APPENDIX I

PRESSURIZER SAFETY VALVES

DYNAMIC ANALYSIS

GINNA STATION UNIT 1

APPENDIX I

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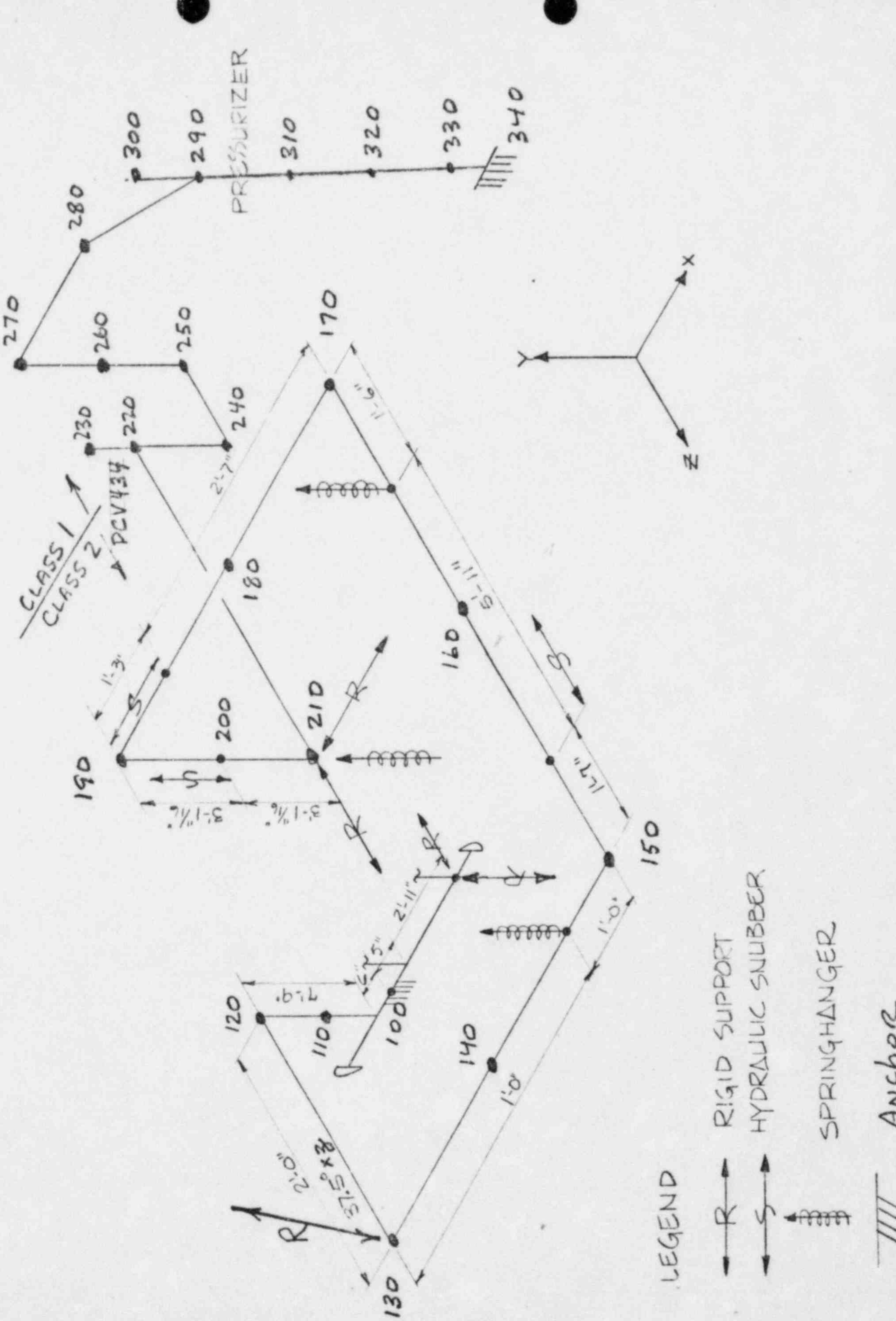
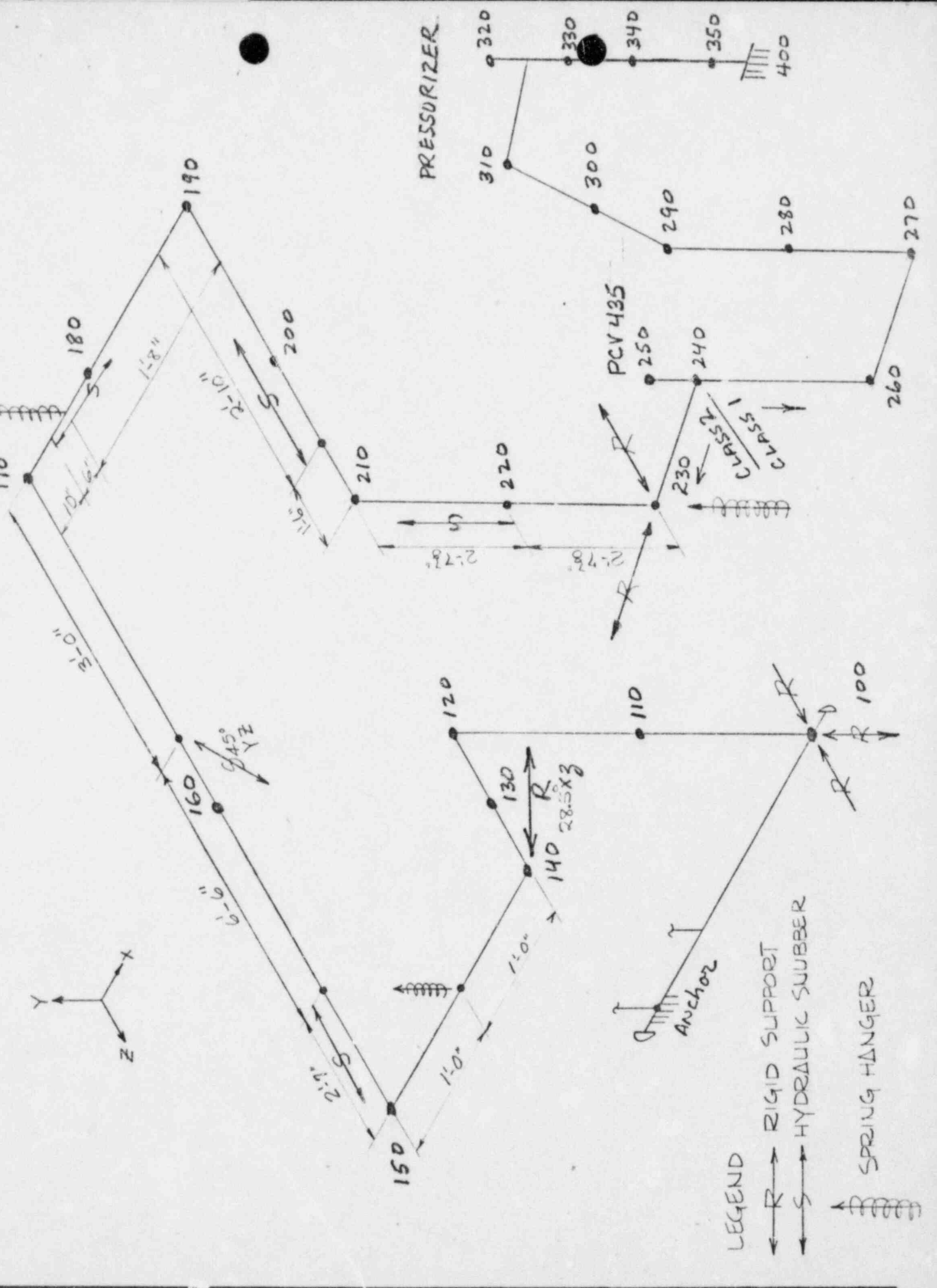
FIG. 1
PCV 434



ROCHESTER GAS & ELECTRIC CORP. ROCHESTER, NEW YORK	GINNA STATION PCV-434 SUPPORTS	DRAWN APP'D SCALE	APP'D NO.

