SPECIFICATIONS
AND
DOCUMENTS

WISCONSIN PUBLIC SERVICE CORPORATION
GREEN BAY, WISCONSIN

KEWAUNEE NUCLEAR POWER PLANT

KEWAUNEE SAFETY AND RELIEF VALVES PIPING QUALIFICATION REPORT

B&V PROJECT 9653
9653.51.1004
REVISION 1

(August 16, 1985)

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of Wisconsin.

....

Date 8-16-85 Reg. No. E-21225

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1.0 SUMMARY

This document provides a final report of the Kewaunee safety and relief valve piping analysis; it also provides an action plan and schedule for completion of the Kewaunee plant specific safety and relief valve (S/RV) piping analysis. The information contained herein partially meets the requirements of NUREG 0737, Item II.D.1.A for qualification of S/RV piping and supports. The S/RV qualification is presented in a separate report titled "Kewaunee Power Plant Safety and Relief Valve Qualification Report."

Revision 0 of this report was submitted to the Nuclear Regulatory Commission (NRC) in July 1982.[1] That report states that with the as-built Kewaunee S/RV piping configuration, the allowable piping stress would be exceeded if a double safety valve actuation occurred. The information herein is being issued as Revision 1 of the July report and contains documentation to support the piping modifications which will be implemented at the Kewaunee plant. With these piping modifications the design basis, as presented in the Kewaunee Final Safety Analysis Report (FSAR), will be satisfied for the S/RV piping and associated piping supports.

Part of the overpressure protection system (OPPS) for the Kewaunee Power Station contains two Crosby $6M_16$ safety valves with loop seals, two Masoneilan power operated relief valves (PORV), and associated piping which provide pressure relief to the Kewaunee-Westinghouse nuclear steam supply system (NSSS). Overpressure events which may occur in the primary system will first exceed the set points of the PORVs and then the safety valves. The activation of these valves causes large forces to develop in the discharge piping, which produces stresses in the safety/relief valve piping network.

The NRC, in their July 1979 report, NUREG 0578,[2] recommended in Section 2.1.2 that utilities operating and constructing nuclear power plants develop a program of performance tests for power-operated relief valves and self-activated safety valves used in the reactor primary coolant system. The requirement of NUREG 0578 was later incorporated into the NRC Action

Plan, NUREG 0660,[3] and further clarified in NUREG 0737, Item II.D.1.A.[4,5] At the request of utilities with pressurized water reactors (PWR), developed and implemented a test program for power-operated relief valves and safety valves. As part of this test program, load measurements were taken during the actuation of the tested valve at various downstream pipin locations of one of the test facilities.

The EPRI testing program consisted of four major parts.

(1) Justification that the valves tested in the EPRI test program were comparable to the valves used in PWR OPPS.

(2) Justification that the test conditions used in the EPRI test program were comparable to the expected PWR operating and accident conditions.

(3) Results and descriptions of power operated relief and safety valve tests.

(4) Verification and application of RELAP5/MOD1 for calculation of safety and PORV discharge piping hydrodynamic loads. The Combu tion Engineering (CE) test facility provided measured load data on the downstream piping which were used to qualify cal ion procedures used to determine Kewaunee plant specific piping loa due to the actuation of a safety or PORV(s).

This report deals specifically with the piping loads created by the opening of the Kewaunee safety and/or PORVs due to an overpressure event the NSSS.

This report describes the Kewaunee plant specific S/RV and piping co figuration and the EPRI safety valve test facility (Sections 3.0 and 4.0) Qualifications of the calculations and methods to determine the thermal/ hydraulic loads on the Kewaunee S/RV piping are presented in Section 5.0. Plant-specific Kewaunee S/RV discharge piping load calculations are presented in Section 6.0. The method used to determine piping stresses caus by S/RV actuation and appropriate stress allowables is presented in Section 7.0. A discussion for implementing the final S/RV piping modificat is presented in Section 8.

The computer codes RELAP5/FORCE were used to simulate various S/RV transients which produced thermal/hydraulic loads on the discharge piping. These loads were used as input to the stress code, ADLPIPE, to determine the piping stresses on the Kewaunee S/RV piping network. These stresses were then compared to the Kewaunee Final Safety Analysis Report (FSAR) code allowables to determine the adequacy of the Kewaunee piping and piping restraint layout. These evaluations concluded that, with appropriate modifications to the S/RV discharge piping, the piping stresses created by a worst case safety valve actuation were below Kewaunee FSAR stress allowables.

Design modifications for the Kewaunee S/RV piping include the installation of two rupture disk/baffle plate assemblies, additional 10-inch piping, and an orifice plate in the discharge piping which will reduce the safety valve transient thermal/hydraulic loads to acceptable levels.

In reviewing the results of the analyses, it should be noted that identification of the valves is incorrect. PR-3A should be identified as PR-3B, and PR-3B should be identified as PR-3A. The correct identification is shown on Figure 9-1. This misidentification does not change the results.

2.0 INTRODUCTION

An overpressure protection system (OPPS) is provided on each pressurized water reactor (PWR) to prevent overpressurization of the primary coolant boundary. The OPPS typically includes two or three spring-loaded safety valves and one to three power operated relief valves (PORV), each in a separate piping system that extends from the pressurizer steam dome to a pressure suppression (relief) tank. The OPPS design details vary considerably among PWR power plants. Some contain a small water volume in a U-tube piping configuration preceding the safety valve which acts as a loop seal. A large number of different safety and PORVs are used in various system designs, and the discharge piping configurations vary from plant to plant.

Under all normal operating conditions and most postulated transients, the safety or PORVs, if actuated, pass high quality steam (after loop seal discharge, if present). The discharge of the water slug (if loop seal is present) followed by expanding steam in the safety and power operated relief valve (S/PORV) discharge piping causes large thermal/hydraulic [illegible]es to develop in the discharge piping.

2.1 NRC REQUIREMENTS

2.1.1 <u>Performance Testing and Boiling Water Reactor and Pressurized-Water Reactor Power Operated Relief and Safety Valves (Item II.D.1.A)</u>

"Licensees and applicants are to determine the expected valve operating conditions through the use of analyses of accidents and anticipated operational occurrences referenced in Regulatory Guide 1.70, Revision 2. The single failures applied to these analyses are to be chosen so that the dynamic forces on the S/PORVs are maximized. Test pressures shall be the highest predicted by conventional safety analysis procedures. Reactor coolant system power operated relief and safety valve qualifications are to include qualification of piping and supports, as well as the valves themselves."

2.1.1.1 <u>Performance Testing of S/RVs</u>. The following information should be provided in report form to the NRC.

(1) Test evidence of S/RV functionability for expected operating and accident (nonanticipated transcience without scram) conditions must be provided to the NRC. Tests should demonstrate that the valves will open and reclose under the expected flow conditions.

Test data including criteria for success and failure of tested valves must be provided for NRC staff review and evaluation. These test data should permit plant-specific evaluation of discharge piping and supports that are directly tested.

(2) Because it is not planned to test all valves on all plants, eac licensee must submit a correlation or other evidence to substantiate that the valves tested in the EPRI generic test program demonstrate the functionability of as-installed primary S/RVs. This correlation must show that the test conditions used are equivalent to expected operating and accident conditions as prescribed in the FSAR. The effect of as-built S/RV discharge piping on valve operability must also be accounted for, if it i different from the generic test loop piping.

2.2 EPRI S/RV TEST PROGRAM AND OBJECTIVES

The first objective of the EPRI PWR Safety and Power Operated Relief Valve Test Program is to provide full-scale test data confirming the func tionability of primary system power operated relief valves and safety valves for expected operating and accident conditions. The second object of the program is to obtain piping thermal/hydraulic load data sufficient to confirm models which may be used in plant-unique analyses of S/PORV discharge piping systems.

2.3 REPORT OBJECTIVES

The primary objective of this report is to demonstrate that the modi fied Kewaunee S/RV piping configuration is qualified to withstand dynami loading caused by safety or power operated relief valve actuations.

Other objectives of this report are as follows.

(1) To present information on the Kewaunee as-built S/RV piping configuration.

(2) To discuss the EPRI safety valve testing facilities.

(3) To qualify the calculation procedure used to determine plant-specific loads for the Kewaunee S/RV discharge piping.

(4) To discuss the piping stresses on the as-built S/RV piping system created by the actuation of safety and/or power operated relief valves at the Kewaunee power plant.

(5) To present a modification to the Kewaunee S/RV discharge piping system which will reduce piping loads induced by safety valve actuation so that piping stresses are below allowable stresses and to present the final thermal/hydraulic and stress results from simulating the modified Kewaunee S/RV piping.

3.0 KEWAUNEE S/R VALVE AND PIPING LAYOUT

The overpressure protection system (OPPS) for the Kewaunee-Westinghouse Nuclear Steam Supply System (NSSS) includes two spring-loaded Crosby safety valves and two power operated Masoneilan relief valves. Each valve is in a separate piping system that extends from the pressurizer steam dome through the valves. Downstream of the valves, the discharge piping forms a common header for all valves and is discharged into the pressurizer relief tank. The piping upstream of the Crosby safety valves contain a small water volume (approximately 5.3 gallons) in a U-tube piping configuration which acts as a loop seal. The water loop seals provide a protective barrier against corrosive gases and minimize steam leakage.

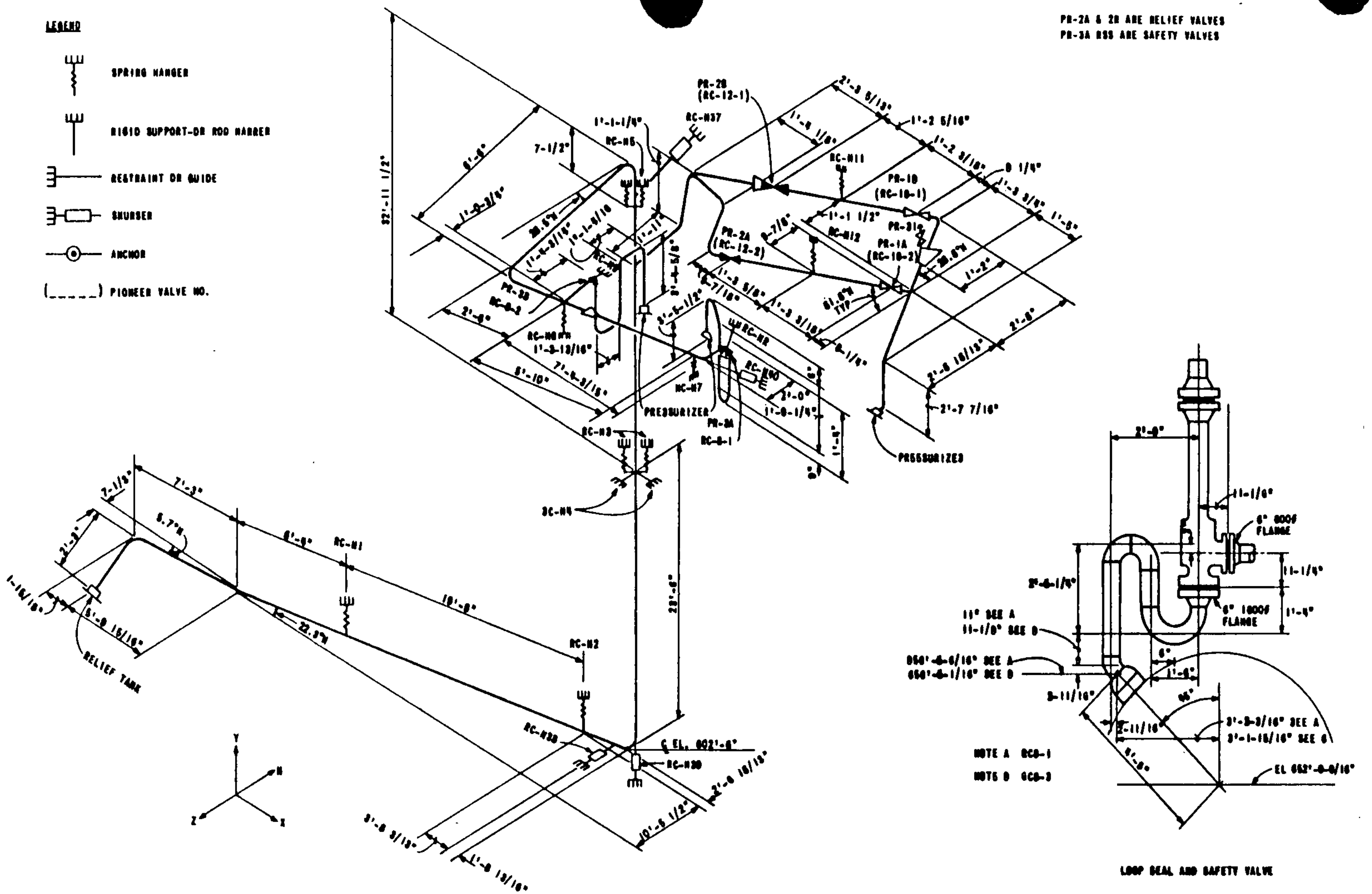
This report presents analytical evidence to support the modified S/RV discharge piping qualification. For comparison, the as-built piping configuration is also presented. The piping configuration upstream of the safety valves and power operated relief valves remain the same.

The as-built Kewaunee S/RV piping is shown on Figures 3-1 and 3-2. Figure 3-1 is an isometric of the as-built piping layout from the pressurizer to the pressurizer relief tank. Figure 3-1 contains all dimensions, including valve designations and piping support designations. Figure 3-2 presents the S/RV piping layout. Other detailed design information is presented in Table 3-1.

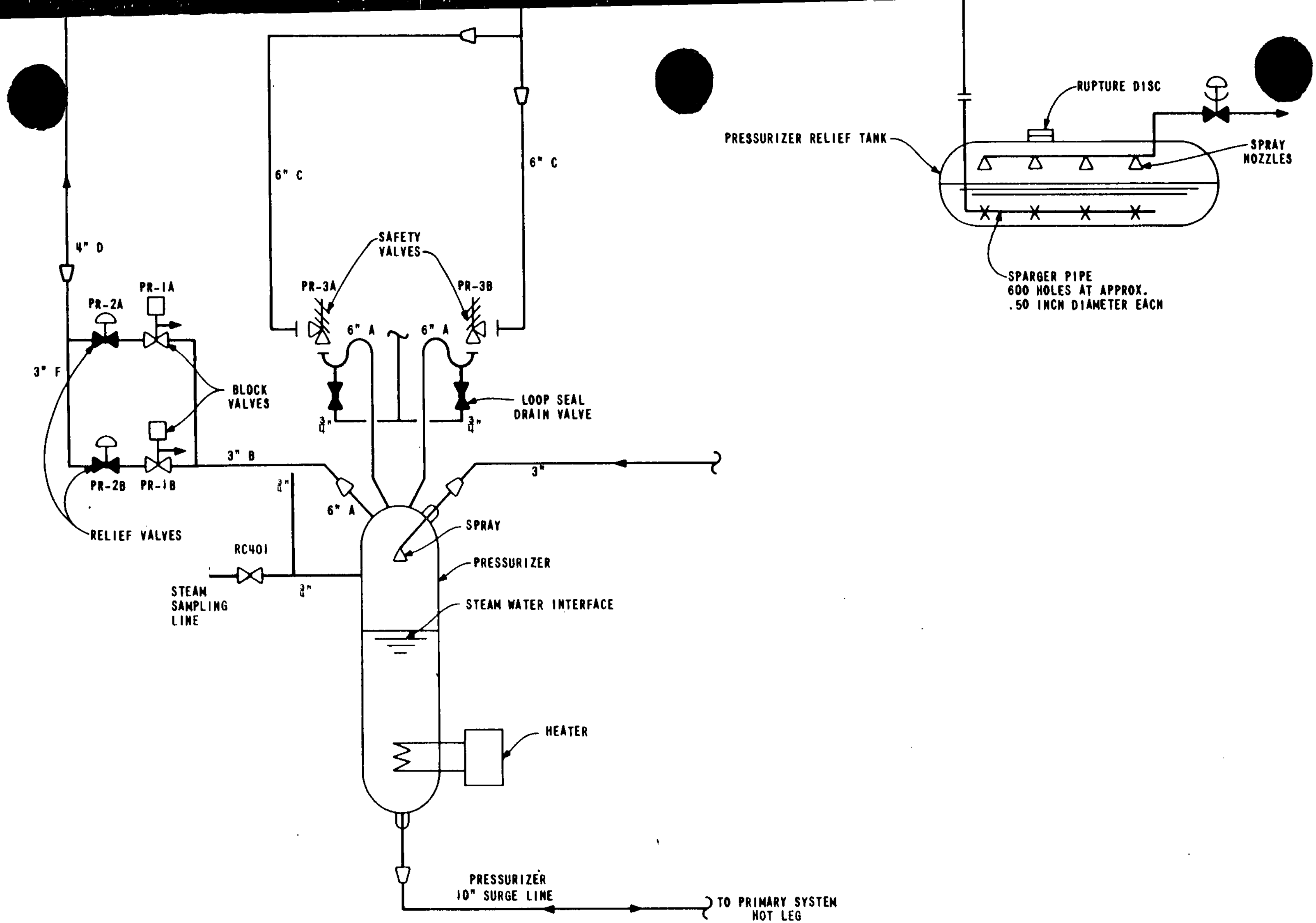
3.1 DESCRIPTION OF THE KEWAUNEE SAFETY AND POWER OPERATED RELIEF VALVES

3.1.1 Kewaunee Safety Valves

The Kewaunee OPPS contains two safety valves which are designated PR-3A and PR-3B and are shown on Figures 3-1 and 3-2. These valves are set to open in the event of an overpressure transient which exceeds 2,500 psia in the primary system.



KEWAUNEE S/RV DISCHARGE PIPING ISOMETRIC[6]
FIGURE 3-1



KEWAUNEE NUCLEAR POWER PLANT SAFETY/RELIEF
VALVES AND DISCHARGE PIPING LAYOUT
FIGURE 3-2

TABLE 3-1. PRESSURIZER AND PRESSURIZER RELIEF TANK DESIGN DATA FOR THE KEWAUNEE NUCLEAR POWER PLANT

Pressurizer	
Design/Operating Pressure, psig	2,485/2,235
Hydrostatic Test Pressure (cold), psig	3,107
Design/Operating Temperature, F	680/653
Water Volume, Full Power, cu ft*	600
Steam Volume, Full Power, cu ft	400
Surge Line Nozzle Diameter, in./Pipe Schedule	14/Sch 140
Shell ID, in./Minimum Shell Thickness, in.	84/4.1
Minimum Clad Thickness, in.	0.188
Electric Heaters Capacity, kW (total)	1,000
Heatup Rate of Pressurizer Using Heaters Only, F/h	55 (Approximately)
Power Relief Valves	
Number	2
Set Pressure (open), psig	2,335
Capacity, lb/h saturated steam/valve	179,000
Safety Valves	
Number	2
Set Pressure, psig	2,485
Capacity (ASME Rated Flow) lb/h/valve	345,000
Pressurizer Relief Tank	
Design Pressure, psig	100
Rupture Disc Release Pressure, psig	85
Design Temperature, F	340
Normal Water Temperature, F	120
Total Volume, cu ft	800
Rupture Disc Relief Capacity, lb/h	6.5×10^5

*60 percent of net internal volume (maximum calculated power).

The pressurizer safety valves were designed using the ASME Boiler and Pressure Vessel Code Section III Nuclear Vessels, Winter 1968, as designated in the Kewaunee FSAR.[8]

Detailed information concerning the safety valves is given in Table 3-2 and References 8, 9, and 10.

The Kewaunee Safety Valve is of the Crosby Style HB-BP-86. An illustration of the safety valve is presented on Figure 3-3.

3.1.2 Kewaunee Power-Operated Relief Valves

The Kewaunee OPPS contains two Masoneilan power-operated relief valves[11] (PORV) which are designated PR-2A and PR-2B and are shown on Figures 3-1 and 3-2. These valves are set to open in the event of an overpressure transient which exceeds 2,335 psig in the primary system.

