Loop Energy Flow (BTU/SEC)	Triple Loop Energy Flow (BTU/SEC)
0.000	0.0	0.0	0.00000E+00	0.00000E+00
0.020	7117.5	7071.4	7.17672E+06	7.36495E+06
0.040	6877.9	7005.5	7.58499E+06	7.91457E+06
0.060	6564.0	6337.2	7.48887E+06	6.95145E+06
0.080	6489.9	5989.2	7.42525E+06	6.60814E+06
0.100	6489.3	5852.8	7.44343E+06	6.54072E+06
0.120	6471.2	5778.7	7.38963E+06	6.50233E+06
0.140	6339.2	5753.5	7.14948E+06	6.49439E+06
0.160	6076.6	5750.7	6.75264E+06	6.48682E+06
0.180	5733.5	5700.4	6.29299E+06	6.41231E+06
0.200	5374.0	5648.1	5.85325E+06	6.35126E+06
0.220	5044.0	5598.3	5.47312E+06	6.29397E+06
0.240	4763.7	5551.1	5.16257E+06	6.24023E+06
0.260	4533.4	5507.8	4.91230E+06	6.19199E+06
0.280	4342.5	5467.5	4.70633E+06	6.14679E+06
0.300	4179.5	5428.7	4.52844E+06	6.10252E+06
0.320	4032.9	5391.4	4.36714E+06	6.06002E+06
0.340	3898.0	5356.5	4.21751E+06	6.02111E+06
0.360	3771.8	5325.4	4.07775E+06	5.98765E+06
0.380	3653.7	5300.2	3.94793E+06	5.96267E+06
0.400	3543.9	5283.5	3.82855E+06	5.94953E+06
0.420	3442.7	5285.4	3.72017E+06	5.96867E+06
0.440	3350.3	5282.6	3.62242E+06	5.95269E+06
0.460	3266.4	5291.1	3.53443E+06	5.98732E+06
0.480	3190.3	5332.1	3.45585E+06	6.05856E+06
0.500	3121.6	5390.6	3.38559E+06	6.14376E+06
0.520	3059.4	5463.8	3.32258E+06	6.24649E+06
0.540	3003.1	5550.1	3.26594E+06	6.36420E+06
0.560	2951.9	5645.9	3.21461E+06	6.49069E+06
0.580	2905.3	5746.6	3.16808E+06	6.61963E+06
0.600	2862.9	5846.5	3.12613E+06	6.74439E+06
0.620	2824.4	5940.4	3.08823E+06	6.85815E+06
0.640	2789.4	6023.8	3.05404E+06	6.95607E+06
0.660	2757.8	6093.8	3.02322E+06	7.03688E+06
0.680	2729.2	6149.5	2.99549E+06	7.09912E+06
0.700	2703.4	6190.5	2.97062E+06	7.14331E+06
0.720	2680.2	6217.5	2.94828E+06	7.17090E+06
0.740	2659.2	6232.6	2.92817E+06	7.18522E+06
0.760	2640.3	6237.4	2.91004E+06	7.18799E+06
0.780	2623.5	6251.8	2.89392E+06	7.21018E+06
0.800	2608.4	6237.9	2.87940E+06	7.18321E+06
0.820	2594.6	6221.6	2.86626E+06	7.16576E+06
0.840	2582.2	6206.2	2.85434E+06	7.14929E+06
0.860	2570.9	6189.6	2.84354E+06	7.13016E+06
0.880	2560.7	6171.8	2.83373E+06	7.10962E+06
0.900	2551.4	6153.8	2.82482E+06	7.08915E+06
0.920	2543.0	6136.2	2.81671E+06	7.06942E+06
0.940	2535.3	6119.4	2.80933E+06	7.05071E+06

0.960	2528.3	6103.6	2.80262E+06	7.03303E+06
0.980	2522.0	6088.7	2.79653E+06	7.01639E+06
1.000	2516.3	6074.7	2.79103E+06	7.00084E+06
1.020	2511.1	6061.8	2.78611E+06	6.98646E+06
1.040	2506.6	6050.0	2.78178E+06	6.97331E+06
1.060	2502.7	6039.2	2.77808E+06	6.96137E+06
1.080	2499.5	6029.4	2.77499E+06	6.95057E+06
1.100	2496.9	6020.6	2.77254E+06	6.94076E+06
1.120	2495.0	6012.5	2.77073E+06	6.93179E+06
1.140	2493.9	6005.1	2.76957E+06	6.92348E+06
1.160	2493.6	5998.3	2.76906E+06	6.91568E+06
1.180	2494.0	5991.8	2.76920E+06	6.90821E+06
1.200	2495.3	5985.5	2.76996E+06	6.90091E+06
1.220	2497.3	5979.4	2.77132E+06	6.89363E+06
1.240	2500.1	5973.2	2.77325E+06	6.88617E+06
1.260	2503.8	5966.9	2.77575E+06	6.87836E+06
1.280	2508.2	5960.1	2.77882E+06	6.87000E+06
1.300	2513.4	5952.9	2.78244E+06	6.86091E+06
1.320	2519.4	5945.1	2.78660E+06	6.85098E+06
1.340	2526.7	5936.6	2.79158E+06	6.84014E+06
1.360	2534.9	5927.4	2.79730E+06	6.82844E+06
1.380	2544.0	5917.6	2.80368E+06	6.81598E+06
1.400	2554.0	5907.3	2.81090E+06	6.80293E+06