FIGURE 2
PCV 435



ROCHESTER GAS & ELECTRIC CORP. ROCHESTER, NEW YORK	GINNA STATION PCV 435 PRESSURIZER SAFETY VALVE SUPPORTS	DRAWN AV APP'D SCALE	APP'D NO.

RG&E Pressurizer Safety Valve System
Calculation of Transient Hydraulic Loads

1.0 The Pressurizer Safety Valve piping system is a closed system so that no sustained reaction force from a free discharging jet of fluid can exist. However, transient hydraulic loads can be imposed at various points in the piping system from the time a safety valve begins to pop open until steady flow is completely developed. The calculations described here were performed to provide a time-history of such loads acting on each straight leg of pipe from the safety valve downstream to the relief tank header. These calculations were based on the following conservative consumptions:

1. Valve opens full in 40 milliseconds: test data show opening to be approximately 70% in 40 miliiseconds.

2. Loop seal water is pushed ahead of steam: actually some break-up of the water slug is expected to occur as water is forced past the valve seat and as the water passes successive downstream elbows.

3. Two-phase flow in the downstream piping is homogeneous: thus any flashing of loop seal water will result in steam bubbles trapped in the water slug. Actually some phase separation is likely, reducing the acceleration of the liquid phase.

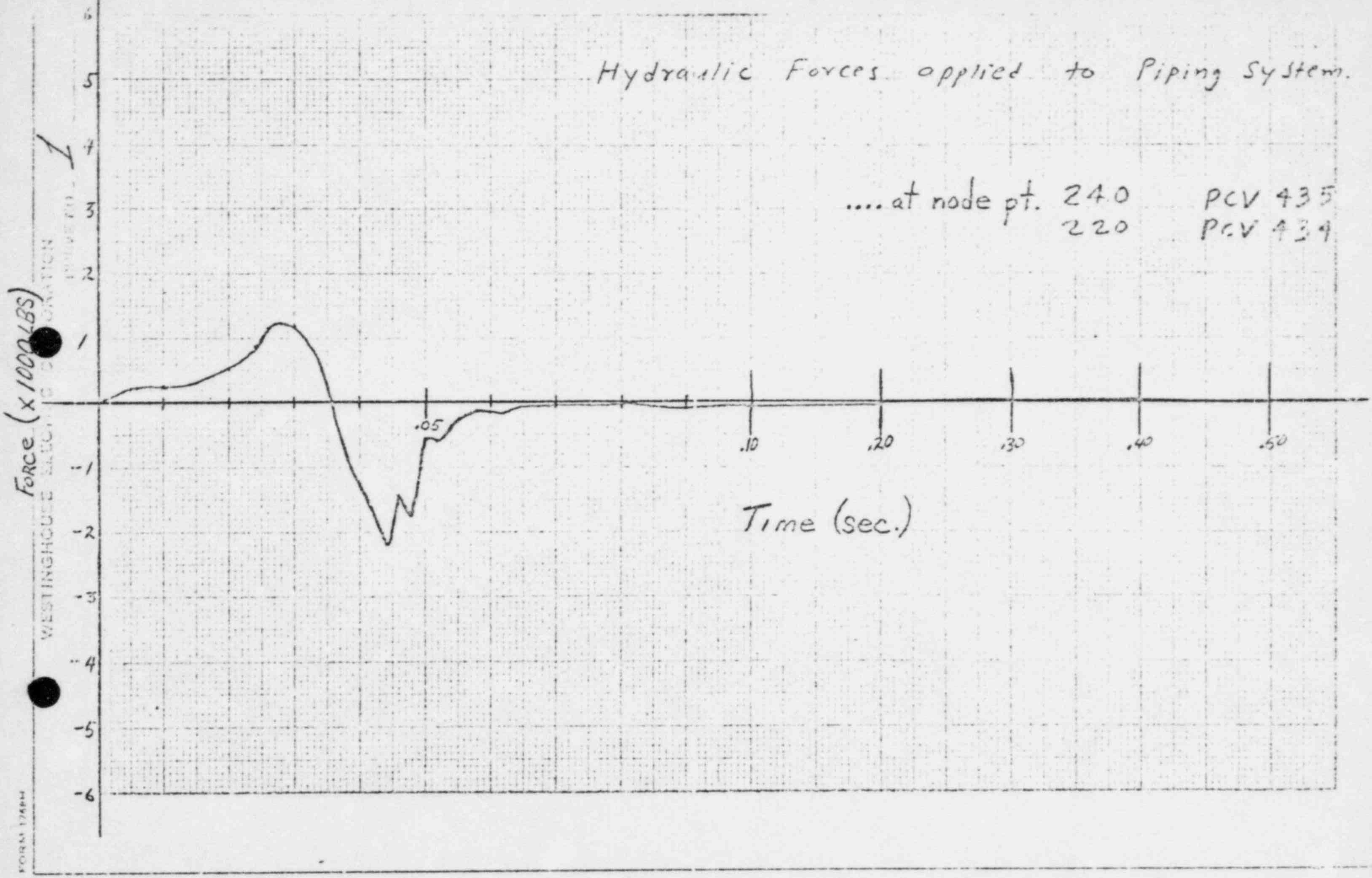
4. No credit is taken for Power Operated Relief Valves: actuation of power operated relief valves would increase the back-pressure in the relief tank piping system thereby reducing the transient hydraulic loads from subsequent safety valve actuation. For this analysis, the lowest back-pressure was assumed (3 psig) corresponding to conditions just prior to actuation of the first safety valve with relief valves closed.

The FLASH IV digital computer program (reference) was employed in performing these calculations. The piping system shown in figure 1 & 2 was represented in FLASH by starting with an infinite source of steam at the pressurizer, and segmenting the piping leading to the header into various nodes. The safety valve was represented as a "leak element" with choked flow into the valve calculated by the Moody correlation. The code was also setup to check the flow choking at the end of the downstream piping. Frictional losses were incorporated for this piping and associated elbows. A special output edit was incorporated in FLASH to provide data for calculations of hydraulic force time-histories.