The Kewaunee Masoneilan PORVs are top guided, single-seat globe valves with pneumatic actuators. The Masoneilan PORV is illustrated on Figure 3-4. During an overpressure event of the primary system, the valve plug is lifted off the seat by pneumatically loading the actuator.

Detailed information concerning the Kewaunee Masoneilan PORV is presented in Table 3-3 and is given in References 9, 11, and 12.

3.2 DESCRIPTION OF THE AS-BUILT KEWAUNEE S/RV PIPING LAYOUT

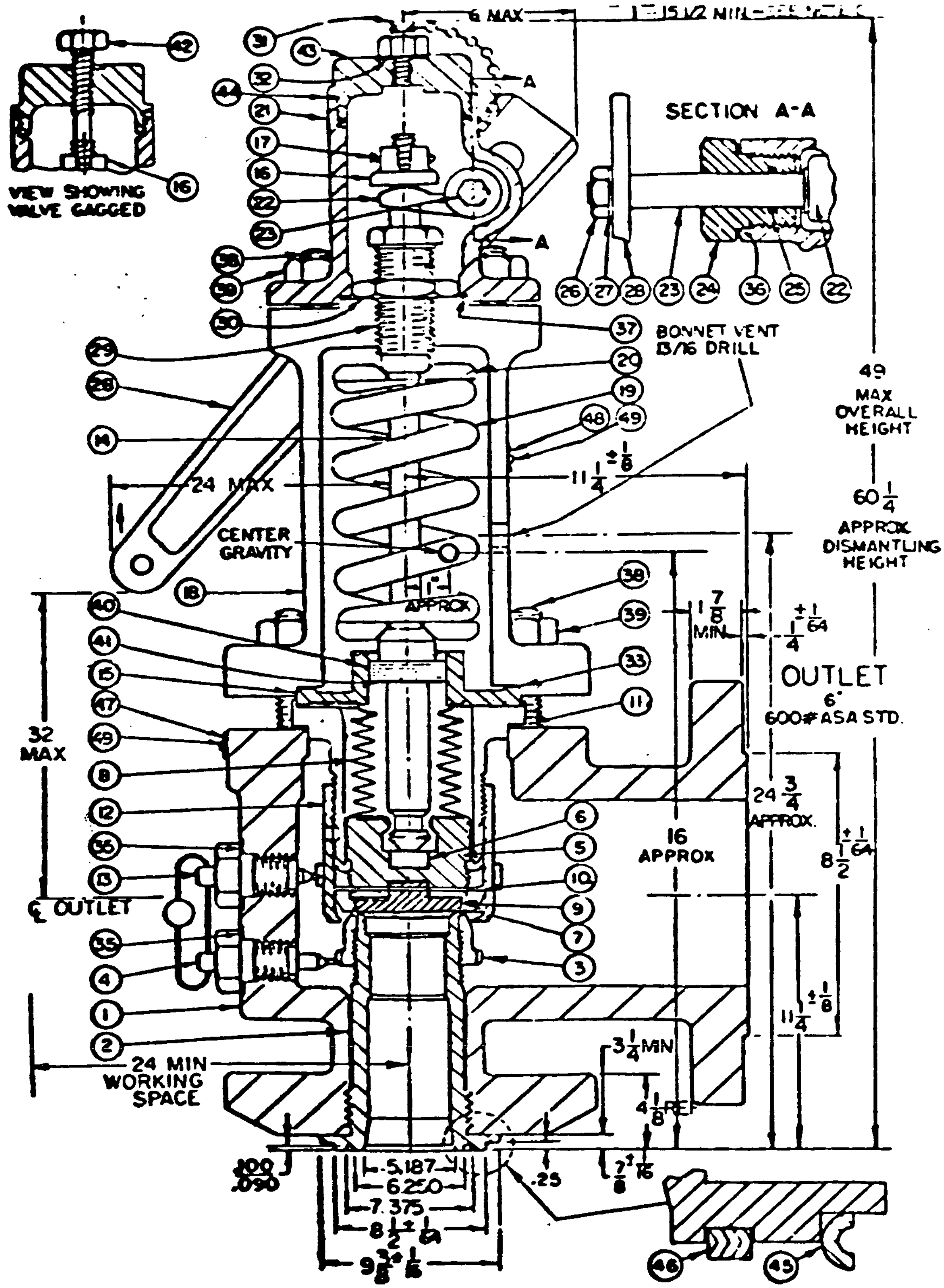
The details of the as-built Kewaunee discharge piping are shown on Figures 3-1 and 3-2. A detailed description of the piping layout is presented in Table 3-4. Design specifications for the piping are presented for the upstream and downstream piping in Tables 3-5 and 3-6, respectively.

The upstream piping which includes the loop seals for the safety valves consists of 6-inch Schedule 160 piping approximately 10 feet from the pressurizer to the safety valve. The loop seals each contain 5.3 gallons of 120 F water. The loop seal is approximately 5 feet in center line length from the steam-water interface to the inlet of the valve. A temperature gradient of 73 F per inch was calculated to occur in the first 6 inches from the steam water interface into the water of the loop seal. A

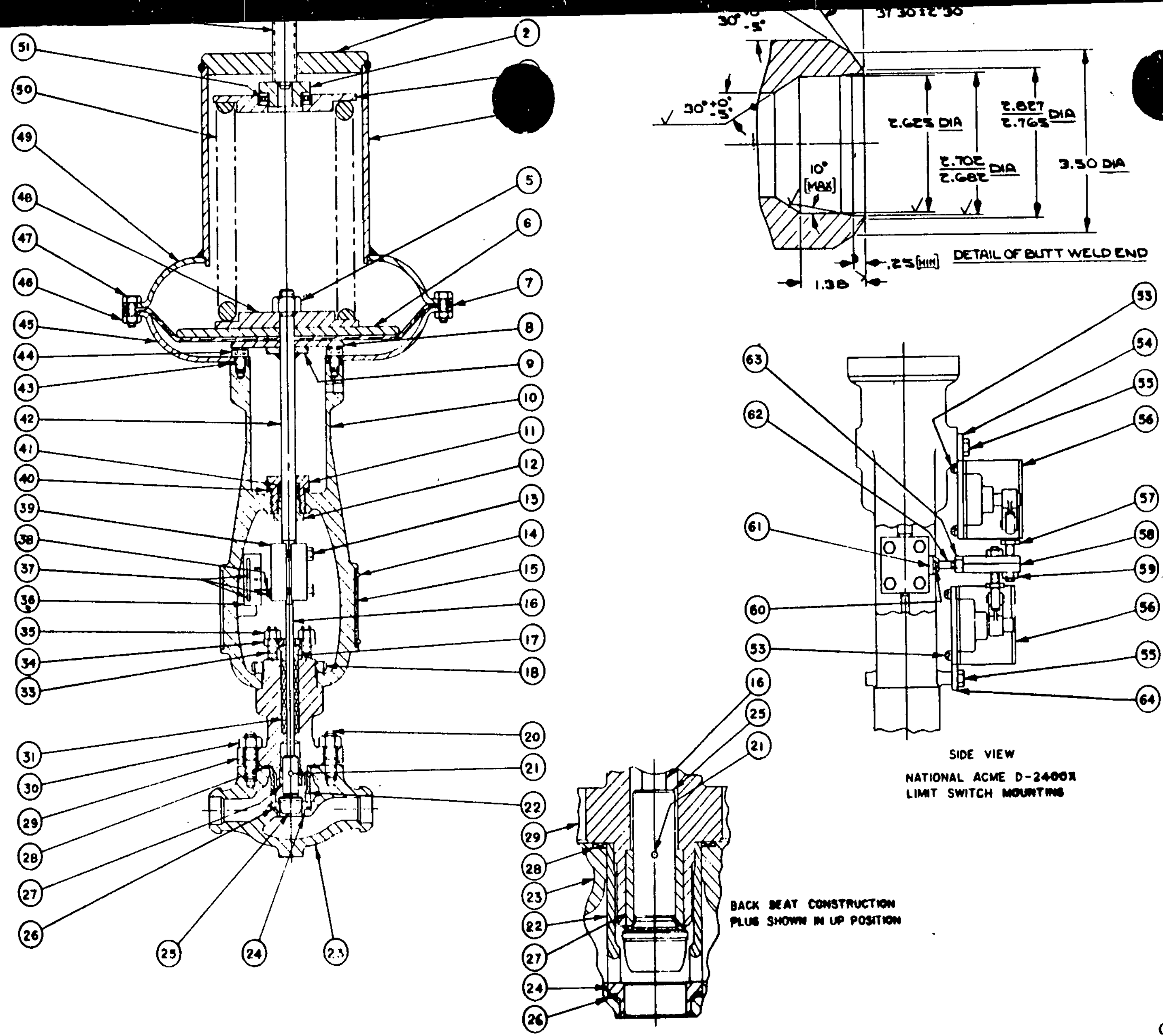
TABLE 3-2. KEWAUNEE SAFETY VALVE PLANT SPECIFIC INFORMATION

ety Valve Information	
Number of Valves	2
Manufacturer	Crosby
Factory Order	901642
Assembly No.	52137
Drawing No.	H-52137
I.D. No.	6-RVS8L5B
Size	
Inlet	6-in. Schedule 160
Orifice	M_1; Area = 0.0207 sq ft
Outlet	6-in. Schedule 40S
Seating Materials	Stellite
Disk Holder and Construction	347 SST with Stellite Lands and Disk Bushing
Rated Flow	345,000 lb/h
Pressure	2,485 psig
pressure	3 Percent
Blowdown	5 Percent
Inlet Flange Rating	1,500 lb
Discharge Flange Rating	600 lb
Stamped Ring Settings	
Guide Ring	-96
Nozzle Ring	-18
Isometric Designation*	PR-3A, PR-3B

*Figures 3-1 and 3-2 show locations.



CROSS SECTION OF KEWAUNEE CROSBY[13]
SAFETY VALVE
FIGURE 3-3



MASONEILAN RELIEF VALVE[9]
FIGURE 3-4

TABLE 3-3. KEWAUNEE POWER OPERATED RELIEF VALVE PLANT SPECIFIC INFORMATION[9,11]

<u>Power Operated Relief Valve Information</u>	
Number of Valves	2
Manufacturer	Masoneilan
Type	Globe
Assembly Drawing No.	A-8435
Identification No.	3-IA58RGP
Model No.	38-20721
Size	2-in.
Steam Flow Capacity Rated	179,000 lb/h
Steam Flow Capacity--Actual[a]	199,000 lb/h
Temperature at Flow	650 F
Set Point Pressure	2,335 psig
Inlet Flange Rating	1,500 lb
Discharge Flange Rating	1,500 lb
Allowable Applied Load[b]	35,600 in.-lb
Opening Pressure[b]	2,477
Closing Pressure[b]	2,216
Air-Operated Valve	
ASCO Solenoid Model No.	831654
Full Stroke	1-1/2-in.
Isometric Designation[c]	PR-2A; PR-2B

[a]Tested flow.

[b]Tested values.

[c]Figures 3-1 and 3-2 show locations.

TABLE 3-4. DESCRIPTION OF KEWAUNEE S/RV PIPING

Description	Value
Safety Valve PR-3A and PR-3B Loop Seal from Pressurizer to Center of Safety Valve	
Loop Seal	6-in. SCH 160 piping
Vertical Pipe From Pressurizer to First 180 Degree Bend	2.9 ft
Center Line Length of First 180 Degree Bend	2.0 ft
Length of Vertical Pipe from First 180 Degree Bend to Second	0.8 ft
Center Line Length of Second 180 Degree Bend	2.4 ft
Length of Vertical Portion of Valve and Flange	0.9 ft
Restraint in Plane with Loop Seal Provided by Rigid Strut at End of Second 180 Degree Bend	
Safety Valve PR-3A Discharge Piping from Center of Valve to 10-in. by 10-in. by 6-in. Tee	
Discharge Piping	6-in. SCH 40S
Length of Horizontal Portion of Valve and Flange	0.9 ft
Length of 6-in. Horizontal Piping from Valve to First Discharge Elbow	0.5 ft
Center Line Length of First Discharge Elbow	0.8 ft
Length of 6-in. Horizontal Piping from First Discharge Elbow to 10-in. by 10-in. by 6-in. Tee*	6.8 ft
Safety Valve PR-3B Discharge Piping from Center of Valve to 10-in. by 10-in. by 6-in. Tee (tee assumed to be first discharge elbow)	
Discharge Piping	6-in. SCH 40S
Length of Horizontal Portion of Valve and Flange	0.9 ft
Length of Horizontal Piping from Center of Valve to First Discharge Elbow (horizontal piping beyond first discharge elbow restrained in axial direction by Snubber RC-H40)	1.1 ft

TABLE 3-4 (Continued). DESCRIPTION OF KEWAUNEE S/RV PIPING

Description	Value
Safety Valve PR-3A and PR-3B Discharge Piping from 10-in. by 10-in. by 6-in. Tee to Relief Tank	
Discharge Piping	10-in. SCH 40S
Length of Horizontal Piping from 10-in. by 10-in. by 6-in. Tee to Second Discharge Elbow (piping restrained in axial direction by Snubber RC-H40)	1.25 ft
Center Line Length of Discharge Elbows	
Second	1.9 ft
Third	1.9 ft
Fourth	1.9 ft
Fifth	1.9 ft
Length of Horizontal Piping Between Discharge Elbows	
Between Second and Third Elbows (piping restrained in axial direction by Snubber RC-H37 just past third discharge elbow)	4.0 ft
Between Third and Fourth Elbows (piping restrained in axial direction by Snubber RC-H38 near fourth elbow. Vertical run restrained in horizontal plane by Guide RC-H4 about midspan)	56.4 ft
Between Fourth and Fifth Discharge Elbow (pipe restrained in axial direction by Snubber RC-H39)	33.3 ft
Between Fifth Discharge Elbow and Pressurizer Relief Tank	2.3 ft
Pressurizer to 3-in. Tee and 3-in. Tee to Power Operated Relief Valves PR-2A and PR-2B	
Piping	3-in. SCH 160
Length of Vertical Pipe from Pressurizer to First Elbow	2.2 ft

TABLE 3-4 (Continued). DESCRIPTION OF KEWAUNEE S/RV PIPING

Description	Value
Center Line Length of First Elbow	0.6 ft
Length of Horizontal Pipe from First Elbow to the 3-in. Tee	2.8 ft
Length of Horizontal Piping from First 3-in. Tee to Center of Block Valve PR-1A	0.8 ft
Length of Horizontal Piping from the Block Valve PR-1A to Center of PORV PR-2A	2.8 ft
Length of Horizontal Pipe from the 3-in. Tee to the Second Elbow	2.4 ft
Center Line Length of Second Elbow	0.6 ft
Length of Horizontal Piping from Second Elbow to Block Valve PR-1B	0.8 ft
Length of Horizontal Piping from Block Valve PR-1B to Center of PORV PR-2B	2.4 ft
PORVs PR-2A and PR-2B to 3-in. by 4-in. Branch Connection and 3-in. by 4-in. Branch Connection 0-in. by 4-in. Branch Connection on Vertical harge Header	
Piping	3-in. and 4-in. SCH 40S
Length of Horizontal Piping from PORV PR-2A to the First Elbow	0.5 ft
Center Line Length Elbows	
First	0.6 ft
Second	0.3 ft
Third	0.7 ft
Fourth (45-degree)	0.4 ft
Length of Horizontal Piping from First Elbow to Second Elbow	1.3 ft
Length of Horizontal Piping from Second Elbow to 3-in. by 4-in. Branch Connection	0.7 ft
Length of Horizontal 4-in. Pipe from PORV PR-2B to 3-in. by 4-in. Branch Connection	2.5 ft

TABLE 3-4 (Continued). DESCRIPTION OF KEWAUNEE S/RV PIPING

Description	Value
Length of Horizontal 4-in. Pipe from 3-in. by 4-in. Branch Connection to Third Elbow	0.4 ft
Length of Vertical 4-in. Pipe from Third Elbow to Fourth Elbow	1.0 ft
Length of 4-in. Pipe (45 degrees from vertical) Between Fourth Elbow and 10-in. by 4-in. Branch Connection	1.0 ft

*Axial restraint for horizontal piping provided by RC-H40 snubber near first discharge elbow.

.E 3-5. PIPELINE LIST PIPING SPECIFICATION--PIPE CODE A, B* U AM PIPING - KEWAUNEE FSAR CLASS I

Design Conditions

Pressure	2,510 psig (Max)	2,485 psig	2,485 psig
Maximum Temperature	650 F	650 F	680 F

Material--Stainless Steel of ASTM Specification listed below for each item.

Pipe					
Size	3/4 in. to 3 in.		4 in.	8 in. and 10 in.	6 in. and 12 in. to 16 in.
Construction	Seamless		Seamless	Seamless	Seamless
ASTM Spec	A376 TP 304		A376 TP 316	A376 TP 316	A376 TP 316
Schedule	160		120	140	160
Fittings					
Size	2 in. and Smaller	3 in.	4 in.	8 in. and 10 in.	6 in. and 12 in. to 16 in.
Type	Forged	Seamless	Seamless	Seamless	Seamless
Joint	Socket Weld	Butt Weld	Butt Weld	Butt Weld	Butt Weld
ASTM Spec	A182 F 304	A403 WP 304	A403 WP 316	A403 WP 316	A403 WP 316
Rating	6000#	Schedule 160	Schedule 120	Schedule 140	Schedule 160
Flanges					
Size	2 in. and Smaller	3 in.	4 in.	8 in. and 10 in.	6 in. and 12 in. to 16 in.
Type	Forged	Forged	Forged	Forged	Forged
Joint	Socket Weld	Weld Neck	Weld Neck	Weld Neck	Weld Neck
ASTM Spec	A182 F 316	A182 F 316	A182 F 316	A182 F 316	A182 F 316
Rating	1500# RF	1500# RF	1500# RF	1500# RF	1500# RF
Bored to	Schedule 160	Schedule 160	Schedule 120	Schedule 140	Schedule 160

NOTES: Design of sizes 18 in. O.D. and larger subject to Wisconsin Public Service approval.

*Figure 3-2 shows locations of A and B.

Source: Piping Specification Category 2501 received from Wisconsin Public Service.

Design Conditions				
Pressure	600 psig	700 psig	875 psig	600 psig
Maximum Temperature	600 F	400 F	200 F	400 F
Material--Stainless Steel of ASTM Specification listed below for each item.				
Pipe				
Size		3/4 in. to 6 in.	8 in. and 10 in.	12 in. to 18 in.
Construction		Seamless	Seamless	Welded
ASTM Spec		A312 Type 304	A312 Type 316	A358 Class 1 Type 316
Schedule		40S	40S	40
Fittings				
Size	2 in. and Smaller	3 in. to 6 in.	8 in. and 10 in.	12 in. and 18 in.
Type	Forged	Seamless	Seamless	Welded
Joint	Socket Weld	Butt Weld	Butt Weld	Butt Weld
ASTM Spec	A182 F 304	A403 WP 304	A403 WP 316	A403 WP 316
Rating	3000#	Schedule 40S	Schedule 40S	Schedule 40
Flanges				
Size	2 in. and Smaller	3 in. to 6 in.	8 in. and 10 in.	12 in. and 18 in.
Type	Forged	Forged	Forged	Forged
Joint	Socket Weld	Welding Neck	Welding Neck	Welding Neck
ASTM Spec	A182 F 304	A182 F 304	A182 F 304	A182 F 304
Rating	600# RF	600# RF	600# RF	600# RF
Bored to	Schedule 40S	Schedule 40S	Schedule 40S	Schedule 40

*Figure 3-2 shows locations of C, D, E, and F.

Source: Piping Specification Category 601 received from WPSC.

constant temperature of 120 F (assumed ambient temperature) is reached approximately one foot from the steam-water interface.

Heat loss from the loop seal piping is primarily due to natural convection and radiation from the outside surface, with most of the heat loss occurring in the first 6 inches of piping. TAC2D, a two-dimensional heat transfer computer code was used to determine the loop seal temperature distribution. More details concerning the TAC2D analyses are given in Appendix C.