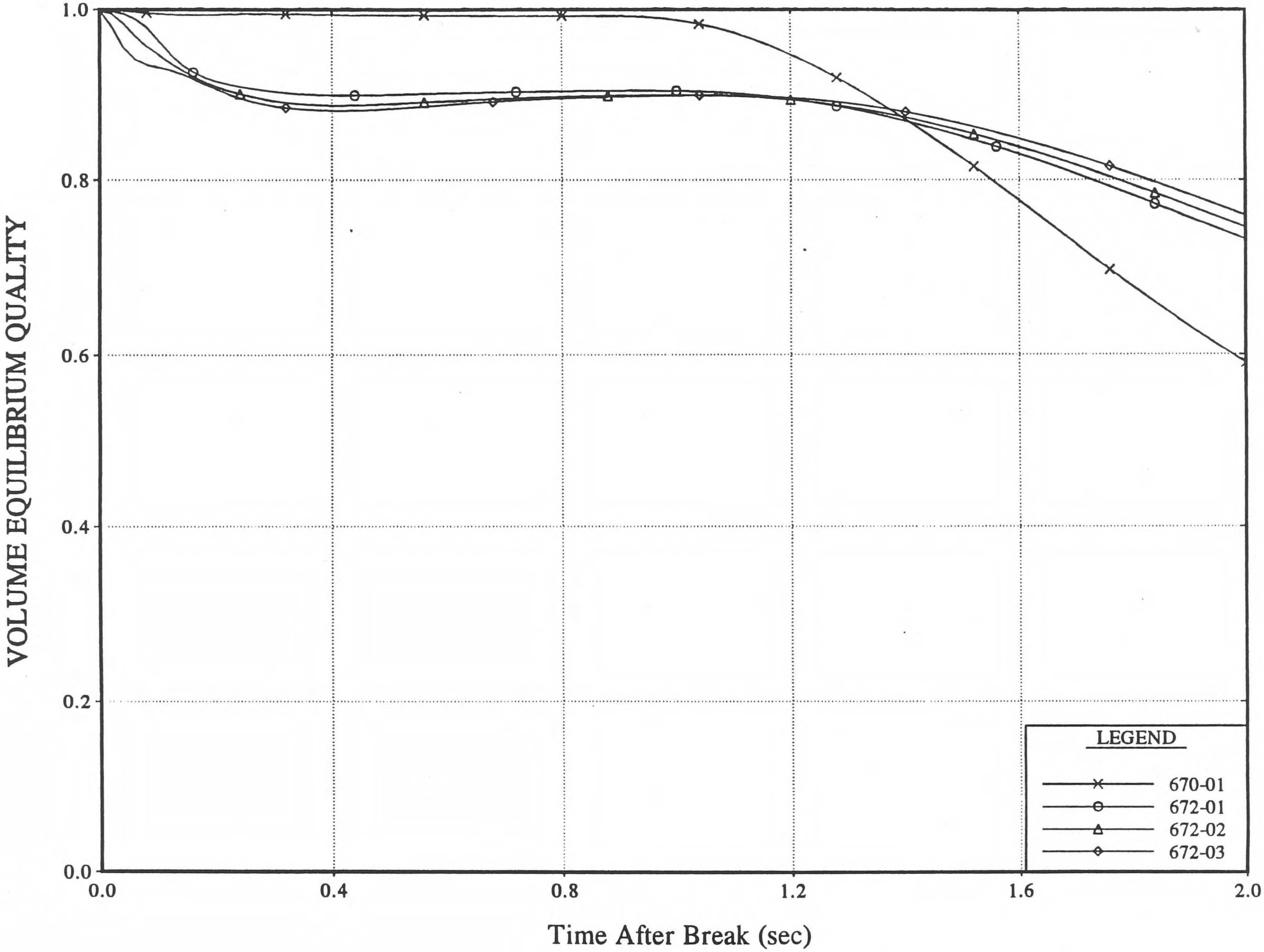


Calc. No. 3C8-0282-001
Revision : 3
Page No. B 39 of
Project Nos. 4391-00

32-1258100-00

9

COMED SLB INSIDE CONTAINMENT
102% POWER, 4.4ft2, MSIV failure



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COMPUTER DISK DIRECTORY

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part1    out     1535287 09-06-96   9:03a
part2    inp        7567 09-06-96  10:32a
part2    out     1535311 09-06-96  11:22a
part3    inp        7565 09-06-96   1:11p
part3    out     1535309 09-06-96   3:01p
part4    inp        7560 09-06-96   3:15p
part4    out     1535695 09-09-96  11:14a
part5    inp        7568 09-05-96  10:54a
part5    out     1535773 09-05-96  11:35a
part6    inp        7568 09-05-96   2:13p
part6    out     1535773 09-05-96   3:00p
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Standard configuration
Mon 10-21-1996 13:22
C:\BB\MSTU1>
```

MICROFICHE OF COMPUTER OUTPUT