The results of the calcuations for the RG&E safety valve system are shown in figures 2 through 9. The force is considered positive in direction opposite to the flow direction for these calculations. For each leg of the piping system, a positive force is first applied as the flow is accelerated around the upstream elbow followed by a force reversal after the loop seal water slug arrives at the downstream elbow. As the flow develops, forces first appear at the leg immediately downstream of the safety valve (node point 240) and subsequently appear at successive legs downstream of the valve (node point 220, node point 220, etc.). Note that the flow achieves steady-state conditions after approximately 150 milliseconds. A comparison of peak magnitudes of these forces with the free blowing reaction force for the safety valve (7, 100 lbs.) indicates that the forces in the closed piping system are substantially smaller than those for an open free blowing configuration. These data also show that the force applied directly at the valve is relatively small while forces further downstream in the piping system can be comparatively large. The relative magnitues of these forces and the interrelation of the time-histroy behavior led to the conclusion that a complete dynamic analysis of the structural responses for the piping and support systems would be appropriate.

The time-history hydraulic forces were determined based on several loop seal temperatures. The calculated loop seal temperature for Ginna Station Unit 1 with a 3 inch thick insulated water loop is 330^{o}F. The hydraulic forces assuming a 300^{o}F water temperature were applied to the structrual dynamic model at each change in flow direction throughout the system. This constitues a true impulsive dynamic analysis with simultaneous contributions from all the dynamic modes of the system.

Reference: WAPD-TM-840, "FLASH IV: A Fully Implicit Fortran IV Program for the Digital Simulation of Transients in a Reactor Plant", T.A. Porsching, J.H. Murphy, J.A. Redfield, V.C. Davis.



Hydraulic Forces applied to Piping System.
....at node pt. 240 PCV 435
220 PCV 434
Force (x 1000 LBS)
Time (sec.)
.05
.10
.20
.30
.40
.50
5
4
3
2
1
-1
-2
-3
-4
-5
-6

Figure 3

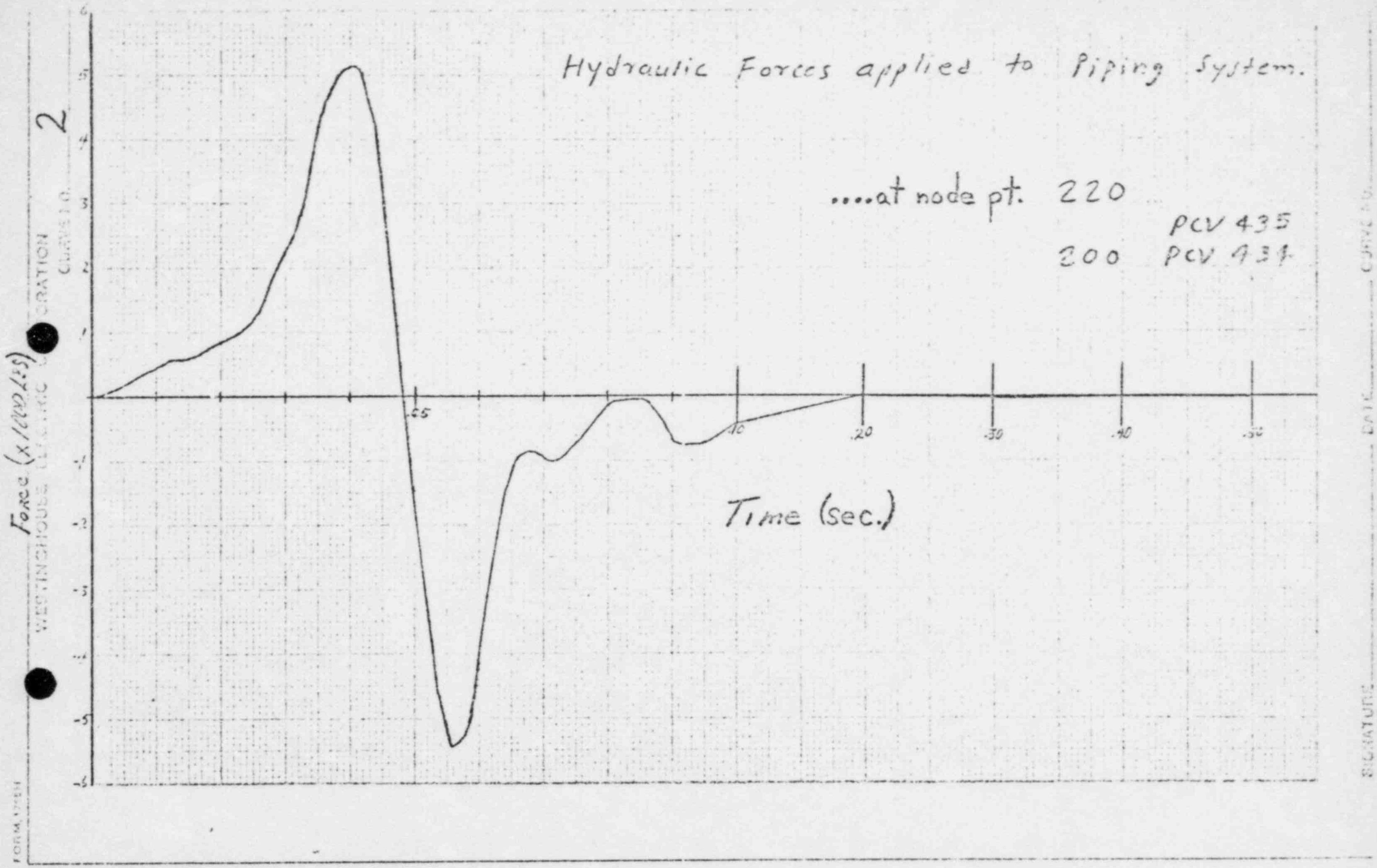
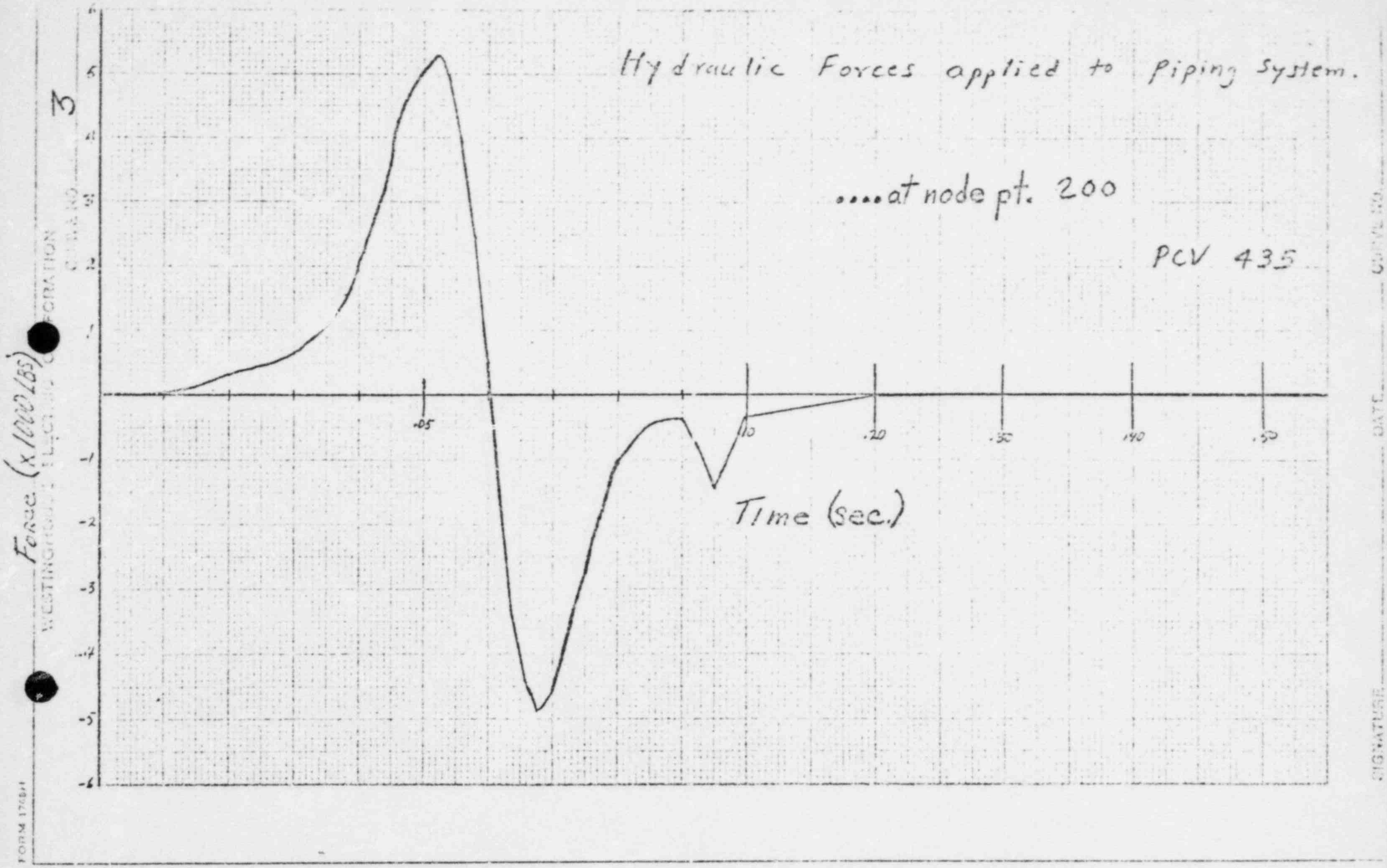