The discharge piping from the safety valve PR-3A is 6-inch Schedule 40S piping. The distance from the safety valve to the center of the first elbow is approximately 1.8 feet. There are approximately 7.2 feet from the first elbow for safety valve PR-3A to the 10-inch by 10-inch by 6-inch tee where the 6-inch Schedule 40S discharge piping for safety valve PR-3B couples with the discharge piping from safety valve PR-3A. The distance from this coupling tee to the center of the next horizontal elbow is about 2.2 feet. The coupled discharge piping for both safety valves continues for approximately 6 feet to the center of the third horizontal elbow. The discharge piping continues to the pressurizer relief tank as shown on Figure 3-1 and as described in Table 3-4.

4.0 EPRI S/RV TEST FACILITIES

4.1 COMBUSTION ENGINEERING TEST FACILITY

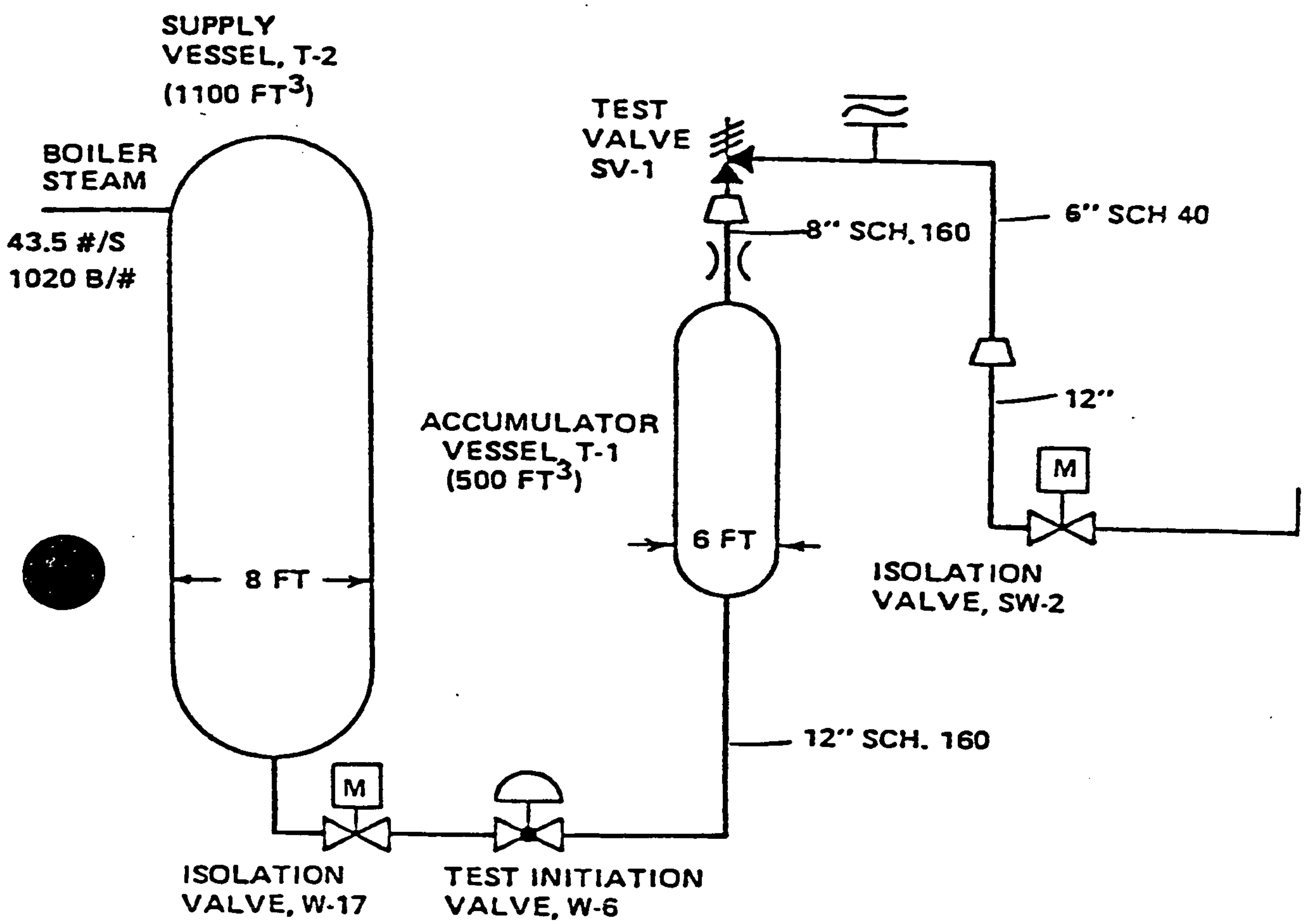
The Combustion Engineering (CE) test facility was designed for full-flow tests of selected safety valves under a wide range of inlet fluid conditions and inlet piping configurations. This section provides a description of the test facility, the test valves and piping, the instrumentation and measurements, as well as the data processing. Because the Kewaunee safety valve is a Crosby $6M_16$ safety valve with a loop seal, that part of the test facility which tested the Crosby 6M6 safety valve will be emphasized. The measured load data used in this report were taken from the CE test facility.[15] Most of the following description was taken from References 15 and 16.

4.1.1 <u>Overall Facility Description</u>

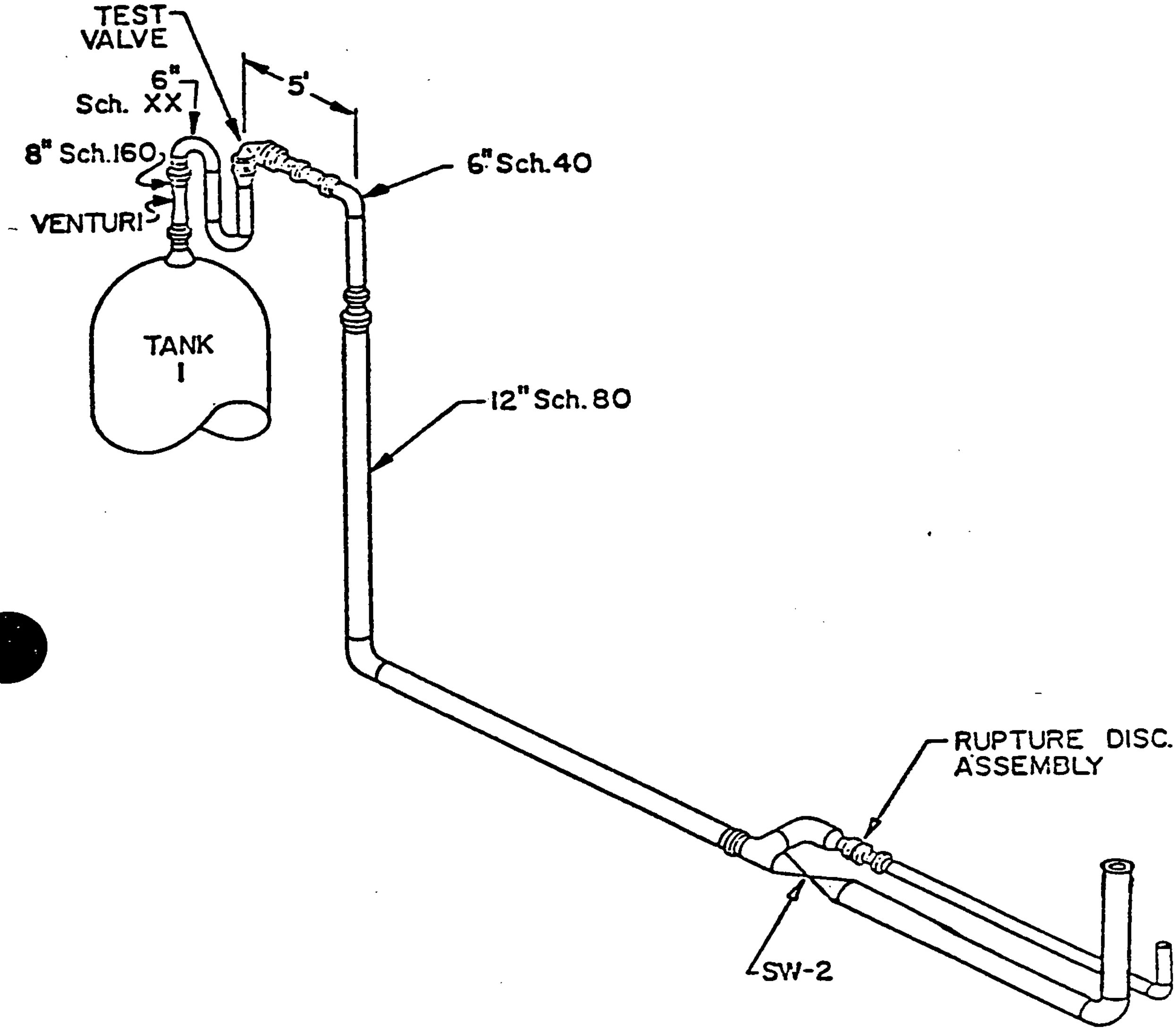
Figure 4-1 shows a simplified schematic of the CE test facility. The major components of the facility are two large tanks with interconnected piping, a high-pressure boiler, and a test valve with its associated inlet and discharge piping. By varying the initial fluid conditions in the tanks, the opening rate of the valve between the tanks, as well as the boiler flow, it was possible to simulate a wide range of transients which challenge the test valve. A more detailed drawing of the test facility piping, showing the loop seal inlet piping configuration, is shown on Figure 4-2.

Table 4-1 presents design parameters of the CE facility. In addition to the equipment mentioned above, a recirculation pump and heaters were provided for each tank to maintain uniform fluid conditions in the tanks. Insulation and heat tracing were available so that the test valves could be heated to a specified uniform temperature. The back pressure on the test valve could be controlled by means of a back pressure regulator valve or an orifice located in the discharge piping.

The test facility is located at the CE Kreisinger Development Laboratory in Windsor, CT. All pressure boundary parts were constructed in



SCHEMATIC OF THE CE TEST FACILITY[16]
FIGURE 4-1



ISOMETRIC OF THE TEST FACILITY PIPING[16]
FIGURE 4-2

TABLE 4-1. CE TEST FACILITY DESIGN PARAMETERS

Piping and Components Upstream of Test Valve	
Design pressure	3,250 psig
Design temperature	700 F
Boiler capacity	150,000 lb/h
Piping and Components Downstream of Test Valve	
Design pressure 700 F	1,000 psig
System Flow Capacity	
Continuous steam flow	150,000 lb/h
Transient steam flow (15 seconds)	600,000 lb/h*
Transient liquid flow (15 seconds)	5,500 gpm*

*The flow rates noted above are achieved by expansion or evaporation of the fluid in the larger accumulator tank. Additional capacity is available by supplementing accumulator capacity with that of the test facility boiler, either directly or as a driving head to push water through the test valve.

accordance with Section VIII of the ASME Boiler and Pressure Vessel Code and Power Piping, ANSI B31.1.

4.1.2 Test Valves and Piping

4.1.2.1 Description of Test Valves. Because the Crosby 6M6 safety valve represented the Kewaunee 6M$_1$6 safety valve performance at the CE test facility, it is described here. More information related to valve justification is presented in Section 6.0.

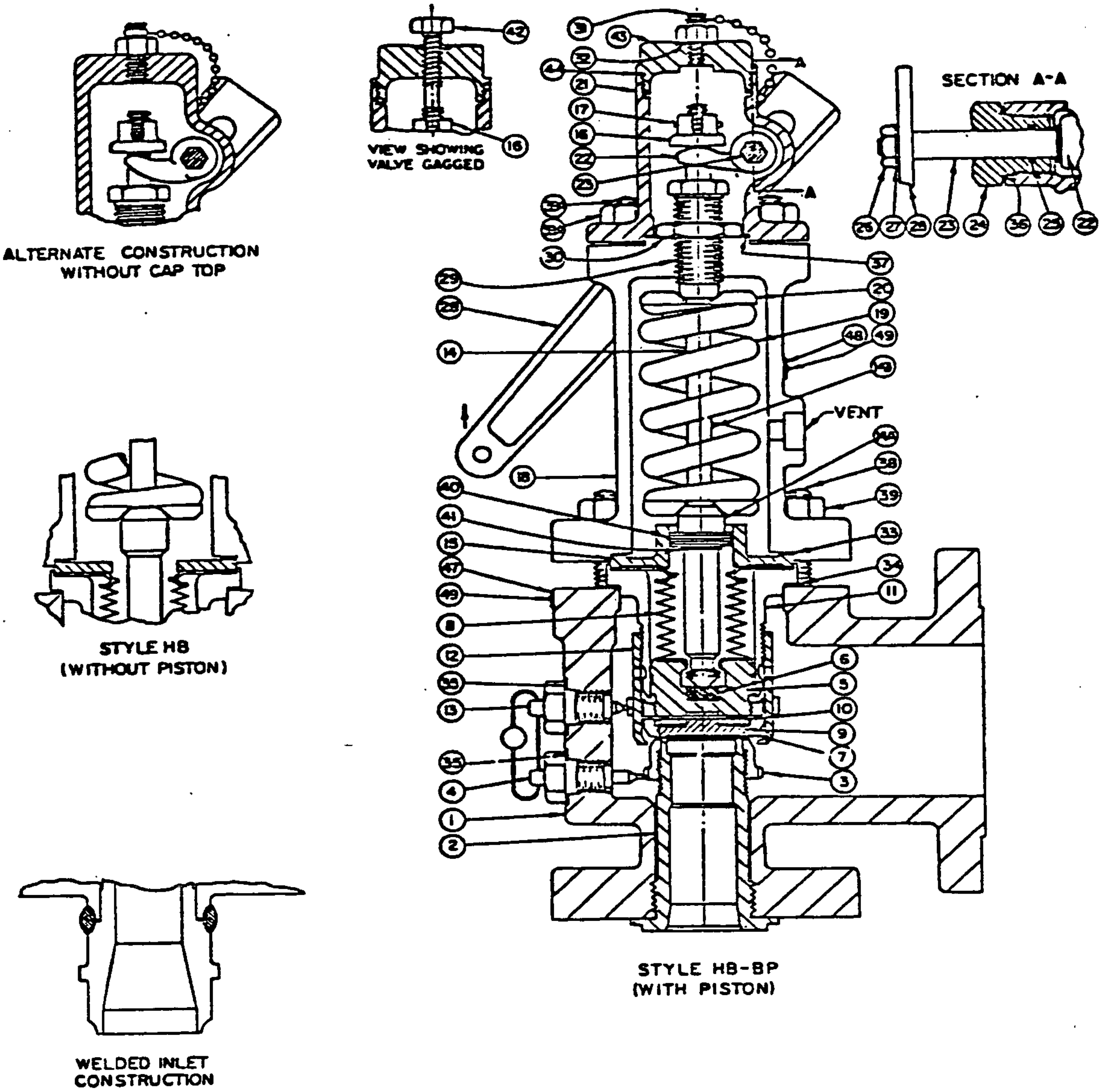
A diagram of the Crosby 6M6 safety valve is shown on Figure 4-3. The valve is a spring-loaded safety valve manufactured by Crosby Valve and Gage Company, Wrentham, MA. The test valve model number is HB-BP-86, the serial number is N56964-00-0086, and the manufacturer's drawing number for the valve is Crosby DS-C-56964, Rev. C. An M orifice with a flow area of 0.0253 ft^2 was installed in the Crosby 6M6 valve during testing. The rated flow capacity of the valve with the M orifice was 420,000 lb/h at the rated lift of 0.538 in.

4.1.2.2 Discharge Piping Description. Figure 4-4 shows a schematic diagram of the safety valve discharge piping for the Crosby 6M6. This figure indicates how the spoolpieces were connected for each test. Detailed drawings for the individual spoolpieces may be found in Reference 16.

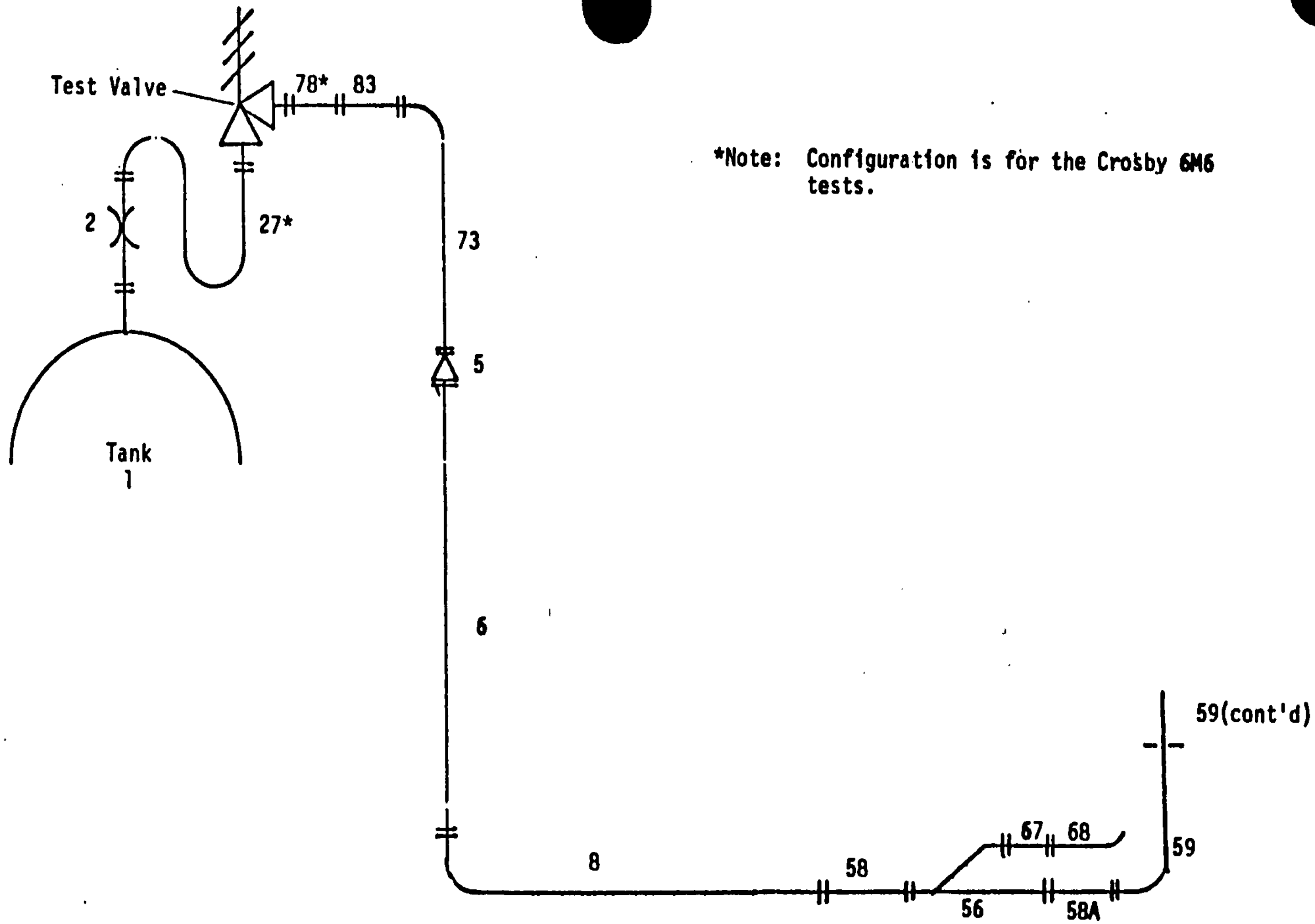
4.1.2.3 Piping Support Description. The design approach for the test loop piping supports was to provide supports which would facilitate experimental measurement of piping loads. Based on this design goal, extremely rigid dynamic support structures were designed for the test valve stand and test valve discharge piping.

The test valve stand is shown on Figure 4-5. This structure allowed most of the shear and moment at the test valve inlet flange to be transmitted through a pair of linkage assemblies.