Hydraulic Forces applied to Piping System.
....at node pt. 220
PCV 435
200 PCV 431
Time (sec.)
Force
2
.05
.10
.20
.30
.40
.50
6
5
4
3
2
1
-1
-2
-3
-4
-5
-6
WESTINGHOUSE ELECTRIC CORPORATION
CURVE NO.
DATE
SIGNATURE

Figure 4



Hydraulic Forces applied to Piping System.
....at node pt. 200
PCV 435
Force (x 1000 lbs)
Time (sec.)
.05
.10
.20
.30
.40
.50
6
5
4
3
2
1
-1
-2
-3
-4
-5
-6
3

Figure 5

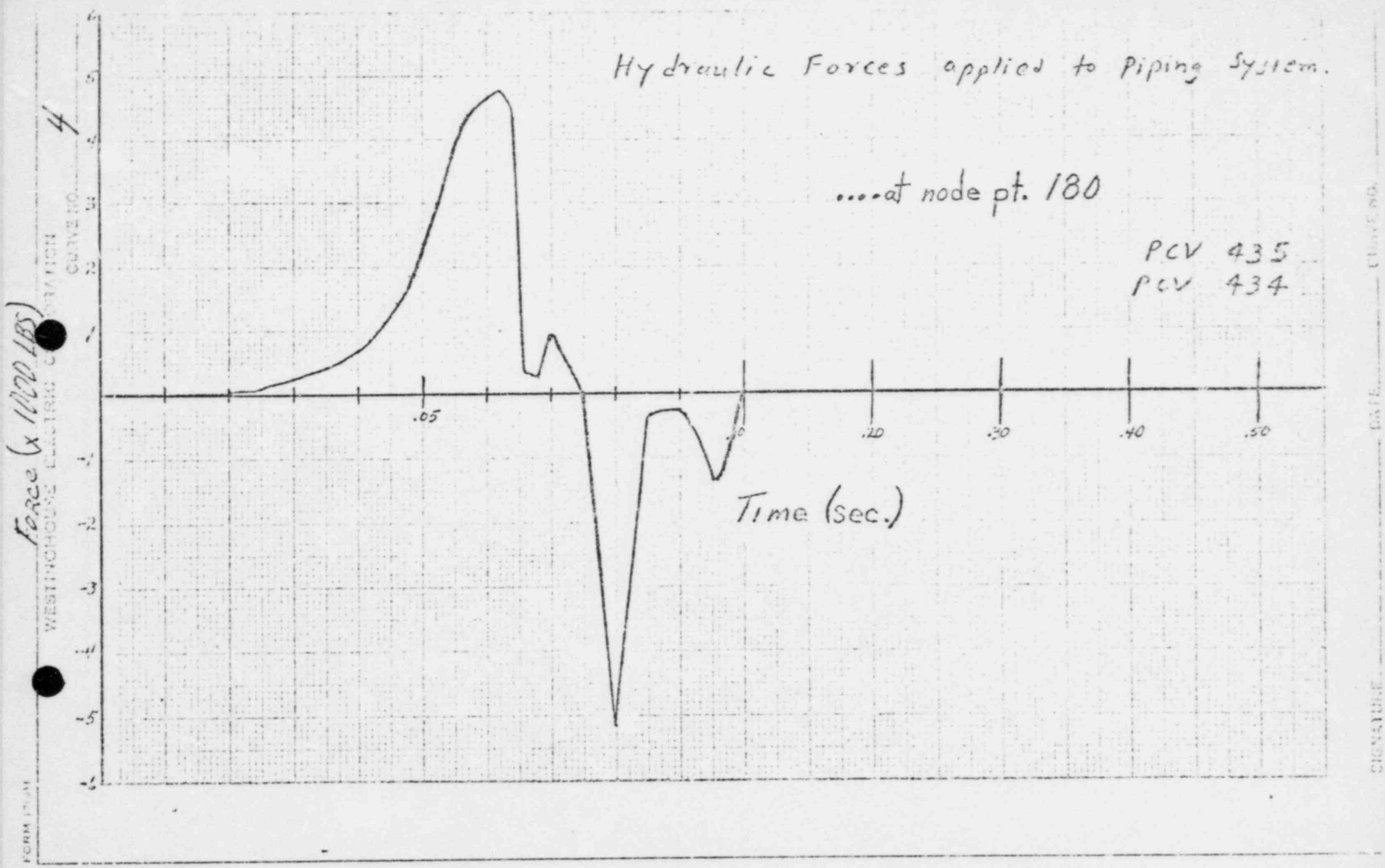
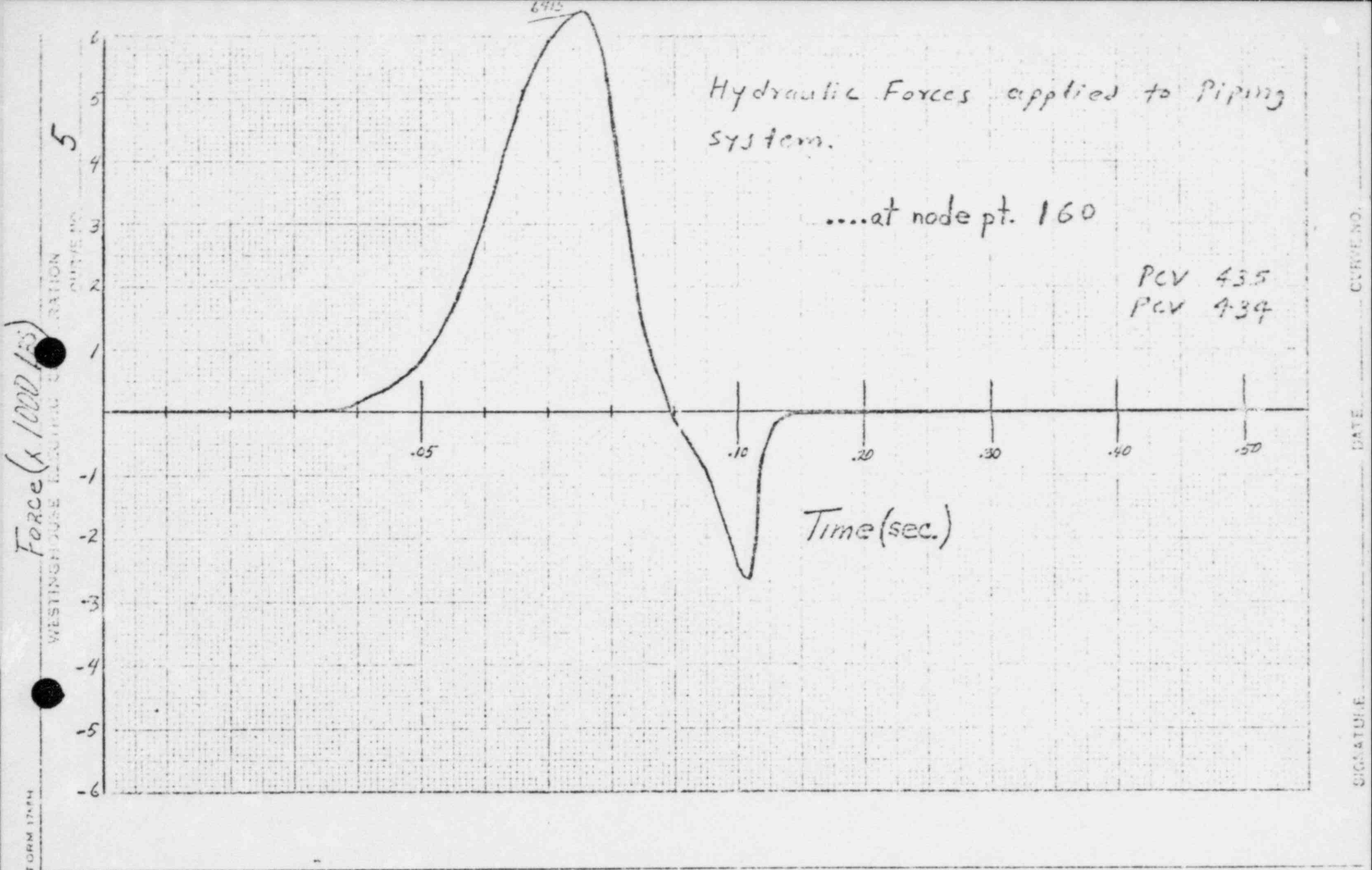

Hydraulic Forces applied to Piping System.
....at node pt. 180
PCV 435
PCV 434
Time (sec.)
Force (x 1000 LBS)
4
.05
.10
.20
.30
.40
.50
WESTINGHOUSE ELECTRIC CORPORATION
CURVE NO.

Figure 6



Hydraulic Forces applied to Piping system.
....at node pt. 160
PCV 435
PCV 437
Time (sec.)
Force (x 1000 lbs)
6415
6
5
4
3
2
1
-1
-2
-3
-4
-5
-6
.05
.10
.20
.30
.40
.50
5
CURVE NO.
DATE
SIGNATURE
WESTINGHOUSE ELECTRIC CORPORATION
FORM 17474

Figure 7

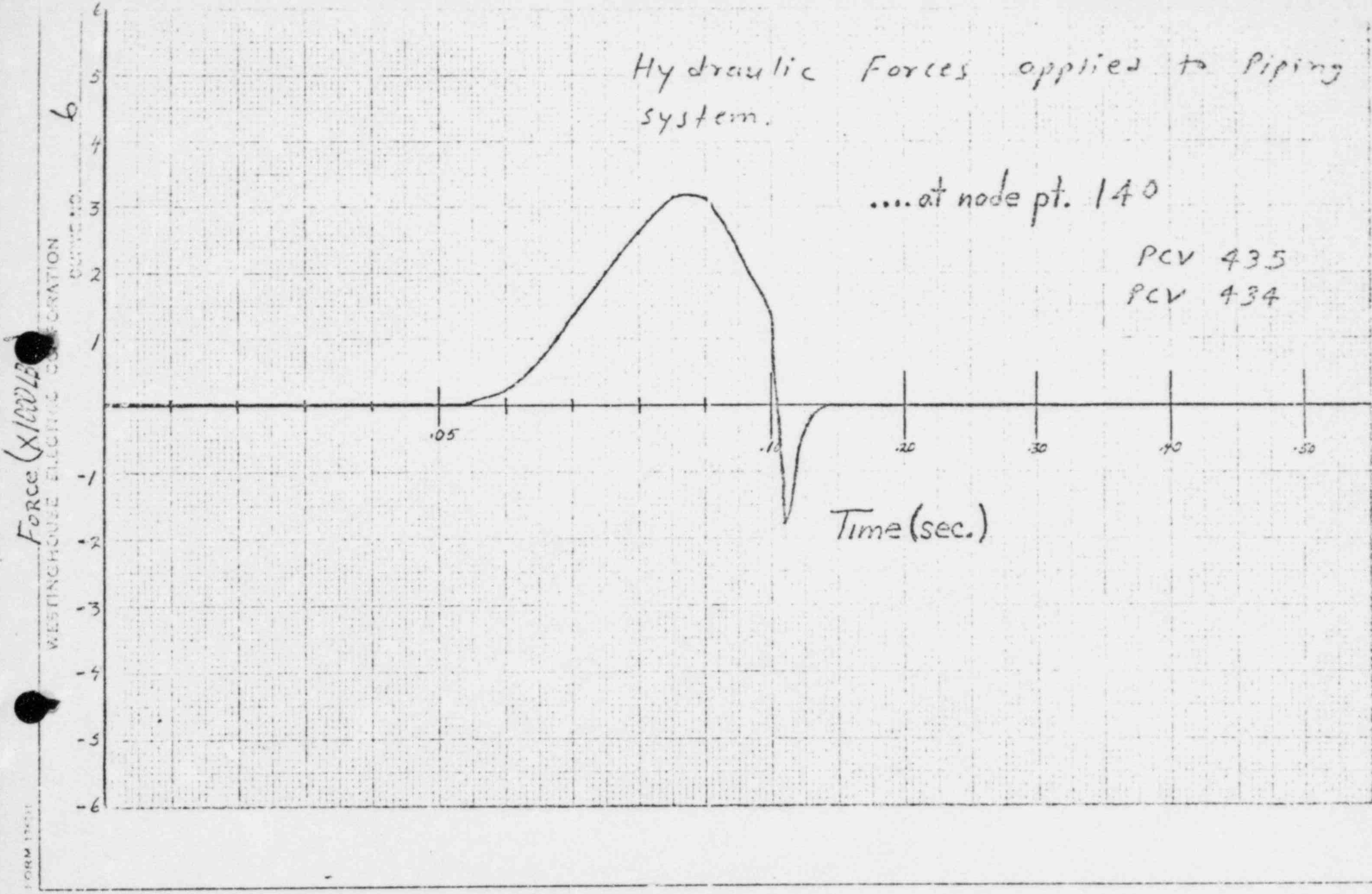
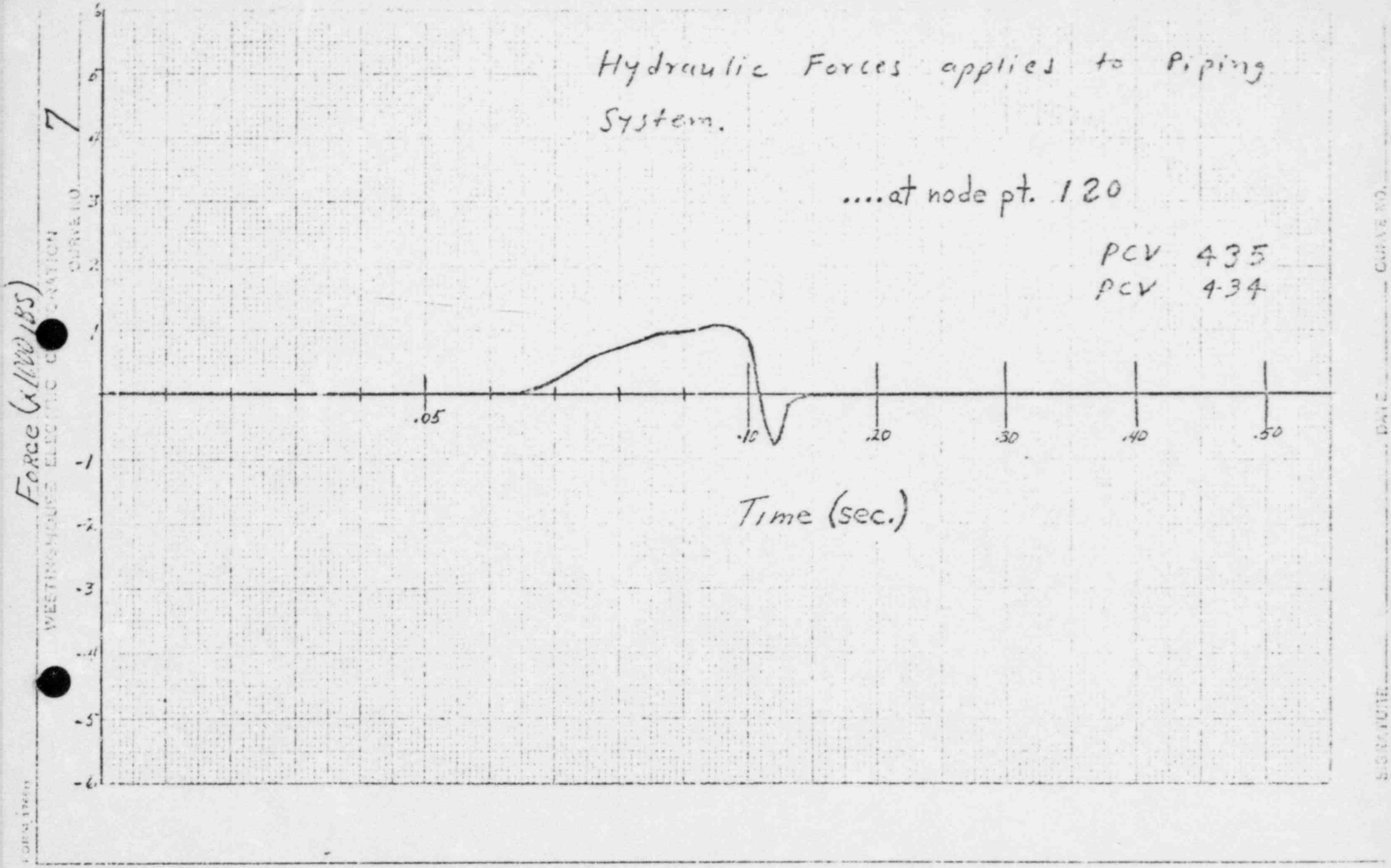

Hydraulic Forces applied to Piping system.
....at node pt. 140
PCV 435
PCV 434
Time (sec.)
Force (X1000 LB)
6
5
4
3
2
1
-1
-2
-3
-4
-5
-6
.05
.10
.20
.30
.40
.50

Figure 8



Hydraulic Forces applies to Piping System.
....at node pt. 120
PCV 435
PCV 434
Force (x1000 lbs)
Time (sec.)
.05
.10
.20
.30
.40
.50
7

Figure 9

2.0 The piping system was modeled as a multi degree of Freedom lumped mass system as shown in figures 1 & 2.

The natural frequencies and mode shapes of the system were solved using program WESTDYN. This normal solution and the time-history forces from blowing safety valve were input to program FIXFM. This program was used to calculate the response of the lumped mass system.

This time-history response of the lumped mass system was input into program WESTDYN-2 which calculated the complete stress, force, and displacement time-history solution of the structure (and supports) for the applied transient loads.

2.1 WESTDYN

WESTDYN is a special purpose program designed for the static and dynamic solution of redundant piping systems with arbitrary loads and boundary conditions. It computes, at any point in the piping system, the stresses, forces, moments, translations, and rotations which result from the imposed anchor or junction loads in any combination of the three orthogonal axes. The section properties have been specialized to piping cross sections plus the addition of curved members or elbows. Valves may also re represented as stiffer members. The piping system may contain a number of sections, a section being defined as a sequence of straight and/or curved members lying between two network points. A network point is 1) a junction of two or more pipes, 2) an anchor or any point at which motion is prescribed, or 3) any arbitrary point.