The discharge pipe was supported at the second discharge elbow, midway between the second and third discharge elbows, and at the third discharge elbow. The structures at the second and third discharge elbows are shown on Figures 4-6 and 4-7, respectively. At the second discharge elbow, the pipe was restrained by solid numbers in both the horizontal and vertical

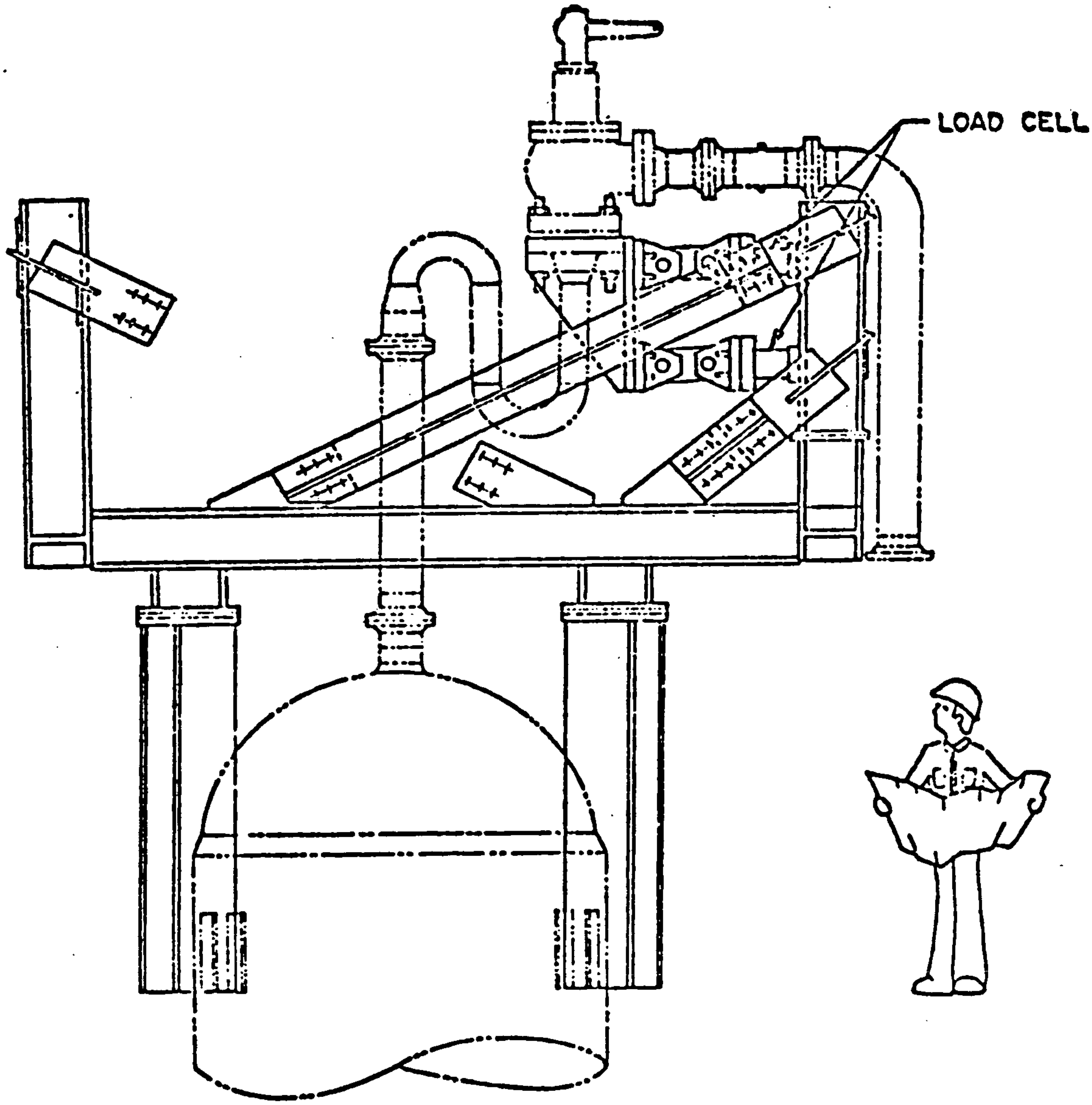


CROSBY 6M6 SAFETY VALVE[9]
FIGURE 4-3

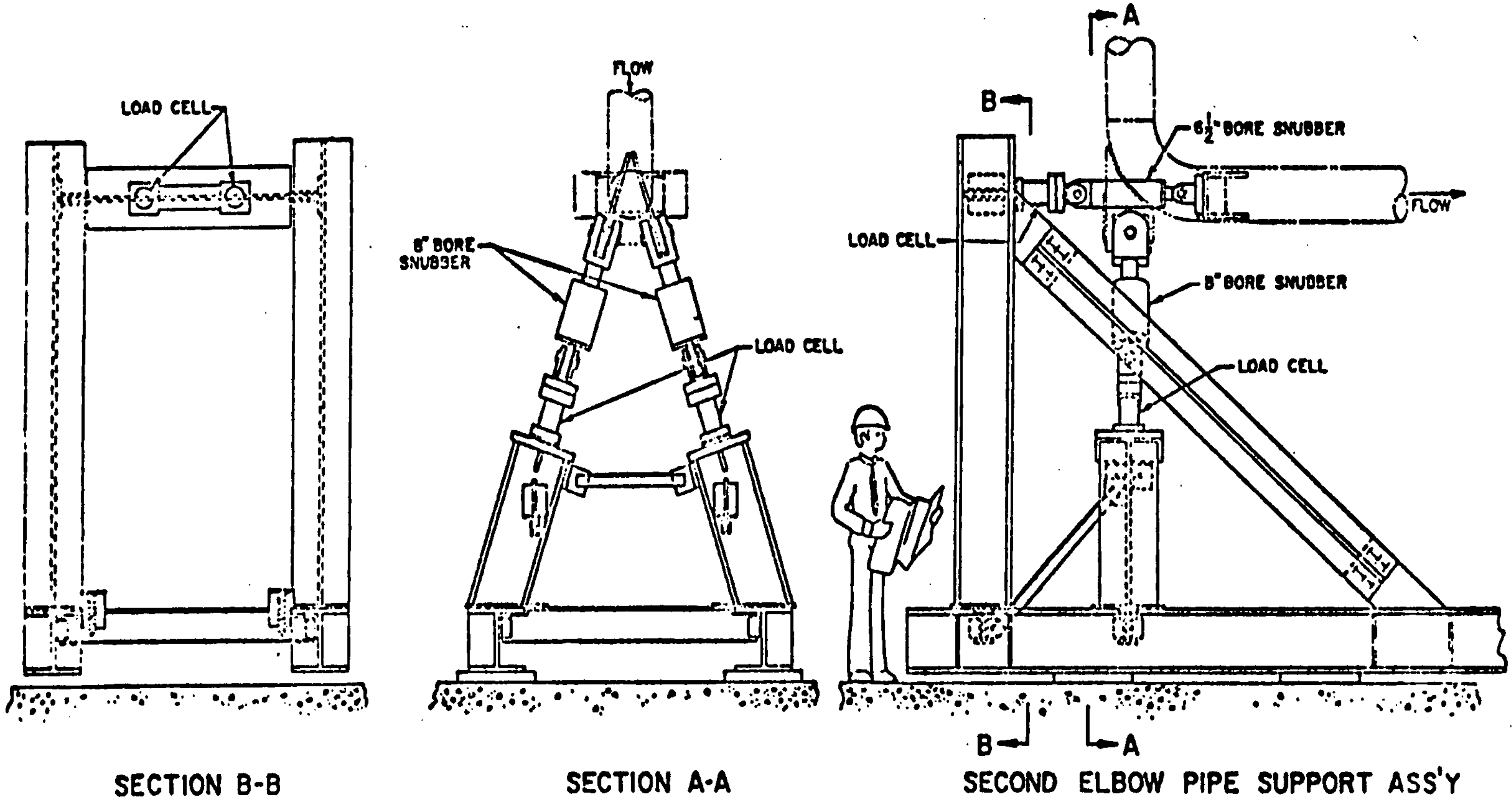


*Note: Configuration is for the Crosby 6M6 tests.

SPOOLPIECE DIAGRAM FOR THE CROSBY 6M6[16]
FIGURE 4-4



UPPER TEST VALVE STAND ASSEMBLY[15]
FIGURE 4-5



SECOND DISCHARGE ELBOW PIPE SUPPORT ASSEMBLY[15]
FIGURE 4-6

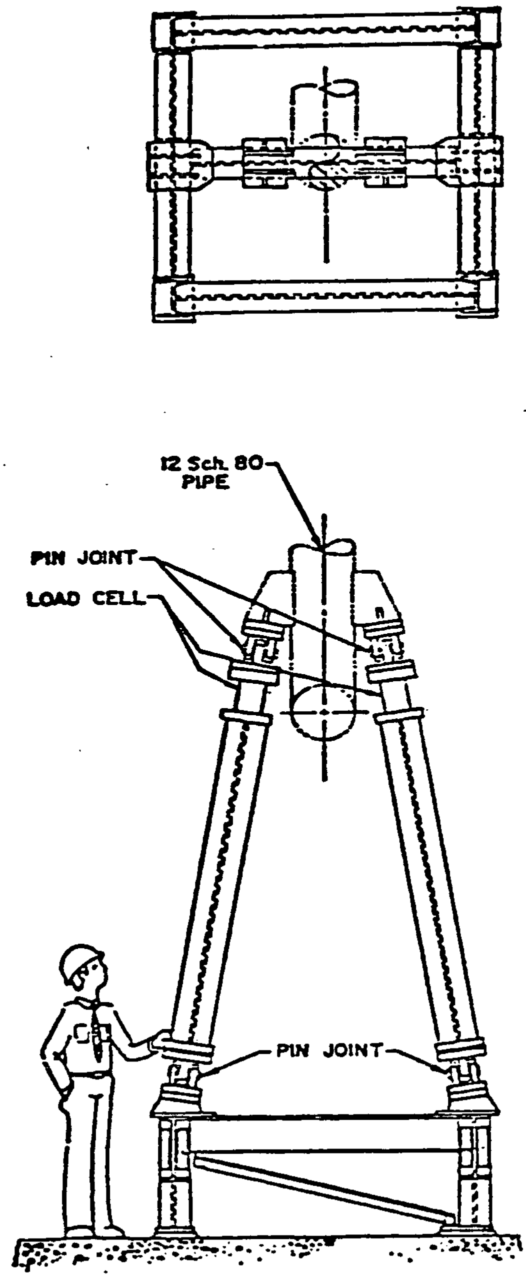


DIAGRAM OF THE THIRD ELBOW[15]
PIPE SUPPORT ASSEMBLY
FIGURE 4-7

directions. The structure midway between the second and third discharge ows also included hydraulic snubbers and was installed to restrict out-of-plane vibration of this relatively long section of pipe. The third elbow support allowed free in-plane horizontal motion but was rigid vertically. A description of the load, strain, and displacement instrumentation installed for measuring valve and piping reaction forces is provided in Subsection 4.1.3.

4.1.3 Instrumentation and Measurements

The instrumentation used in the valve test facility may be divided into two groups: test instrumentation and process instrumentation. Test instrumentation consists of those instruments that provided the basic data for assessing valve operability and for measurement of valve and piping reaction forces. Process instrumentation consists of those instruments provided to aid in operating the test loop and monitoring equipment performance.

Table 4-2 presents a partial list of the instrumentation used in the ve test facility. Figure 4-8 shows the locations of the instrumentation. The instruments are described by measurement types in the following subsections.

4.1.3.1 Load Cell Measurements. Force measurements were made by summing the output of a pair of load-cell transducers. This summation was necessary because of the geometry of the pipe supports. The load cells were Lebow 3156 strain gage type transducers, with an accuracy of ±0.5 percent of the full-scale value.

4.1.3.2 Pressure Measurements. Pressure measurements were made using strain gage-diaphragm type transducers. The accuracy of the 0-3,500 psia as well as the 0-1,500 psia measurements were ±0.27 percent of the full-scale value.

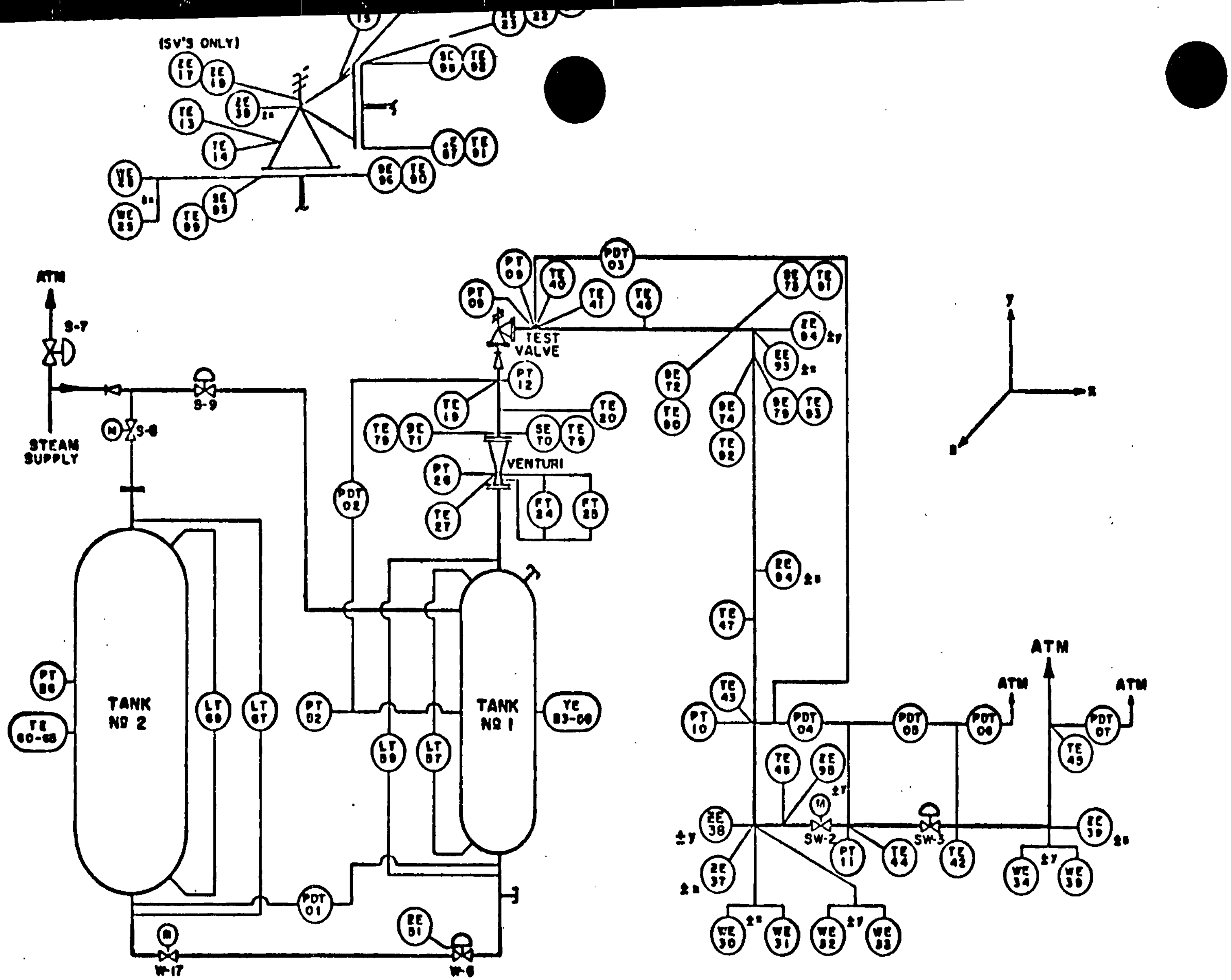
4.1.3.3 Temperature Measurements. Transient temperature measurements were made using Type K thermocouples. The accuracy of these measurements was ±0.75 percent of reading or 4.0 F, whichever was larger.

BLE 4-2. PARTIAL LIST OF CE TEST INSTRUMENTATI

Instrument	Location	Range	Maximum Frequency (HZ)
LOAD CELL MEASUREMENTS			
WE 28 and 29	Support test valve inlet flange (x-axis)	± 25 kips ± 100 kips	200
WE 30 and 31	End of first vertical run discharge pipe (x-axis)	± 25 kips ± 100 kips	200
WE 32 and 33	End of first vertical run discharge pipe (y-axis)	± 25 kips ± 100 kips	200
WE 34 and 35	Support at exterior elbow (y-axis)	± 25 kips ± 100 kips	200
PRESSURE MEASUREMENTS			
PT 08	Valve exit	0-1500 psia	200
PT 09	First horizontal run discharge pipe	0-1500 psia	200
PT 10	Vertical run of discharge pipe at inlet to first elbow	0-1500 psia	200
PT 11	Pressure between SW-2 and SW-3	0-1500 psia	200
PT 12	Test valve inlet	0-3500 psia	500
TEMPERATURE MEASUREMENTS			
TE 19	Test valve inlet	0-800 F	2
TE 20	Test valve inlet	0-800 F	2
TE 40	Test valve outlet	0-800 F	2
TE 41	Test valve outlet	0-800 F	2
TE 42	Downstream of back pressure valve SW-3	0-800 F	2
TE 43	Inlet to second elbow in discharge pipe	0-800 F	2

LE 4-2 (Continued). PARTIAL LIST OF CE TEST I MENTATION[16]

Instrument	Location	Range	Maximum Frequency (HZ)
TEMPERATURE MEASUREMENTS (Continued)			
TE 44	Between valves SW-2 and SW-3	0-800 F	2
TE 45	Exit nozzle	0-800 F	2
TE 46	Inside discharge pipe wall in first horizontal run	0-800 F	2
TE 47	Inside discharge pipe wall in vertical run	0-800 F	2
TE 48	Inside discharge pipe wall in second horizontal run	0-800 F	2
TE 78	Test valve inlet pipe strain gage	0-800 F	2
TE 91	Test valve outlet flange strain gage	0-800 F	2
MASS FLOW MEASUREMENTS			
FT 24	Valve inlet venturi	0-40 psid	20
FT 25	Valve inlet venturi	0-40 psid	20
DISPLACEMENT MEASUREMENTS			
ZE 17	Test valve	± 5 inches	200
ZE 36	Test valve	± 5 inches	200



CE TEST INSTRUMENTATION[15]
FIGURE 4-8

4.1.3.4 Mass Flow Measurements. Mass flow measurements were made by using short-form venturi made by Vickery-Simms (Model Number V-11928-1).

4.1.3.5 Valve Stem Position Measurements. Valve stem position measurements were made using LVDT transducers.

4.1.4 Data Processing

The test program data acquisition system, illustrated schematically on Figure 4-9, provided for the acquisition of test data and processing and presentation of "quick look" data in engineering units. The data obtained were recorded with an on-line digital system. Selected high-frequency measurements were recorded simultaneously on an analog tape recorder.

The digital system consisted of the following hardware.

(1) A Data General S-140 Eclipse CPU with 256 kilobytes of memory and floating-point capabilities.

(2) A 192-channel multiplexer with a 14 bit analog-to-digital converter with a maximum conversion speed of 50,000 Hz.

(3) A 190 megabyte moving head disk unit.

(4) Two digital, nine-track dual-density (800/1,600 BPI) magnetic tape drives.