Any location in the system may sustain prescribed loads or may be subject to elastic constraint in any of its six degrees of freedom. For example, hangers may be arbitrarily spaced along a section and may be of the rigid, flexible, or constant force type.

The response to seismic excitation is determined by using normal mode techniques with a lumped mass system. The maximum spectral acceleration is applied for each mode at its corresponding frequency from response spectra. A basic assumption is that the maximum modal excitation of each mode occur simultaneously. The modal participations are then summed.

2.2 WESTDYN-2

This program is a slightly modified version of the WESTDYN program. The program accepts (does not calculate) time-history displacement vectors as boundary conditions and proceeds to an usual WESTDYN static solution. In addition to the usual stress solution, the program also calculates axial stress, shear stress, and stress intensity.

2.3 FIXFM

FIXFM is a digital computer program which determines the time-history response of a three-dimensional structure excited by an internal forcing function. FIXFM accepts (input) normalized mode shapes, natural frequencies, forcing functions and an initial deflection vector. The program sets up the modal differentail equations of motion. The modal differential equations are then solved numerically by a predictor-corrector technique of numerical integration. The modal contributions are then summed at various nodal or mass points throughout the structure to get the actual time-history response.

2.4 Typical selected stress and global force outputs of the dynamic analysis for the Class 1 piping for PCV434 & PCV435 are shown in the attached tables.