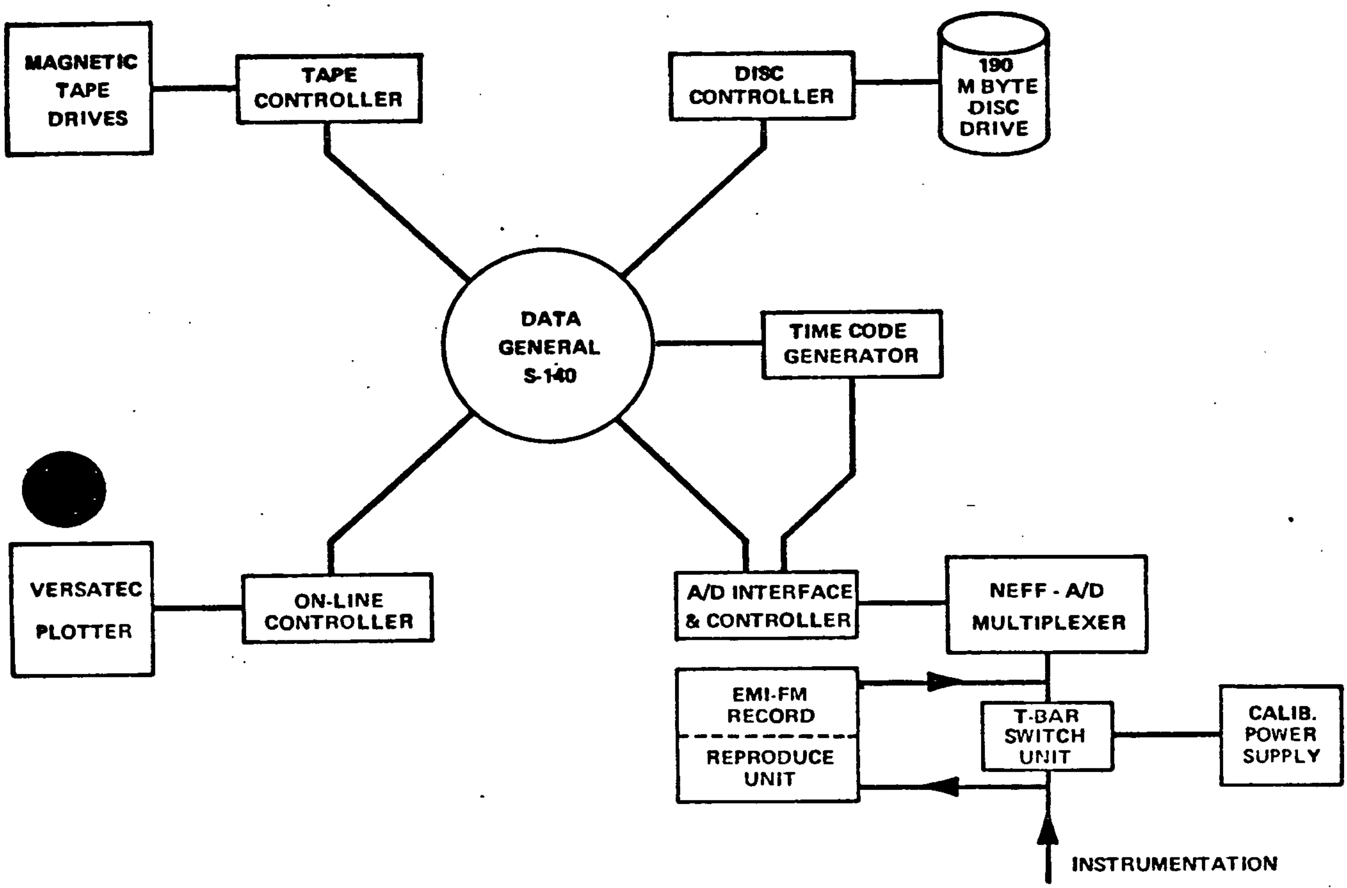
(5) Two cathode-ray tube terminals for system control.

(6) An 11-inch wide electrostatic type plotter.

(7) A 180-characters per second, 132-column printer.

The analog recording system consists of a 42-track EMI magnetic tape record/playback unit. This unit was operated in a frequency-modulated (FM) mode for the acquisition of test data. Event time information was recorded on one track during testing. This feature allowed the location of a particular event on the tape for analysis. An interface between the analog and digital systems allowed the FM tapes to be digitized after the test had been completed.

A software package for the digital system was designed to meet the specific needs of the test program. Operational features of this software were divided into three groups: instrument/calibration history, on-line test loop monitoring, and data acquisition and processing. During pretest



EPRI/CE SAFETY VALVE TEST[15]
DATA ACQUISITION SYSTEM
FIGURE 4-9

and post-test periods of loop operation, a monitor program provided the operations engineer with the pertinent loop-status information. This facilitated the process of bringing the loop to the required pretest conditions. Flexibility was designed into each of these areas to meet present and future requirements for the data package. The instrumentation and calibration history programs compiled a comprehensive set of documentation detailing the measurement system for the duration of testing, thus providing traceability for the measurements made for each individual test.

The data acquisition program was designed to acquire data during loop transients. Data for each measurement were recorded according to the specifications provided in the instrumentation list. As the transient occurred, the data were logged in scan format on the 190-Mbyte disk unit. At the completion of a test, the data file was reorganized into a time-history format. This reorganized data, along with the calibration information for each instrument, were then transferred to magnetic tape for transmittal to the CE Data Center. To meet the requirements of test acceptance, a quick-look data reduction package was written. The required measurement parameters were converted to engineering units and plotted as time histories at the completion of each test. The software package was designed so that the specific parameters to be converted for plotting could be altered during the course of testing.

A software package was provided for the digitizing of FM data. These data were stored on the 190-Mbyte disk and then reorganized to time histories. This file was organized identically to the file generated from the digital data acquired during testing.

4.1.5 <u>Comparison Between CE Test Facility Piping and Kewaunee S/RV Piping</u>

Because the upstream and downstream piping geometrics are important parameters in the safety valve testing, a comparison between the CE Test Facility loop seal piping configuration used to test the Crosby 6M6 safety valve and the Kewaunee safety valve piping configuration is presented below.

The description of the CE Test Facility discharge piping is given in Table 4-3 and an isometric sketch of the CE Test Facility is shown [illegible] Figure 4-10.

S/RV piping configurations of the Kewaunee Power Station are shown on Figures 3-1 and 3-2. A detailed description of the Kewaunee S/RV piping layout is given in Table 3-4 of Subsection 3.2.

The general discharge piping configurations for the CE Test Facility and the Kewaunee Power Plant are in agreement, as shown on Figure 4-11. I should be noted that the Kewaunee piping representation on Figure 4-11 represents the piping from the safety valve PR-3A. Both the test valve an the actual valve discharge into 6-inch Schedule 40 piping proceeds throug a 90 degree elbow and expands through a reducer.

The major differences between the tested discharge piping and the Kewaunee discharge piping are (1) the length of the piping between elbows is longer for the CE facility, (2) the CE Test Facility piping expands int a 12-inch pipe, whereas the Kewaunee piping expands into a 10-inch pipe, and (3) the first discharge elbow at the CE Test Facility is a vertical elbow whereas the Kewaunee first discharge elbow is a horizontal e[illegible].

These differences between the test facility discharge piping and the Kewaunee discharge piping produce significantly different loads; therefor a direct application of the CE tested loads to the Kewaunee discharge piping is not appropriate because the loads produced in the Kewaunee discharge piping will be significantly lower.

TABLE 4-3. COMBUSTION ENGINEERING TEST FACILITY DISCHARGE PIPING

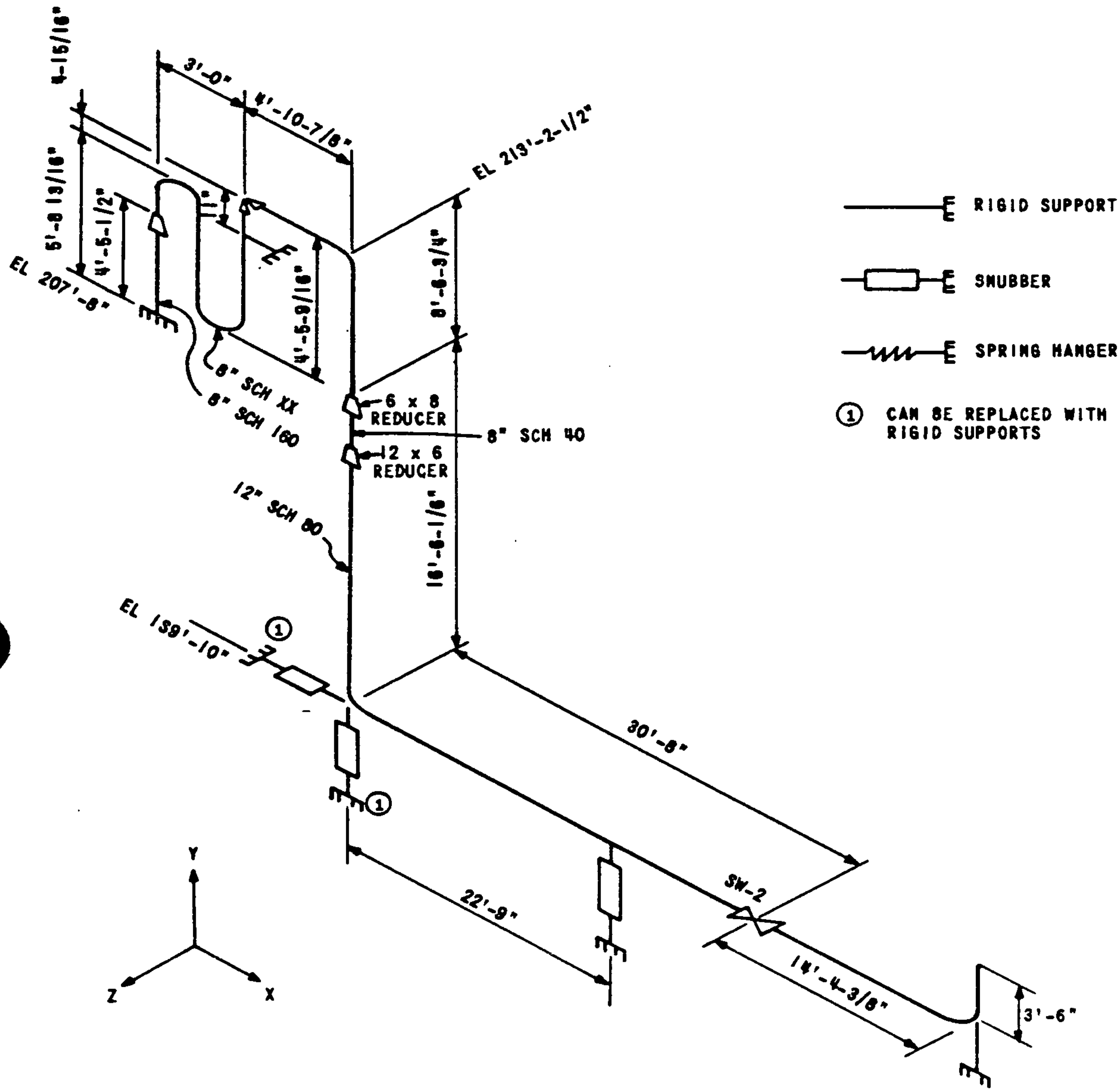
Description	Value
Loop Seal and Tank 1 to the Center of the Safety Valve	
Loop Seal	8-in. SCH 160 and 6-in. SCH XX
Length of 8-in. Pipe from Tank to First 180-Degree Bend	4.7 ft
Center Line Length of First 6-in. 180-Degree Bend	2.4 ft
Length of 6-in. Vertical Pipe from First 180-Degree Bend to Second 180-Degree Bend	1.1 ft
Center Line Length of Second 6-in., 180-Degree Bend*	2.4 ft
Length of 6-in. Vertical Pipe Between Second 180-Degree Bend and Valve	2.3 ft
Length of Vertical Portion of Valve and Flange	0.9 ft
Test Facility Discharge Piping	
Discharge Piping	8-in. SCH 40 and 12-in. SCH 80
Length of Horizontal Portion of Valve and Flange	0.9 ft
Length of 8-in. Horizontal Piping from Valve to First Discharge Elbow	3.9 ft
Center Line Length of First Discharge Elbow	1.6 ft
Length of 8-in. Vertical Piping Between First and Second Discharge Elbow**	7.0 ft
Length of 10-in. Vertical Piping Between First and Second Discharge Elbow**	13.8 ft
Center Line Length of Second Discharge Elbow	2.4 ft
Length of 12-in. Horizontal Piping Between Second Discharge Elbow and Pair of Snubbers Providing Horizontal and Vertical Support**	21.4 ft

TABLE 4-3 (Continued). COMBUSTION ENGINEERING TEST FACILITY DISCHARGE PIPING

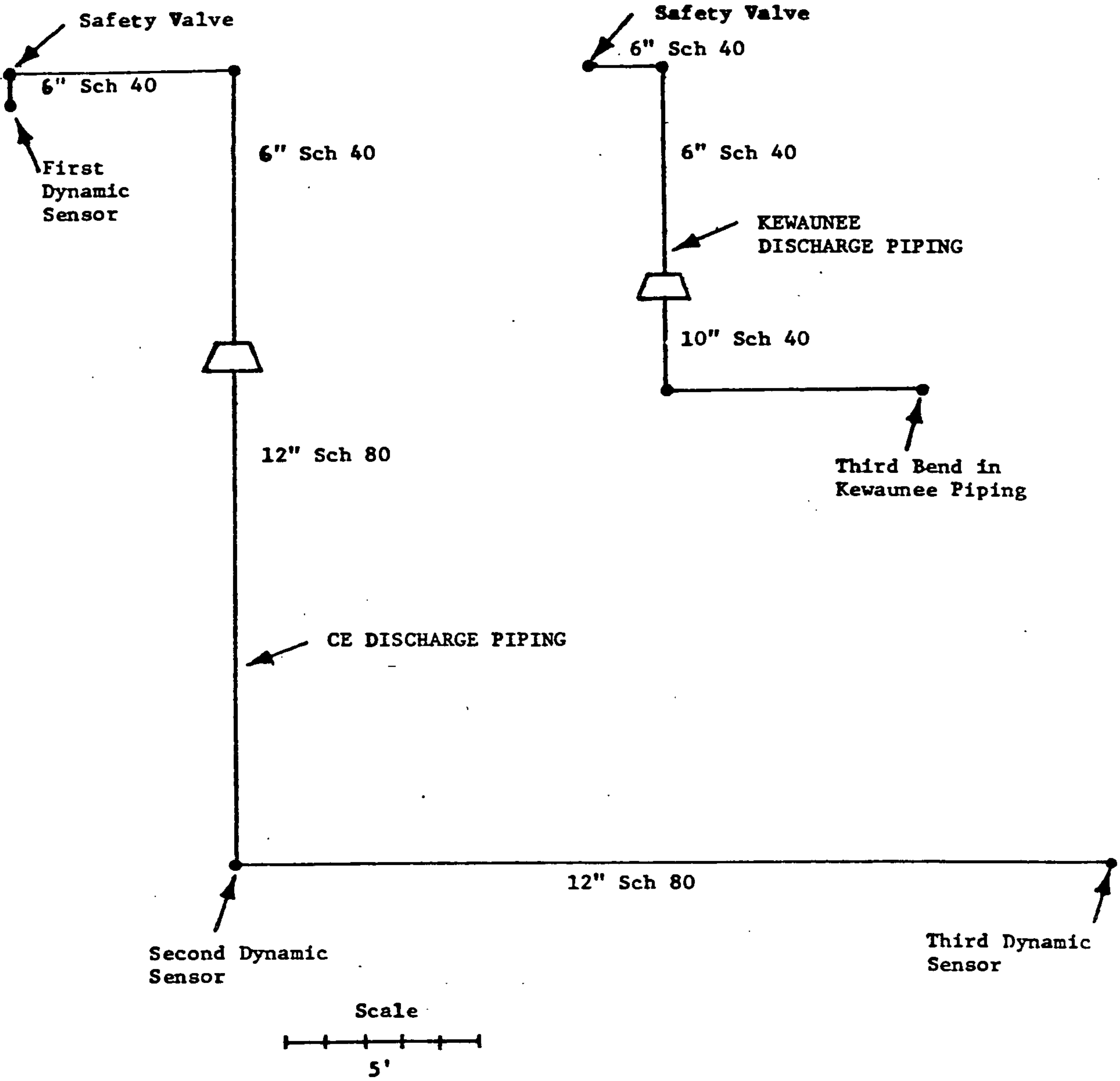
Description	Value
Length of Horizontal Piping Between Snubber Pair and Third Discharge Elbow	16.7 ft
Center Line Length of Third Discharge Elbow (a rigid restraint provides vertical support at third discharge elbow. Pipe then discharges to the atmosphere.)	2.4 ft

*A rigid restraint located at end of second 180-degree bend provides support in plane with loop seal.

**This piping is restrained in the axial direction by a snubber located on the second discharge elbow.



ISOMETRIC OF CE TEST PIPING
SAFETY VALVE WITH LOOP SEAL
FIGURE 4-10



DISCHARGE PIPING SIZE COMPARISON
BETWEEN KEWAUNEE AND CE TEST FACILITY
FIGURE 4-11

5.0 CONDITIONS WHICH MAY CAUSE KEWAUNEE SAFETY AND POWER OPERATED RELIEF VALVE ACTUATION

Many transient situations are evaluated in Kewaunee's Final Safety Analysis Report (FSAR) Chapter 14.[8] The events, which cause actuation of the Kewaunee power operated relief or safety valves, are presented in Table 5-1. Based on the results presented in the Kewaunee FSAR, the power operated relief valves (PORV) provide pressure relief for all evaluations. Some evaluations (locked rotor and loss of load accidents) are evaluated assuming that the PORV did not actuate. Of these two events, the locked rotor accident produces the greater pressure and pressure rise, 2,737 psia and 280 psi/second, respectively. Based on Kewaunee FSAR evaluations, the locked rotor accident, with both PORVs failed, provides the worst case transient for safety valve actuation. The locked rotor accident is presented in the Kewaunee FSAR, page 14.1-35, Subsection 14.1.8. The locked rotor primary pressure transient curve is presented on Figure 14.1-34.

A maximum pressurization rate of approximately 280 psi/second is interpreted from Figure 14.1-34 of the Kewaunee FSAR, and a peak pressure of 2,737 psia is given on page 14.1-38 of the FSAR. The value of 304 psia/second reported in the Kewaunee Piping Report (Table 5-1 of Reference 1), was an overly conservative interpretation of the pressurization rate taken from FSAR Figure 14.1-34. The Kewaunee FSAR lock rotor pressurization rate of 280 psi/second and peak pressure of 2,737 psia are larger than the maximum pressurization rate and peak pressure (240 psi/second and 2,682 psia, respectively) given by Westinghouse for their worst case reference two-loop plant (Table 4-1, "Valve Inlet Fluid Conditions for Pressurizer Safety and Power Operated Relief Valves in Westinghouse-Designed Plants," EPRI NP-2296-LD [March 1982]). Therefore, the Kewaunee locked rotor pressure transient is very conservative when compared with Westinghouse worst case locked rotor analyses and was used in all analyses presented in this report for safety valve actuations.

The loss of load accident with reactor control, pressurizer PORV actuation, and spray valves at the beginning of core life was used as the design basis accident for the double PORV actuation.

TABLE 5-1. KEWAUNEE FSAR EVENTS WHICH CAUSED POWER OPERATED REL[illegible] SAFETY ACTUATION

Accident Condition	Valve Actuated	Maximum Pressure psia/sec	Maximum Pressure Ramp Rate psi/sec	Kewaunee FSAR Section, Figure
Uncontrolled Rod Cluster Control Assemblies Withdrawal from Full Power Terminated by Overtemperature WT Trip	PORV	2,350/42	7.7	14.1.2, 14.1-8
Locked Rotor	Safety Valve[a]	2,737/2.5	280	14.1.8, 14.1-34
Loss of Load with Reactor Control with Pressurizer Power Operated Relief and Spray Valves Beginning of Life[b]	PORV	2,450/15.5	47	14.1.9, 14.1-38
Loss of Load Accident with Reactor Control with Pressurizer Power Operated Relief and Spray Valve End of Life[c]	PORV	2,355/5	43	14.1.9, 14.1-40
Loss of Load Accident with No Reactor Control. No Pressurizer Power Operated Relief or Spray Valves--Beginning of Life[d]	Safety Valve	2,545/8.5	50	None
Loss of Load Accident with No Reactor Control. No Pressurizer Power Operated Relief or Spray Valves--End of Life[d]	Safety Valve	2,528/9	48	None

Accident Condition	Valve Actuated	Description
Rupture of Control Rod Drive Mechanism	PORV	No transient curves. For FSAR and RESAR, the "System Overpress Analysis" indicate the reliefs may open. Relief actuation is covered under other events.
Loss of Normal Feedwater	Pipe break, pump failure, valve malfunctions, or loss of offsite power	"The loss of normal feedwater does not result in any adverse condition in tbe core, because it does not result in water relief from the pressurizer power operated relief or safety valve. . ." (p. 14.1-48 of Kewaunee FSAR).

[a] PORVs would normally open but were left closed for this analysis.

[b] Full credit assumed for pressurizer spray, PORVs and control, and insertion. No credit taken for steam dump.

[c] Full credit assumed for pressurizer spray, PORVs, and control rod insertion.

[d] No credit taken for the pressurizer spray, PORVs, or steam dump.

6.0 QUALIFICATION OF THE PROCEDURE FOR DETERMINING PIPING LOADS DUE TO THE OPENING OF A SAFETY OR POWER OPERATED RELIEF VALVE

There are several postulated reactor coolant system transients which may result in the actuation of the pressure relief system. These transients range from normal system transients to postulated accidents such as those analyzed in plant safety analysis reports. Typically, these plant transients result in a pressurization of the steam in the dome of the pressurizer which causes the power operated relief and/or safety valves to open, thereby mitigating the overpressure transient. In most of the transients postulated, the valves open with the pressurizer steam dome full of saturated or slightly superheated steam.

Several types of valves are in service in pressurized water reactors (PWR). These valves include spring-loaded safety valves and various types of relief valves ranging from power-operated relief valves (PORV) to air-operated, globe-type control valves. Generally, the PORV and safety valves differ in both flow capacity and opening rate. Typically, PORVs are low-capacity valves which open on the order of hundreds of milliseconds, whereas safety valves are high-capacity, fast-acting devices opening on the order of tens of milliseconds. The testing at the Combustion Engineering (CE) test facility focused on spring-loaded safety valves, and all of the results presented in this section are for this type of valve. (Section 4.0 describes the CE test facility.)

Two basic pipe inlet geometries are used between the pressurizer and the safety valve in PWRs. One consists of a vertical run of pipe designed to maintain steam against the valve seat. The other consists of a piping loop configuration designed to maintain a subcooled water seal, or water loop seal, against the valve seat. The latter design, which is employed at Kewaunee, has the advantage of limiting steam leakage through the valve under normal conditions.

The analysis of pressure relief/discharge piping transients is very complex and may involve the flow of nonequilibrium steam, water, or two-phase mixtures through the valve into a discharge pipe generally containing air or nitrogen. The recently released RELAP5/MOD1[17,18,19] code provides the capability to more accurately calculate the phenomena expected to occur during pressure relief system transients. Appendix A of this report discusses the RELAP5/MOD1 code in more detail.

6.1 EPRI RELAP5 QUALIFICATION

As part of the EPRI S/RV testing program, EPRI contracted with Inter-Mountain Technology, Inc., (ITI)[16] to qualify RELAP5/MOD1 for use in determining thermal/hydraulic loading on the S/RV discharge piping caused by the activation of valves. The performance of RELAP5/MOD1 was demonstrated by comparison with test data from the CE safety valve tests for a range of test conditions.

Six CE tests were evaluated in the ITI report. These tests are listed in Table 6-1.

The loads and deflections recorded at the CE test facility were the combined results of two interrelated components. The first of these components was the hydrodynamic loading resulting from safety valve fluid discharge. The second component of the recorded test data was the dynamic structural response of the test facility to these hydrodynamic loadings. If the test facility and its support system had been infinitely rigid, the measured data would have consisted of only the hydrodynamic loadings, and the hydrodynamic loads calculated using RELAP5/MOD1 analyses could have been compared directly with the recorded test data. Because of the structural response characteristics of the test facility, the recorded data deviated from the actual hydrodynamic loading. This phenomenon of dynamic response characteristics is present in all structures which are subjected to dynamic loadings. The magnitude of this response at the CE test facility was determined by performing a dynamic structural analyses. These analyses were performed by Combustion Engineering and ITI.[16] The purpose of the dynamic structural analyses which were performed as part of the EPRI/ITI evaluation of RELAP5/MOD1 was to enable the inclusion of the structural response in comparing RELAP5/MOD1 load predictions with recorded test data.

The RELAP5/MOD1-predicted hydraulic loads, in the form of time history forcing functions, were used as input loads for the CE dynamic structural

TABLE 6-1. CE TESTS USED BY ITI FOR EVALUATION OF RELAP5/MOD1

Test Number	Valve	Actuation Pressure (psia)	Test Conditions
1411	Crosby 6M6*	2,410	Saturated steam actuation followed by steam discharge.
917	Crosby 6M6*	2,460	Hot water (350 F) loop seal actuation followed by steam discharge.
908	Crosby 6M6*	2,560	Cold water (80 F) loop seal actuation followed by steam discharge.
1017	Dresser 31739A**	2,530	Cold water (80 F) loop seal actuation followed by steam discharge.
1027	Dresser 31739A**	2,350	Subcooled liquid (620 F) actuation and discharge.

*6-inch pipe inlet and 6-inch pipe discharge.

**2.5-inch pipe inlet and 6-inch pipe discharge.

: Detailed RELAP5 model descriptions and input listings to all the cases are in Reference 16.

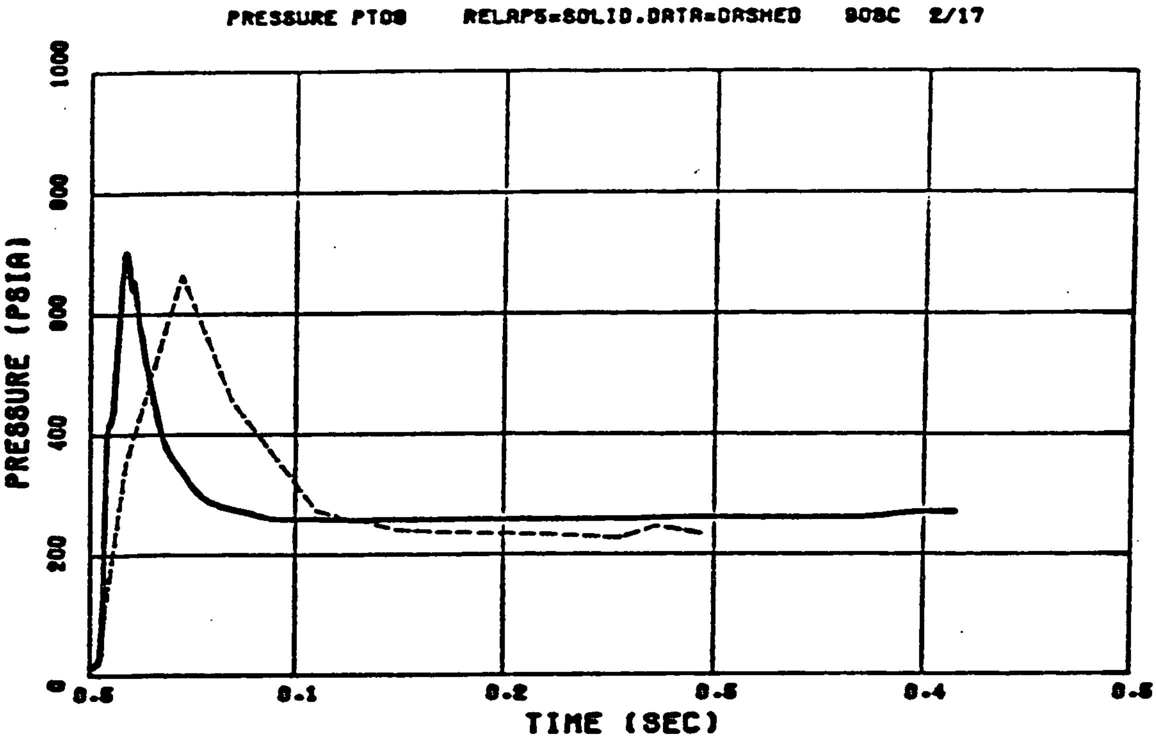
analysis. The RELAP5/MOD1 data consisted of four separate forcing functions ch were applied at pipe segments. The stiffness matrix and inertia matrix of the structural model were calculated by the DYNAL version of the STRUDL computer code.[16] The STRUDL stiffness matrix was then modified to include nonlinear support stiffnesses by the DAGS computer code.[16] The RELAP5/MOD1 forcing functions were then applied to the modified stiffness matrix and the mass matrix with the DAGS computer code. The results of the DAGS analysis consisted of support load time histories.

To complete the EPRI/ITI evaluation of the RELAP5/MOD1 calculations, the results obtained from the DAGS analysis with RELAP5/MOD1 input were compared with experimental data obtained from the CE safety valve test facility. In addition, measured pressures were compared with the code calculations.

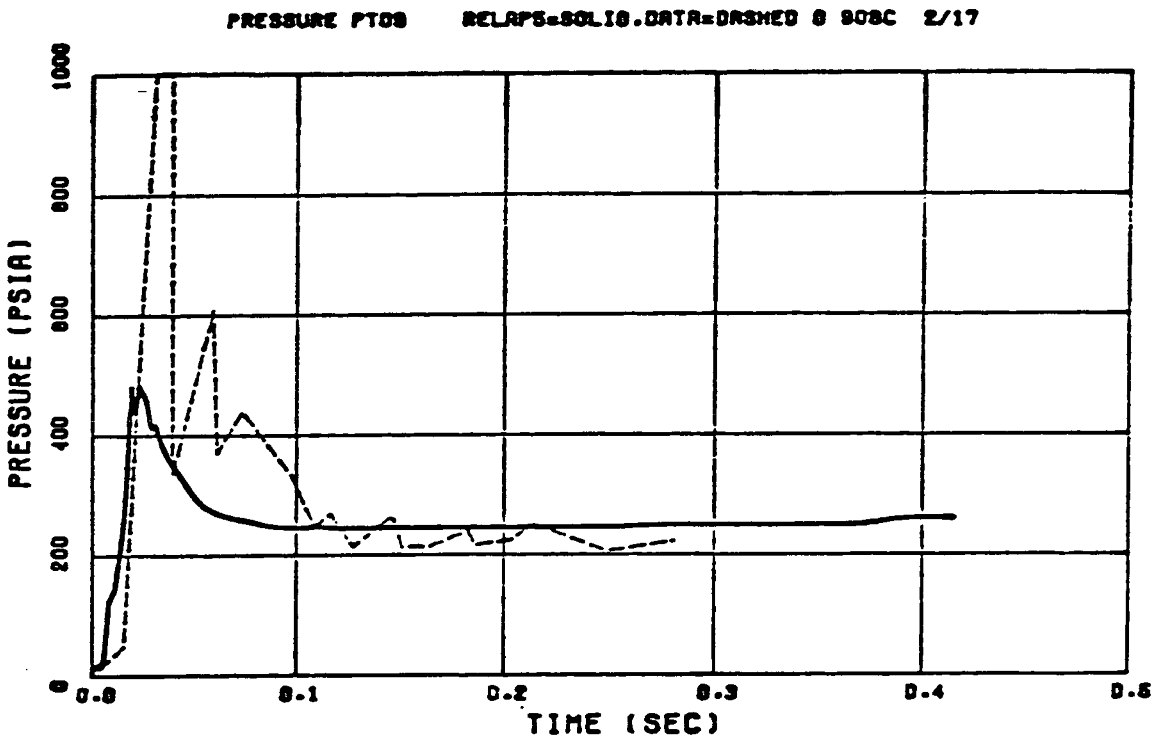
Because the Kewaunee safety valve piping contains a Crosby $6M_{1}6$ safety valve with a cold loop seal, only EPRI/ITI test comparisons with CE test 908 will be presented in this section.

ITI calculated pressures and forces for CE test 908 using RELAP5/MOD1 CE DAGS are shown on Figures 6-1 through 6-10. Description of the referenced pressure measurement points (PT08, PT09, PT10, and PT11) and the load segments are found in Section 4.0 of this report. The RELAP5/MOD1 pressure calculation comparisons were in good agreement with the experimental results (Figures 6-1 through 6-10). The measured pressure of PT09 (Figure 6-2) was determined by EPRI personnel to be a spurious pressure reading and deemed it to be unrealistically high.

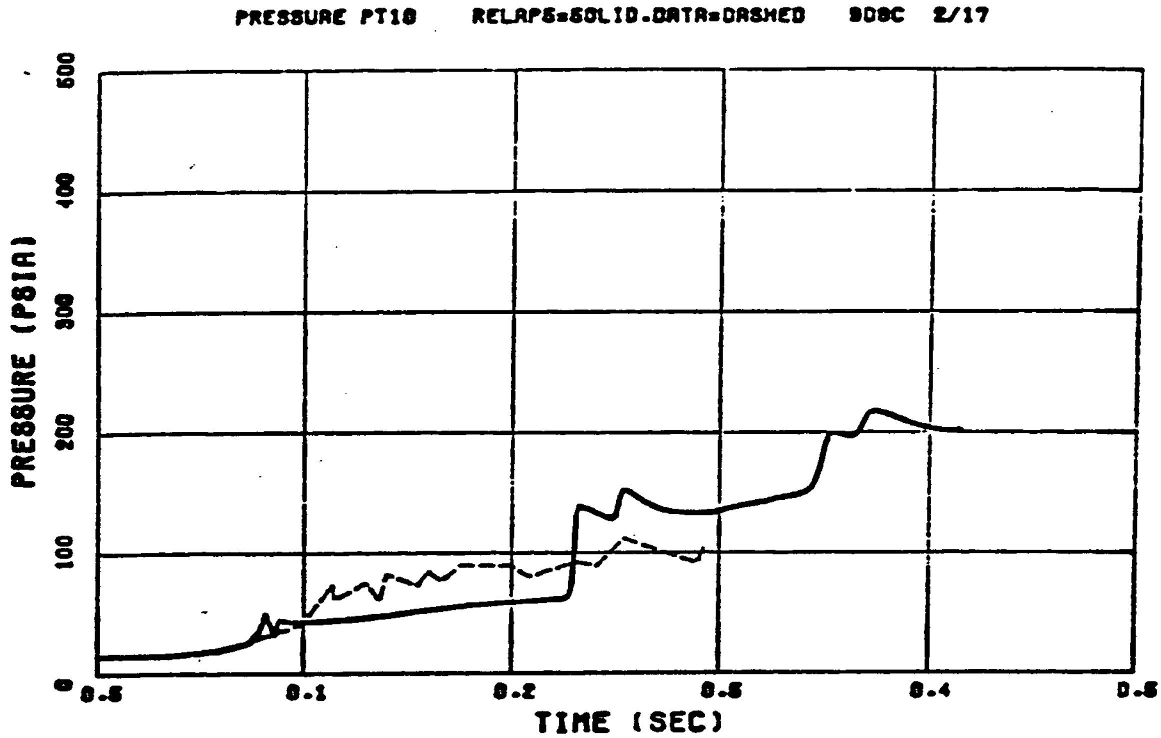
The RELAP5 force calculations for CE test dynamic sensors of Segment 1, Segment 2, and Segment 3 are presented on Figures 6-5 through 6-10. As can be seen from the figures, each force segment measurement has two associated figures. The first figures (Figures 6-5, 6-7, and 6-9) represent the force calculated using RELAP5 only compared against the measured load, and the second figures (Figures 6-6, 6-8, and 6-10) present the calculated results using RELAP5 and the DAGS structural calculation. As seen from these comparisons, the dynamic structural response of the CE test facility has a significant impact on the measured loads. The implication of this is that



COMPARISON PLOT OF ITI RELAP5/MOD1-CALCULATED PRESSURE[16]
WITH PT08 EXPERIMENTAL DATA, TEST 908
FIGURE 6-1

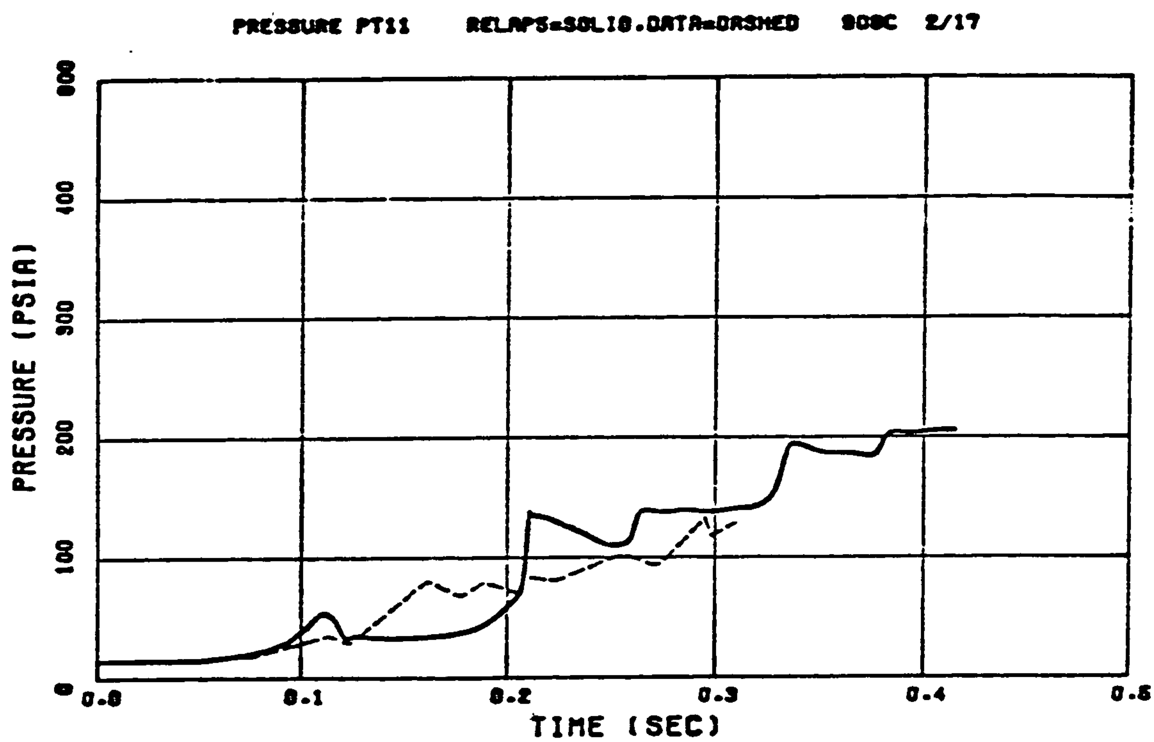


COMPARISON PLOT OF ITI RELAP5/MOD1-CALCULATED PRESSURE[16]
WITH PT09 EXPERIMENTAL DATA, TEST 908
FIGURE 6-2



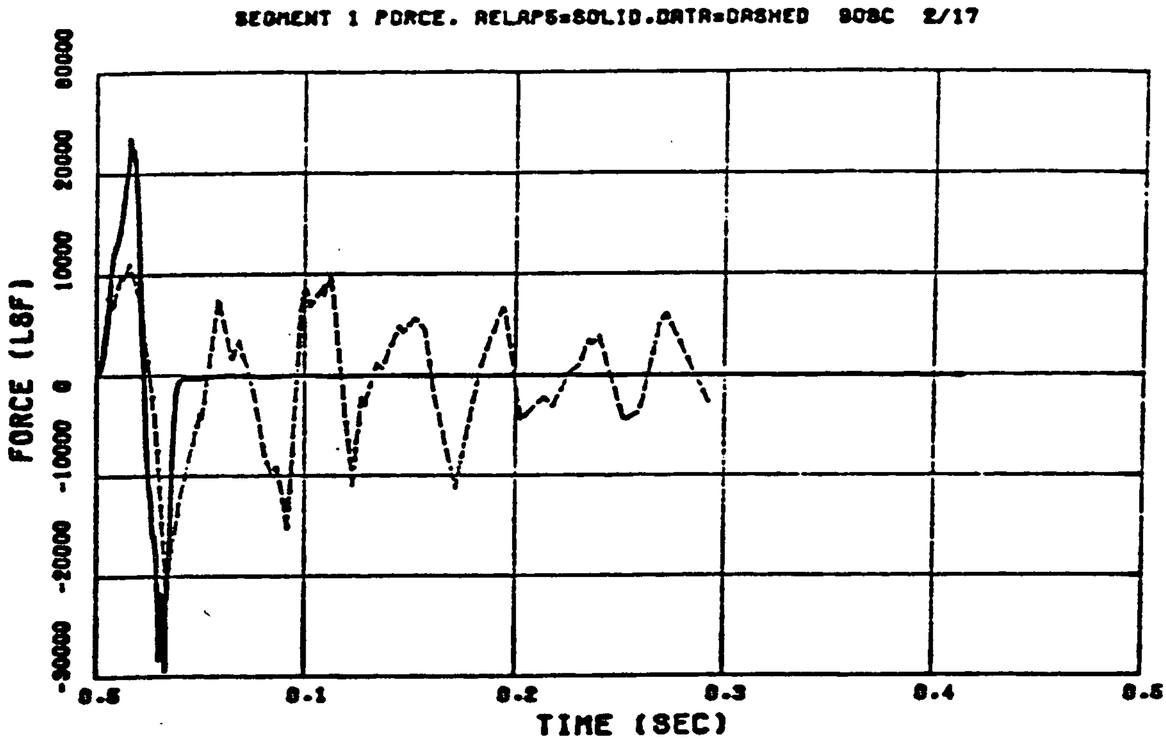
COMPARISON PLOT OF ITI RELAP5/MOD1-CALCULATED PRESSURE WITH PT10 EXPERIMENTAL DATA, TEST 908[16]