RGE PRESSURIZER SAFETY VALVE PIPING SELECTED STRESS OUTPUT PVC 434 at Safe end

STRESS BLOWDOWN ONLY

MEMBER 286 TO 288 AT 285

MAXIMUM VALUE = 2.3KSI AT .2120 SECONDS

MINIMUM VALUE = 0.0KSI AT 0. SECONDS

PRESSURE HOOP STRESS= 0.0 KSI SEISMIC AXIAL STRESS = 0.0 KSI

RADIAL STRESS= 0.0 KSI SHEAR STRESS = 0.0 KSI

THE GRAPH - STRESS BLOWDOWN ONLY - HAS BEEN PLOTTED

TIME (SEC)	VALUE (KSI)	TIME (SEC)	VALUE (KSI)	TIME (SEC)	VALUE (KSI)	TIME (SEC)	VALUE (KSI)
0.000000	0.0	.078000	1.5	.156000	.2	.234000	1.1
.003000	.0	.081000	1.5	.159000	.3	.237000	1.6
.006000	.0	.084000	1.0	.162000	.3	.240000	1.2
.009000	.1	.087000	.5	.165000	.3	.243000	.1
.012000	.1	.090000	.1	.168000	.4	.246000	.8
.015000	.1	.093000	.4	.171000	.6	.249000	1.1
.018000	.1	.096000	.4	.174000	.7	.252000	.8
.021000	.1	.099000	.1	.177000	.6	.255000	.2
.024000	.1	.102000	.5	.180000	.2	.258000	.5
.027000	.2	.105000	1.2	.183000	.8	.261000	.8
.030000	.3	.108000	1.4	.186000	1.5	.264000	.8
.033000	.4	.111000	.9	.189000	1.6	.267000	.6
.036000	.4	.114000	.1	.192000	.8	.270000	.3
.039000	.3	.117000	1.2	.195000	.5	.273000	.0
.042000	.5	.120000	1.8	.198000	1.6	.276000	.3
.045000	.9	.123000	1.8	.201000	1.9	.279000	.5
.048000	1.3	.126000	1.1	.204000	1.0	.282000	.7
.051000	1.2	.129000	.1	.207000	.5	.285000	.7
.054000	.7	.132000	.8	.210000	1.8	.288000	.5
.057000	.4	.135000	1.1	.213000	2.3	.291000	.1
.060000	1.1	.138000	.9	.216000	1.4	.294000	.4
.063000	1.6	.141000	.0	.219000	.3	.297000	.8
.066000	1.1	.144000	.7	.222000	1.7	.300000	.8
.069000	.4	.147000	1.1	.225000	2.3	0.000000	0.0
.072000	.5	.150000	1.1	.228000	1.6	0.000000	0.0
.075000	1.2	.153000	.6	.231000	.2	0.000000	0.0

RGE PRESSURIZER SAFETY VALVE PIPING SELECTED STRESS OUTPUT PCV 434

STRESS BLOWDOWN ONLY

MEMBER 207 TO 210 AT 210

MAXIMUM VALUE = 3.0KSI AT .2010 SECONDS

MINIMUM VALUE = 0.0KSI AT 0. SECONDS

PRESSURE HOOP STRESS= 0.0 KSI SEISMIC AXIAL STRESS = 0.0 KSI

RADIAL STRESS= 0.0 KSI SHEAR STRESS = 0.0 KSI

THE GRAPH - STRESS BLOWDOWN ONLY - HAS BEEN PLOTTED

TIME (SEC)	VALUE (KSI)	TIME (SEC)	VALUE (KSI)	TIME (SEC)	VALUE (KSI)	TIME (SEC)	VALUE (KSI)
0.000000	0.0	.078000	1.1	.156000	1.7	.234000	2.4
.003000	.0	.081000	1.6	.159000	1.5	.237000	2.1
.006000	.1	.084000	1.6	.162000	1.4	.240000	.6
.009000	.1	.087000	1.3	.165000	2.5	.243000	.3
.012000	.1	.090000	1.1	.168000	2.7	.246000	1.7
.015000	.1	.093000	1.0	.171000	2.2	.249000	1.8
.018000	.1	.096000	1.1	.174000	1.1	.252000	1.1
.021000	.2	.099000	1.4	.177000	1.5	.255000	1.4
.024000	.2	.102000	1.9	.180000	1.8	.258000	1.4
.027000	.4	.105000	1.4	.183000	1.2	.261000	1.2
.030000	.4	.108000	1.7	.186000	.6	.264000	1.7
.033000	.4	.111000	1.5	.189000	1.4	.267000	1.7
.036000	.2	.114000	1.3	.192000	1.5	.270000	1.6
.039000	.1	.117000	1.2	.195000	1.3	.273000	.8
.042000	.2	.120000	.6	.198000	2.2	.276000	.7
.045000	.5	.123000	.7	.201000	3.0	.279000	1.2
.048000	.5	.126000	1.1	.204000	2.3	.282000	1.7
.051000	.5	.129000	2.1	.207000	1.4	.285000	1.8
.054000	.3	.132000	2.3	.210000	1.3	.288000	1.7
.057000	.3	.135000	2.6	.213000	1.9	.291000	2.0
.060000	.1	.138000	2.2	.216000	1.4	.294000	1.5
.063000	.3	.141000	1.1	.219000	1.4	.297000	1.1
.066000	.3	.144000	1.1	.222000	1.9	.300000	1.0
.069000	.2	.147000	.6	.225000	2.0	0.000000	0.0
.072000	.1	.150000	.3	.228000	1.8	0.000000	0.0
.075000	.7	.153000	1.2	.231000	1.8	0.000000	0.0

RGE PRESSURIZER SAFETY VALVE PIPING FORCE AT PRESSURIZER (GLOBAL) PCV 434

MEMBER 286 TO 288 AT 286 FORCE

MAXIMUM	F(X)=P	=	0.	KIPS	AT	.1580	SECONDS
MINIMUM	F(X)=P	=	-0.	KIPS	AT	.1580	SECONDS
MAXIMUM	F(Y)	=	0.	KIPS	AT	.2250	SECONDS
MINIMUM	F(Y)	=	-0.	KIPS	AT	.2120	SECONDS
MAXIMUM	F(Z)	=	0.	KIPS	AT	.2120	SECONDS
MINIMUM	F(Z)	=	-0.	KIPS	AT	.2250	SECONDS
MAXIMUM	M(X)=T	=	1.	IN-K	AT	[illegible]	SECONDS
MINIMUM	M(X)=T	=	-2.	IN-K	AT	.2130	SECONDS
MAXIMUM	M(Y)	=	1.	IN-K	AT	.1180	SECONDS
MINIMUM	M(Y)	=	-1.	IN-K	AT	.0500	SECONDS
MAXIMUM	M(Z)	=	6.	IN-K	AT	.2120	SECONDS
MINIMUM	M(Z)	=	-6.	IN-K	AT	.2250	SECONDS

ABSOLUTE MAXIMUM VALUES

AXIAL FORCE	=	0.	KIPS	AT	.1580	SECONDS
SHEAR FORCE	=	0.	KIPS	AT	.2120	SECONDS
TORQUE	=	2.	IN-K	AT	.2130	SECONDS
MOMENT	=	6.	IN-K	AT	.2120	SECONDS

RGE PRESSURIZER SAFETY VALVE PIPING SELECTED STRESS OUTPUT PCV 435
STRESS BLOWDOWN ONLY at Safe End
MEMBER 315 TO 316 AT 315

MAXIMUM VALUE = 1.9KSI AT .5700E-01 SECONDS
MINIMUM VALUE = 0.0KSI AT 0. SECONDS

PRESSURE HOOP STRESS= 0.0 KSI SEISMIC AXIAL STRESS = 0.0 KSI
RADIAL STRESS= 0.0 KSI SHEAR STRESS = 0.0 KSI

THE GRAPH - STRESS BLOWDOWN ONLY - HAS BEEN PLOTTED

TIME (SEC)	VALUE (KSI)	TIME (SEC)	VALUE (KSI)	TIME (SEC)	VALUE (KSI)	TIME (SEC)	VALUE (KSI)
0.000000	0.0	.078000	.9	.156000	.2	.234000	1.5
.003000	.0	.081000	1.3	.159000	.3	.237000	1.6
.006000	.0	.084000	1.8	.162000	.1	.240000	1.4
.009000	.0	.087000	1.3	.165000	.1	.243000	.5
.012000	.1	.090000	.7	.168000	.3	.246000	.4
.015000	.1	.093000	.6	.171000	.1	.249000	1.2
.018000	.0	.096000	1.3	.174000	.1	.252000	1.6
.021000	.0	.099000	1.7	.177000	.2	.255000	1.3
.024000	.1	.102000	1.9	.180000	.5	.258000	1.0
.027000	.1	.105000	1.4	.183000	.6	.261000	.3
.030000	.2	.108000	.7	.186000	.6	.264000	.3
.033000	.3	.111000	.3	.189000	.2	.267000	.7
.036000	.4	.114000	1.3	.192000	.3	.270000	.9
.039000	.3	.117000	1.7	.195000	.8	.273000	.8
.042000	.3	.120000	1.8	.198000	1.1	.276000	.7
.045000	.7	.123000	1.2	.201000	1.0	.279000	.3
.048000	1.3	.126000	.4	.204000	.9	.282000	.1
.051000	1.4	.129000	.4	.207000	.2	.285000	.2
.054000	1.2	.132000	1.1	.210000	.4	.288000	.5
.057000	.6	.135000	1.0	.213000	1.1	.291000	.5
.060000	.8	.138000	1.0	.216000	1.5	.294000	.6
.063000	1.5	.141000	.5	.219000	1.3	.297000	.3
.066000	1.9	.144000	.1	.222000	1.0	.300000	.0
.069000	1.7	.147000	.3	.225000	.3	0.000000	0.0
.072000	.9	.150000	.5	.228000	.4	0.000000	0.0
.075000	.2	.153000	.3	.231000	1.0	0.000000	0.0

RGE PRESSURIZER SAFETY VALVE PIPING SELECTED STRESS OUTPUT *PCV 435*

STRESS BLOWDOWN ONLY

MEMBER 204 TO 210 AT 210

MAXIMUM VALUE = 6.6KSI AT .1250 SECONDS
MINIMUM VALUE = 0.0KSI AT 0. SECONDS

PRESSURE HOOP STRESS= 0.0 KSI SEISMIC AXIAL STRESS = 0.0 KSI
RADIAL STRESS= 0.0 KSI SHEAR STRESS = 0.0 KSI

THE GRAPH - STRESS BLOWDOWN ONLY - HAS BEEN PLOTTED

TIME (SEC)	VALUE (KSI)	TIME (SEC)	VALUE (KSI)	TIME (SEC)	VALUE (KSI)	TIME (SEC)	VALUE (KSI)
0.000000	0.0	.078000	.5	.156000	.9	.234000	5.0
.003000	.0	.081000	.7	.159000	1.9	.237000	5.1
.006000	.0	.084000	.9	.162000	3.5	.240000	4.4
.009000	.0	.087000	1.1	.165000	4.6	.243000	2.9
.012000	.0	.090000	1.6	.168000	5.0	.246000	.8
.015000	.0	.093000	2.5	.171000	4.5	.249000	1.6
.018000	.0	.096000	3.4	.174000	3.6	.252000	3.8
.021000	.0	.099000	4.2	.177000	2.4	.255000	5.2
.024000	.0	.102000	4.5	.180000	.9	.258000	5.7
.027000	.0	.105000	4.0	.183000	1.1	.261000	5.0
.030000	.0	.108000	2.8	.186000	3.0	.264000	3.2
.033000	.1	.111000	1.2	.189000	4.8	.267000	.9
.036000	.1	.114000	1.5	.192000	5.8	.270000	1.6
.039000	.1	.117000	3.6	.195000	5.6	.273000	3.5
.042000	.1	.120000	5.4	.198000	4.1	.276000	4.6
.045000	.2	.123000	6.4	.201000	1.4	.279000	4.7
.048000	.4	.126000	6.5	.204000	1.5	.282000	4.1
.051000	.3	.129000	5.6	.207000	4.0	.285000	3.0
.054000	.1	.132000	3.5	.210000	5.4	.288000	1.5
.057000	.1	.135000	.7	.213000	5.6	.291000	.1
.060000	.4	.138000	2.4	.216000	5.0	.294000	1.5
.063000	.4	.141000	4.8	.219000	3.5	.297000	2.8
.066000	.3	.144000	5.8	.222000	1.6	.300000	3.8
.069000	.2	.147000	5.5	.225000	.6	0.000000	0.0
.072000	.4	.150000	4.0	.228000	2.6	0.000000	0.0
.075000	.5	.153000	2.3	.231000	4.1	0.000000	0.0

RGE PRESSURIZER SAFETY VALVE PIPING FORCE AT PRESSURIZER (GLOBAL) PCV 435

MEMBER 314 TO 315 AT 315 FORCE

MAXIMUM	F(X)=P =	0.	KIPS	AT	.0470	SECONDS
MINIMUM	F(X)=P =	-0.	KIPS	AT	.1040	SECONDS
MAXIMUM	F(Y) =	0.	KIPS	AT	.0850	SECONDS
MINIMUM	F(Y) =	-0.	KIPS	AT	.0550	SECONDS
MAXIMUM	F(Z) =	0.	KIPS	AT	.0460	SECONDS
MINIMUM	F(Z) =	-0.	KIPS	AT	.1030	SECONDS
MAXIMUM	M(X)=T =	4.	IN-K	AT	.0670	SECONDS
MINIMUM	M(X)=T =	-3.	IN-K	AT	.0840	SECONDS
MAXIMUM	M(Y) =	1.	IN-K	AT	.0840	SECONDS
MINIMUM	M(Y) =	-1.	IN-K	AT	.0950	SECONDS
MAXIMUM	M(Z) =	4.	IN-K	AT	.1180	SECONDS
MINIMUM	M(Z) =	-4.	IN-K	AT	.1020	SECONDS

ABSOLUTE MAXIMUM VALUES

AXIAL FORCE =	0.	KIPS	AT	.0470	SECONDS
SHEAR FORCE =	0.	KIPS	AT	.0460	SECONDS
TORQUE =	4.	IN-K	AT	.0670	SECONDS
MOMENT =	4.	IN-K	AT	.1020	SECONDS