FIGURE 6-3



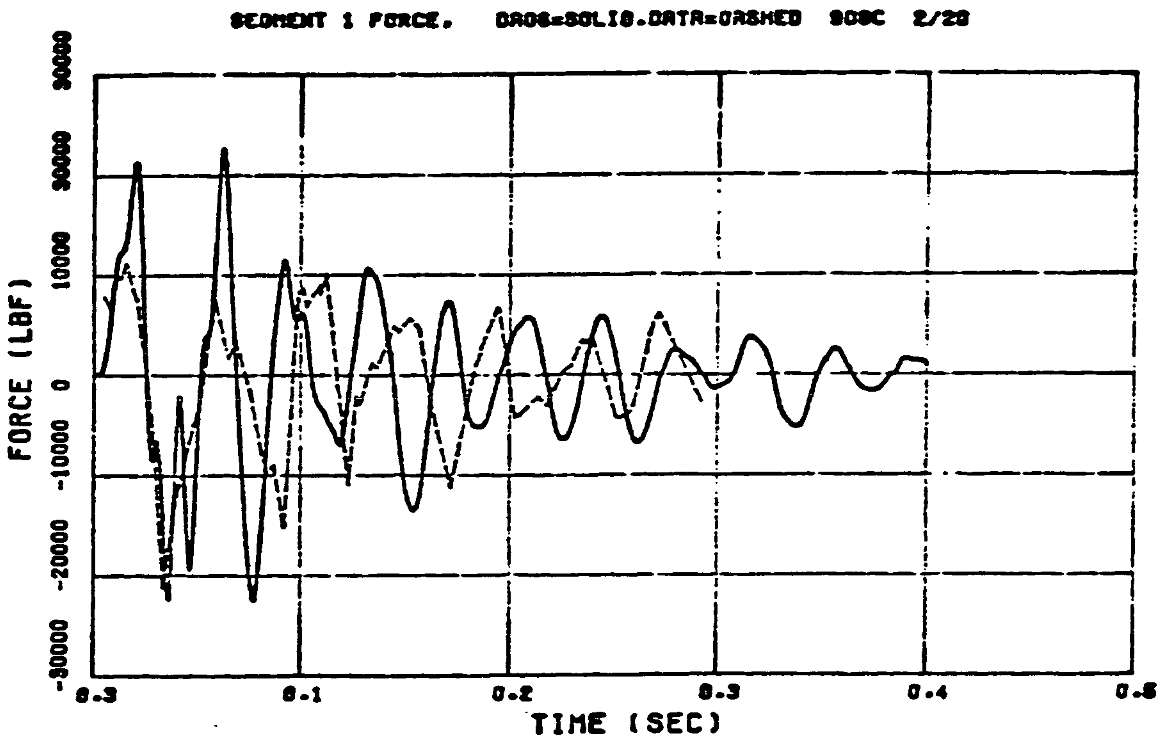
COMPARISON PLOT OF ITI RELAP5/MOD1-CALCULATED PRESSURE WITH PT11 EXPERIMENTAL DATA, TEST 908[16]

FIGURE 6-4



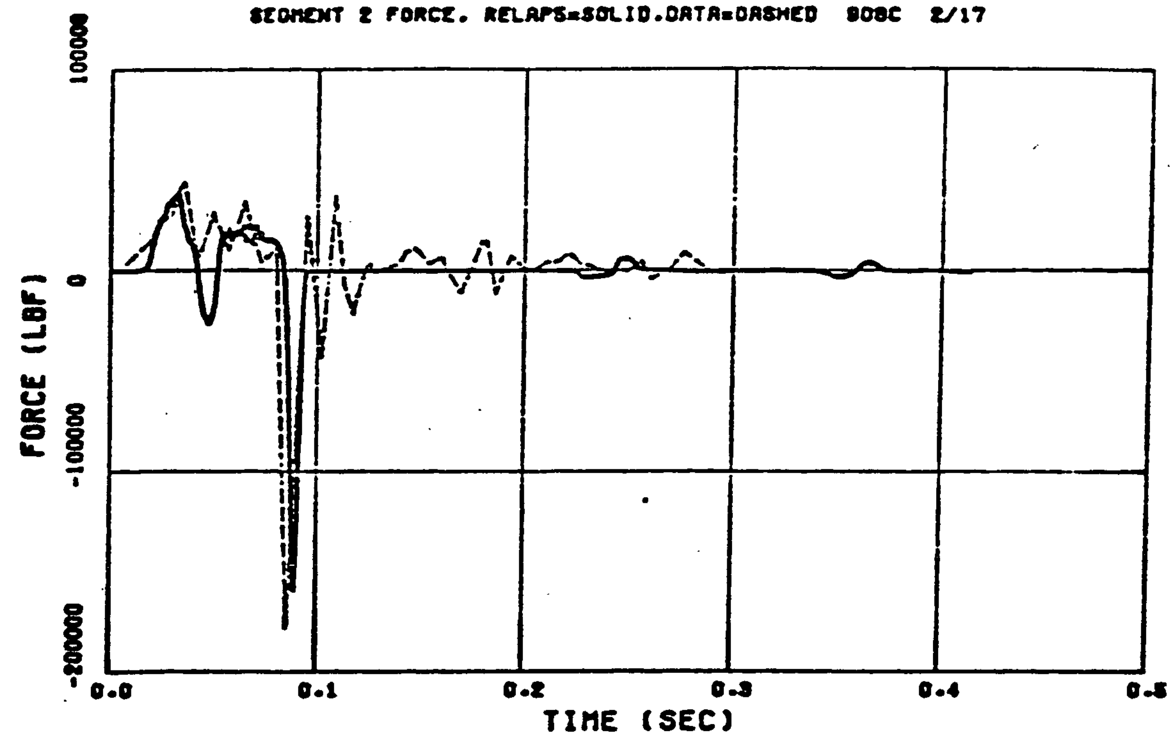
COMPARISON PLOT OF ITI RELAP5/MOD1-CALCULATED SEGMENT 1 FORCE WITH EXPERIMENTAL DATA, TEST 908[16]

FIGURE 6-5

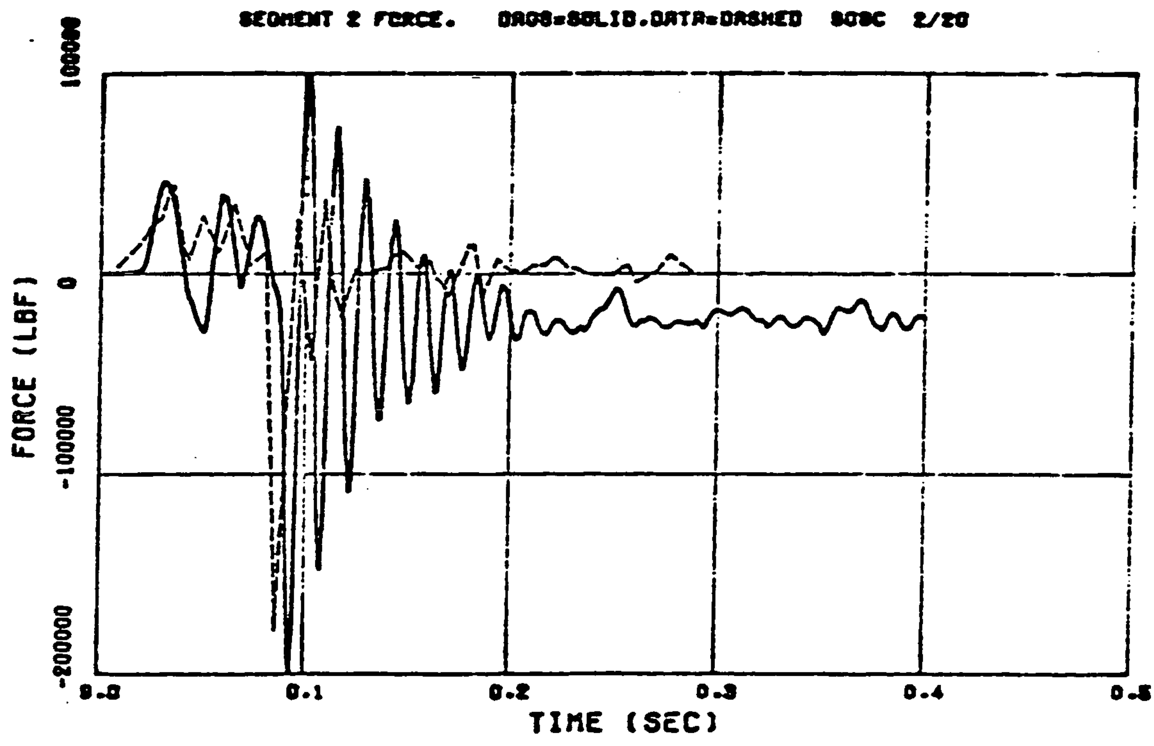


COMPARISON PLOT OF ITI/CE DAGS-CALCULATED SEGMENT 1 FORCE WITH EXPERIMENTAL DATA, TEST 908[16]

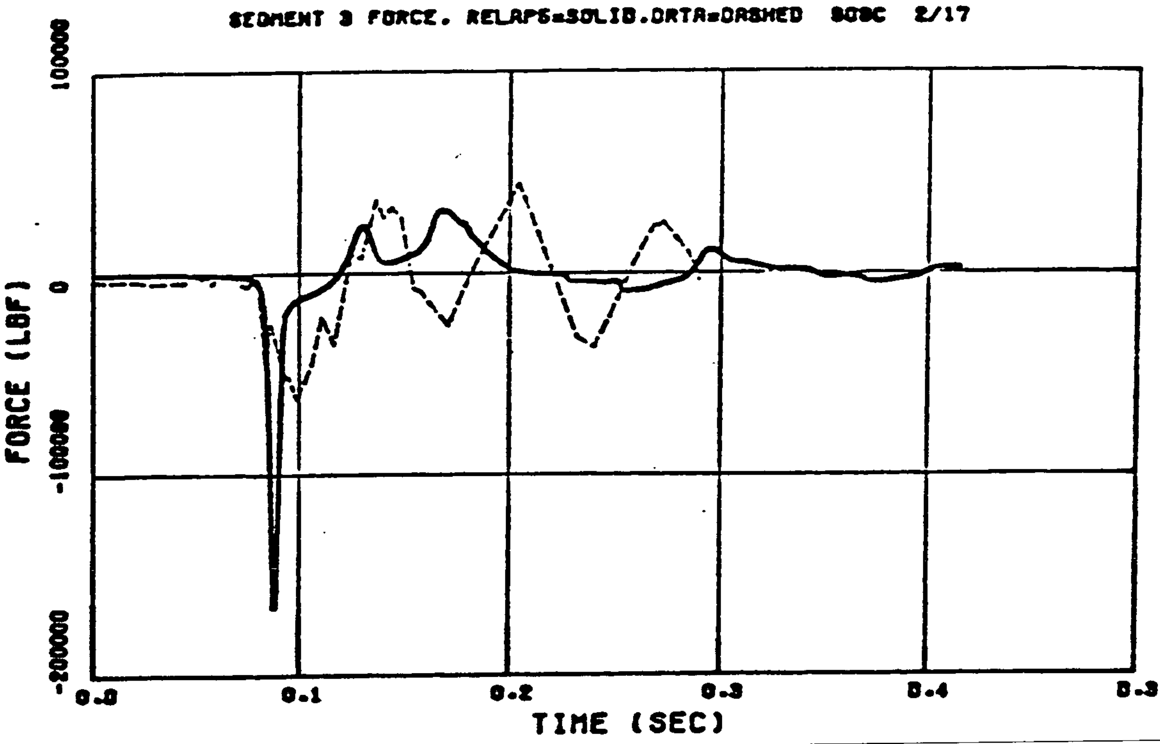
FIGURE 6-6



COMPARISON PLOT OF ITI RELAP5/MOD1-CALCULATED SEGMENT 2 FORCE WITH EXPERIMENTAL DATA, TEST 908[16]
FIGURE 6-7

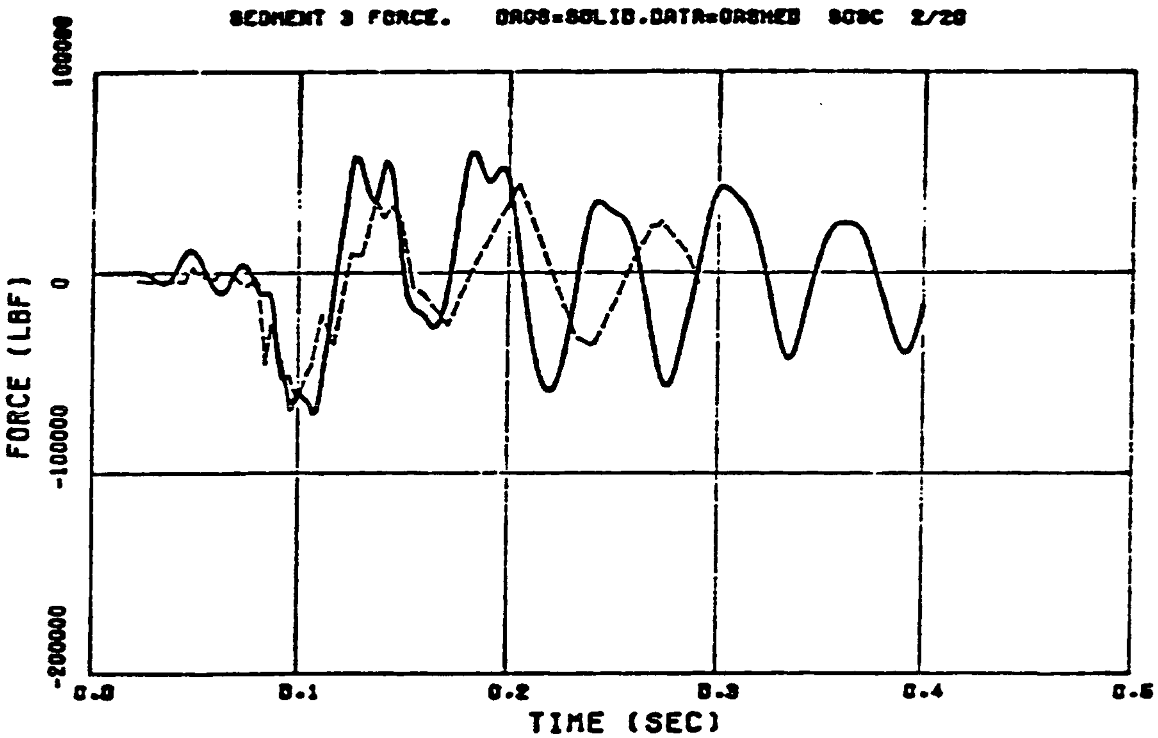


COMPARISON PLOT OF ITI/CE DAGS-CALCULATED SEGMENT 2 FORCE WITH EXPERIMENTAL DATA, TEST 908[16]
FIGURE 6-8



COMPARISON PLOT OF ITI RELAP5/MOD1-CALCULATED SEGMENT 3 FORCE WITH EXPERIMENTAL DATA, TEST 908[16]

FIGURE 6-9



COMPARISON PLOT OF ITI/CE DAGS-CALCULATED SEGMENT 3 FORCE WITH EXPERIMENTAL DATA, TEST 908[16]

FIGURE 6-10

the measured loads at the CE test facility were actually a combination of the thermal/hydraulic loads and the structural response of the CE test facility. In all cases, once the structural response of the CE test facility was accounted for using the DAGS computer code, the RELAP5 prediction proved to be very good and in most cases RELAP5 predicted the peak load response without the DAGS interface.

In the course of the ITI investigations, several RELAP5 code modifications were made. Only one of these modifications was appropriate for use in the Kewaunee piping analysis. During the activation of a safety valve, the downstream air-water critical temperature can be exceeded. Modifications were made to RELAP5 to remove these programming limits. More information concerning this modification is given in Appendix A.

Several recommendations and conclusions were made by ITI. These are discussed in the following.

The capability of RELAP5/MOD1 for calculating the fluid-induced loads on piping downstream of S/PORVs has been evaluated by comparing analytical results with test data from selected CE safety valve tests. The following conclusions were taken from the ITI evaluation.[15]

(1) The RELAP5/MOD1 code can be used to calculate the transient thermal/hydraulic processes which occur in the piping downstream of S/PORVs following valve actuation. The code provides useful results for steam discharge, liquid-water discharge, and water-loop-seal-followed-by-steam discharge with downstream initial conditions of air and steam.

(2) RELAP5/MOD1-calculated parameters can be used as input for several calculational methods to provide useful engineering estimates of the hydrodynamic loads imposed on the discharge piping.

(3) The structural contribution to the measured experimental data must be taken into account when comparing calculated results with measured test data from the CE safety valve test facility.

(4) During this study it was observed that nodalization, time step selection, heat structure applications, and other code options can significantly affect computer running time.

(5) User input data and the selection of RELAP5/MOD1 code options ca significantly affect calculated results. The following men dations are offered in this regard.

   (a) The nodalization of piping networks must be selected with the calculation of hydrodynamic forces in mind if results are to be used for that purpose. For steam discharge transients, the nodalization of short (less than 5 feet) piping lengths must include 8-10 control volumes to avoid underestimating hydrodynamic loads by more than 10 percent. For water loop seal transients, the control volume size should be less than or equal to the water volume to avoid underestimation of loads caused by numerical smearing.

   (b) Estimation of the hydrodynamic loads for cases which invol a cold water (less than 212 F) loop seal should be initialized with the loop seal water distributed in the first few control volumes downstream of the valve.

   (c) For steam-only discharge, piping heat transfer can significantly affect the thermal/hydraulic behavior in th n-stream piping. Best-estimate calculations of piping loads should include the effects of piping heat transfer. Computing costs can be reduced without changing results by not using piping heat transfer at area changes.

   (d) The alternate choking model in RELAP5/MOD1 should not be used in the discharge piping for power operated relief and safety valve transient calculations.

6.2 QUALIFYING TEST AND TEST RESULTS

The post-processor computer codes used on the Kewaunee plant-specif analyses to convert the RELAP5 calculated parameters (pressures, velocit densities, accelerations, etc.) into thermal/hydraulic forces are the REPIPE and FORCE post-processors (Appendix B discusses these codes).

For the original Kewaunee as-built S/RV piping analyses, the RELAP5 REPIPE computer code combination was used to calculate two variations of the loop seal discharges (original piping report[1]). As will be presented in this report and was previously presented in Section 6.3 of Reference 1, a RELAP5/REPIPE model was developed to simulate CE Test 908 which was the test that closely approximated the Kewaunee plant-specific faulted conditions. Two cases were analyzed using REPIPE as the RELAP5 post-processor. As identified in Section 6.4 of Reference 1, comparisons were made between test data[20] and RELAP5/REPIPE CALCULATIONS. The two cases run assumed water upstream and downstream of the safety valve. The results, as presented in Section 6.4 of Reference 1, produced agreement with test information. The REPIPE time steps used for the Kewaunee plant specific evaluation were chosen from experience gained in evaluating these two cases. Based on these calculations using REPIPE, the REPIPE time steps used were judged to be adequate for Kewaunee plant specific evaluations.

The capabilities of RELAP5/REPIPE are demonstrated in the following paragraphs. Comparisons between calculations performed using the RELAP5/REPIPE computer code combination and experimental data were performed to qualify modeling procedures which were used on the plant specific Kewaunee [illegible] piping. Agreement between calculated forces and measured forces qualified the use of REPIPE for post-processor calculations.

Based on results of the ITI report[16] and CE test results, CE Test 908 was chosen for comparison. This test is very representative of the Kewaunee pressurizer safety valve (PSV) and discharge piping configuration except for the following major differences.

(1) The valve orifice (valve flow area) for the Crosby 6M6 has approximately 21 percent greater flow area than the Kewaunee Crosby $6M_16$ valve orifice (3.0 sq in. for M_1 orifice versus 3.64 sq in. for the M orifice).

(2) The loop seal water volume for Test 908 was 1.18 cu ft, whereas the Kewaunee loop seal water volume is 0.7 cu ft. Therefore, the tested 908 loop seal contains approximately 70 percent more loop seal water than the Kewaunee loop seal.

(3) The Kewaunee plant-specific safety valve discharge piping has shorter piping runs between the 90-degree elbows than the CE test facility discharge piping (Figure 4-11).

The CE Test 908 results are presented in Appendix E and are given in Reference 16. In Appendix E, pressures and force measurements, along with valve stem position and the venturi flow, are presented. Basically, the test results showed that the safety valve began to simmer when the Accumulator Tank 1 pressure (this tank at the CE test facility simulates the pressurizer) exceeded 2,580 psia. This simmering process took about 1.0 second. For Test 908, the simmering time of the valve represents the clearing through the safety valve of the cold water in the loop seal. At approximately 34.3 seconds into the CE Test 908 transient, the valve began to "pop" open. This popping process took about 0.012 second.

After the valve popped open, the saturated steam that passed through the safety valve from the Accumulator Tank 1, expanded behind the downstream water slug.

This expanding steam caused the water slug to accelerate through the downstream piping, which created very large thermal/hydraulic forces on th piping system.

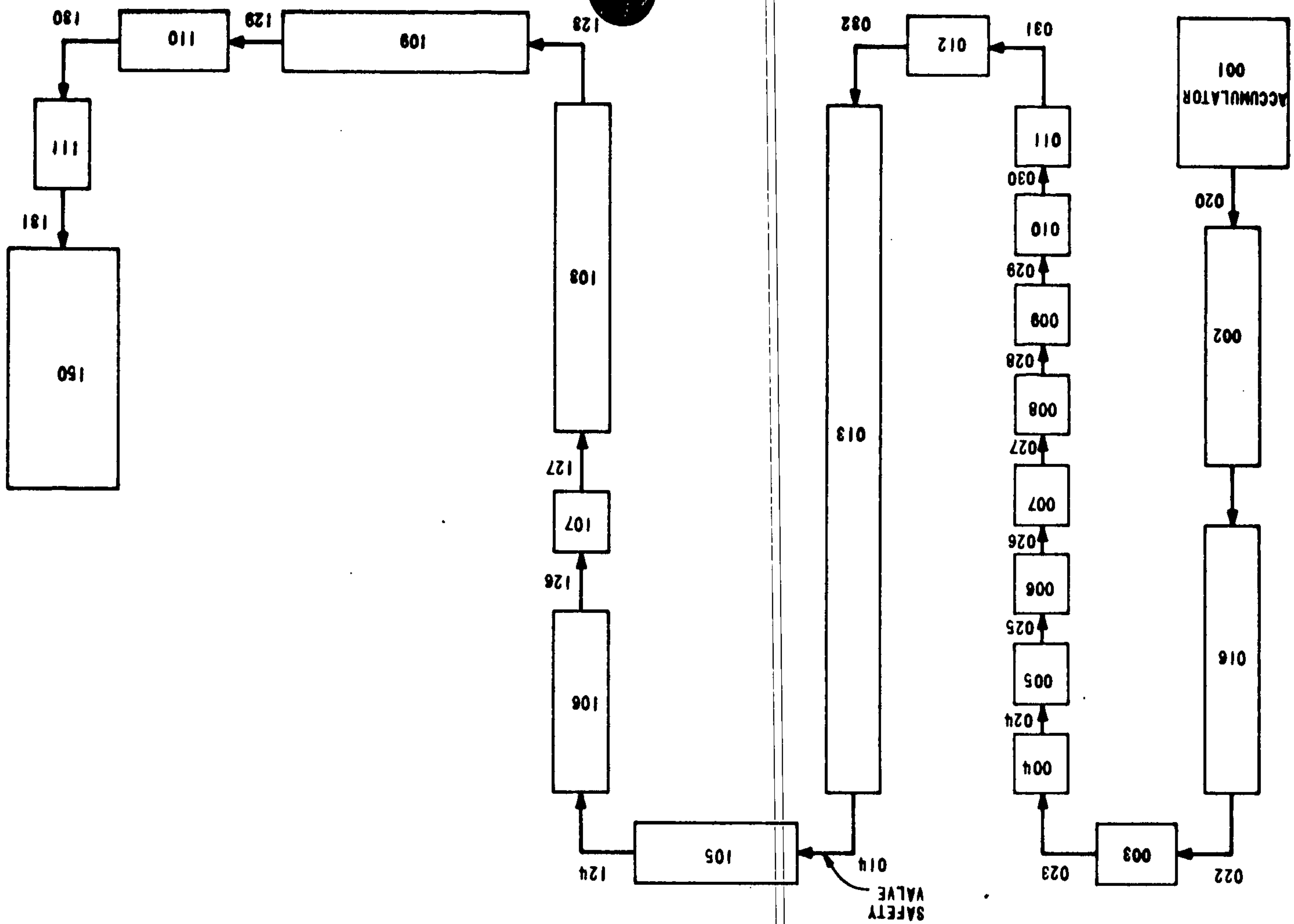
The largest of these forces was measured at the W32 and W33 dynamic sensors in CE Test 908. This peak load was measured to be 177,000 pounds and is shown in Appendix E for W32 and W33. This load is also shown on Figures 6-7 and 6-8.

6.3 RELAP5/REPIPE AND RELAP5/FORCE MODELS AND DESCRIPTIONS FOR EXPERIMEN VERIFICATION

A RELAP5/REPIPE model was developed to simulate CE Test 908. Descri tions of RELAP5 and REPIPE are presented in Appendix A and B, respectivel A RELAP5 nodal diagram of CE Test 908 is presented on Figure 6-11. A detailed description of the input parameters for this RELAP5 model is presented in Table 6-2.

In the subsequent analyses of the Kewaunee rupture disk configuratio (described in Section 9.0), the FORCE post-processor was used in place of REPIPE to determine thermal/hydraulic loads based on the output from RELA FORCE was developed by Dr. Joe Chang for Boeing Computer Services.

Many benchmark comparisons were used to establish the accuracy of th RELAP5/FORCE calculations. The comparisons included running an analysis



RELAP5 NODALIZATION OF THE CE TEST 908
FIGURE 6-11

TABLE 6-2. DOWNSTREAM PIPING DATA--CE TEST 908--WATER DOWNSTREAM*

Component	Component Type	Volume or Junction Number	Area sq ft	Length ft	Vertical Angle degrees	Initial Conditions**	Forward Loss	Reverse Loss	Description
001	TMDPVOL	V1	10.0	50.0	90.0	Table: Time - P - Q_s	--	--	Accumulator vessel volume = 500 cubic feet.
020***	SNGLJUN	J1	0.253	--	--	--	0.485	0.980	
002	PIPE	V1-2	0.253	1.629	90.0	P=2686.0 Q_s=1.0			Vertical segment from pressurizer.
		J1	0.253	--	--	--	0.0	0.0	
021	SNGLJUN	J1	0.144	--	--	--	0.103	0.114	Junction to venturi.
016	PIPE	V1-2	0.253	1.344	90.0	P=2686.0 Q_s=1.0	--	--	8-inch pipe into loop seal.
		J1	0.253	--	--	--	0.0	0.0	
022***	SNGLJUN	J1	0.131	--	--	--	0.188	0.231	8 by 6-inch reducer and first loop seal elbow.
003	PIPE	V1/J=0	0.131	1.745	0.0	P=2686.0 Q_s=1.0	--	--	Horizontal segment, top of loop seal.
023	SNGLJUN	J1	0.131	--	--	--	0.155	0.155	Second loop seal elbow.
004	PIPE	V1/J=0	0.131	0.326	-90.0	P=2686.0 Q_s=1.0	--	--	Vertical segment.
024	SNGLJUN	J1	0.131	--	--	--	0.0	0.0	
005	PIPE	V1/J=0	0.131	0.326	-90.0	P=2686.0 Q_s=1.0	--	--	Vertical segment.
025	SNGLJUN	J1	0.131	--	--	--	0.0	0.0	
006	PIPE	V1/J=0	0.131	0.326	-90.0	P=2686.0 Q_s=1.0	--	--	Vertical segment.
026	SNGLJUN	J1	0.131	--	--	--	0.0	0.0	
007	PIPE	V1/J=0	0.131	0.326	-90.0	P=2686.0 Q_s=1.0	--	--	Vertical segment.
027	SNGLJUN	J1	0.131	--	--	--	0.0	0.0	
008	PIPE	V1/J=0	0.131	0.326	-90.0	P=2686.0 Q_s=1.0	--	--	Vertical segment.
028	SNGLJUN	J1	0.131	--	--	--	0.0	0.0	
009	PIPE	V1/J=0	0.131	0.326	-90.0	P=2686.0 Q_s=1.0	--	--	Vertical segment.
029	SNGLJUN	J1	0.131	--	--	--	0.0	0.0	
010	PIPE	V1/J=0	0.131	0.326	-90.0	P=2686.0 Q_s=1.0	--	--	Vertical segment.
030	SNGLJUN	J1	0.131	--	--	--	0.0	0.0	
011	PIPE	V1/J=0	0.131	0.326	-90.0	P=2686.0 Q_s=1.0	--	--	Vertical segment.
031	SNGLJUN	J1	0.131	--	--	--	0.155	0.155	Third loop seal elbow.
012	PIPE	V1-3	0.131	0.785	0.0	P=2686.0 Q_s=1.0	--	--	Horizontal segment, bottom of loop seal.
		J1-2	0.131	--	--	--	0.0	0.0	
032	SNGLJUN	J1	D.131	--	--	--	0.155	0.155	Fourth loop seal elbow.

6-2 (Continued). DOWNSTREAM PIPING DATA--CE TEST 908--WATER DOWNSTREAM

Component	Component Type	Volume or Junction Number	Area sq ft	Length ft	Vertical Angle degrees	Initial Conditions**			Forward Loss	Reverse Loss	Description
013	PIPE	V1-3	0.131	0.456	90.0	P=2686		Q_S=1.0	--	--	Vertical segment extending to S/RV.
		V4	0.131	0.456	90.0	P=2686	T=627		--	--	
		V5	0.131	0.456	90.0	P=2686	T=376		--	--	
		V6	0.131	0.456	90.0	P=2686	T=273		--	--	
		V7	0.131	0.456	90.0	P=2686	T=213		--	--	
		J1-6	0.131	--	--		--		0.0	0.0	
014***	VALVE-SRVVLV	J1	0.0182	--	--		--		0.9	0.9	S/RV.
105	PIPE	V1	0.201	0.669	0.0	P=14.7	T=165		--	--	Horizontal segment from S/RV to first elbow downstream.
		V2-3	0.201	0.653	0.0	P=14.7	T=132		--	--	
		V4	0.201	0.540	0.0	P=14.7	T=129.6		--	--	
		V5-8	0.201	0.551	0.0	P=14.7	T=117		--	--	
		J1-7	0.201	--	--		--		0.0	0.0	
124	SNGLJUN	J1	0.201	--	--		--		0.172	0.172	First elbow.
106	PIPE	V1-13	0.201	0.492	-90.0	P=14.7	T=80.0	Q_N=0.978	--	--	Vertical segment from first elbow to reducer.
		J1-12	0.201	--	--		--		0.0	0.0	
126	SNGLJUN	J1	0.201	--	--		--		0.0	0.0	
107	PIPE	V1	0.274	0.500	-90.0	P=14.7	T=80	Q_N=0.978	--	--	6 by 12-inch reducer.
		V2	0.347	0.448	-90.0	P=14.7	T=80	Q_N=0.978	--	--	
		V3	0.527	0.667	-90.0	P=14.7	T=80	Q_N=0.978	--	--	
		J1	0.274	--	--		--		0.033	0.026	
		J2	0.347	--	--		--		0.124	0.044	
127	SNGLJUN	J1	0.527	--	--		--		0.0	0.0	
108	PIPE	V1-29	0.706	0.508	-90.0	P=14.7	T=80	Q_N=0.978	--	--	Vertical segment from reducer to second elbow.
		J1-28	0.706	--	--		--		0.0	0.0	
128	SNGLJUN	J1	0.706	--	--		--		0.167	0.167	Second elbow.
109	PIPE	V1-20	0.706	1.515	0.0	P=14.7	T=80	Q_N=0.978	--	--	Horizontal segment from second elbow to gate valve mid-line.
		J1-19	0.706	--	--		--		0.0	0.0	
129	SNGLJUN	J1	0.706	--	--		--		0.15	0.15	

6-2 (Continued). DOWNSTREAM PIPING DATA--CE TEST 908--WATER DOWNSTREAM

Component	Component Type	Volume or Junction Number	Area sq ft	Length ft	Vertical Angle degrees	Initial Conditions**			Forward Loss	Reverse Loss	Description
110	PIPE	V1-8	0.706	1.755	0.0	P=14.7	T=80	Q_N=0.978	--	--	Horizontal segment from gate valve mid-line to third elbow.
		J1-7	0.706	--	--		--		0.0	0.0	
130	SNGLJUN	J1	0.706	--	--		--		0.167	0.167	Third elbow.
111	PIPE	V1-2	0.706	0.583	0.0	P=14.7	T=80	Q_N=0.978	--	--	Vertical segment from third elbow to orifice.
		V3	0.559	0.583	0.0	P=14.7	T=80	Q_N=0.978	--	--	
		J1	0.706	--	--		--		0.0	0.0	
		J2	0.706	--	--		--				
131***	SNGLJUN	J1	0.083	--	--		--		1.29	1.29	Orifice.
150	TMDPVOL	V1	100.0	1.0E9	90.0	Table:	Time - P - T - Q_N		--	--	Atmosphere.

*Assumptions: No choking was assumed to occur in pipe.
Wall friction was computed.
Nonequilibrium calculations were made (unequal phase temperatures).
Pipe roughness was assumed to be 0.00015.

**P = Pressure (psi)
T = Temperature (degrees F)
Q_N = Noncondensable quality (air)
Q_S = Static or equilibrium quality (steam)
Flag 2 has: P, Q_S
Flag 3 has: P, T
Flag 4 has: P, T, Q_N

***Abrupt area change is assumed for junction flag.

using RELAP5/REPIPE and running the same simulation using RELAP5/FORCE. forces generated by each method were almost identical.

Other analyses were made using the RELAP5/FORCE combination which included simulating CE Test 908, CE Test 1411, Edwards' Pipe Problem, and Hanson's Problem. Each of the calculations were in agreement with the test data. Therefore, the time steps used for FORCE calculations were also found to be acceptable in determining Kewaunee plant-specific thermal/hydraulic loads.

6.3.1 Loop Seal Temperature Determination

Because the amount of subcooling in the loop seal is important for the determination of the downstream forces on the discharge piping, an evaluation was made of the temperature profile in the Test 908 loop seal. EPRI provided outside thermocouple measurements of the loop seal.[16,20] These measurements are presented on Figure 6-12. Because most of these measurements were made on the outside wall of the loop seal, an evaluation of the actual temperature profile for the water inside the pipe was made using the dimensional heat transfer code - TAC2D. A description of this code is given in Appendix C of this report.

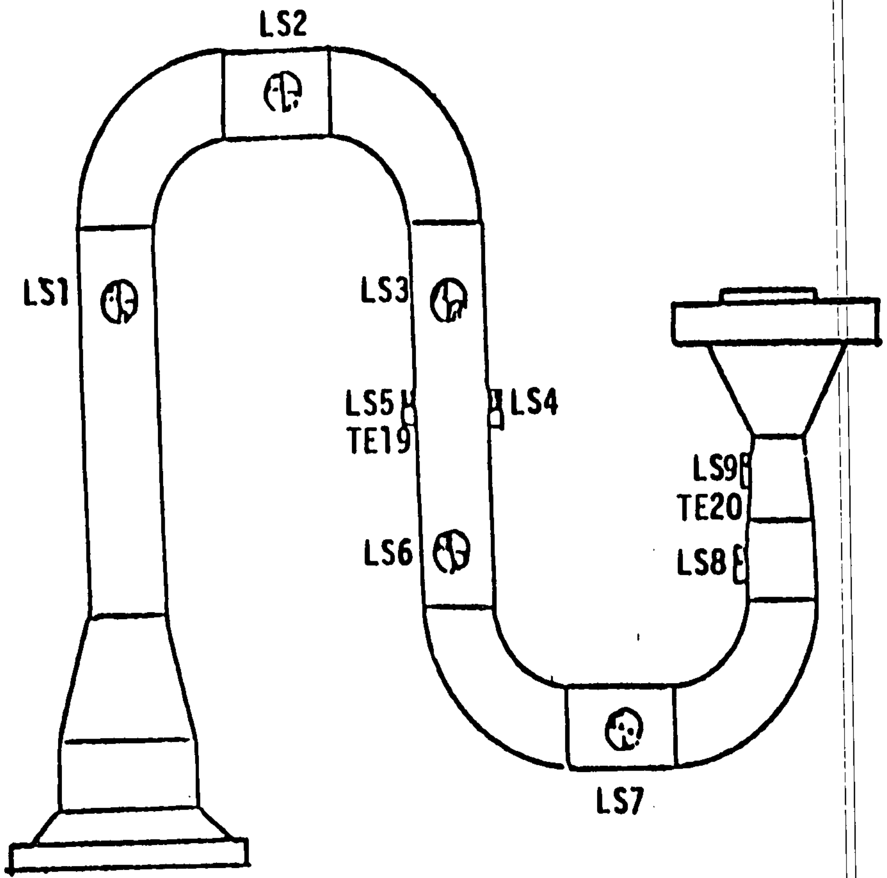
The Test 908 loop seal, including piping steel thickness and ambient conditions, was modeled using TAC2D to determine the actual temperature profile of the water in the Test 908 loop seal piping. The loop seal with the TAC2D mesh intervals is illustrated on Figure 6-13. The TAC2D calculated results are presented in Table 6-3 and are shown on Figure 6-14.

The results of the TAC2D temperature profile calculation were integrated into the RELAP5 input by applying the appropriate water temperature to the appropriate RELAP5 control volume.

6.4 COMPARISONS BETWEEN CALCULATED AND TEST RESULTS

The RELAP5 model discussed in Section 6.3 was used to evaluate two simulation cases of CE Test 908.

The first RELAP5/REPIPE simulation was to assume that during the valve simmering time all subcooled water above 212 F was displaced as an intact



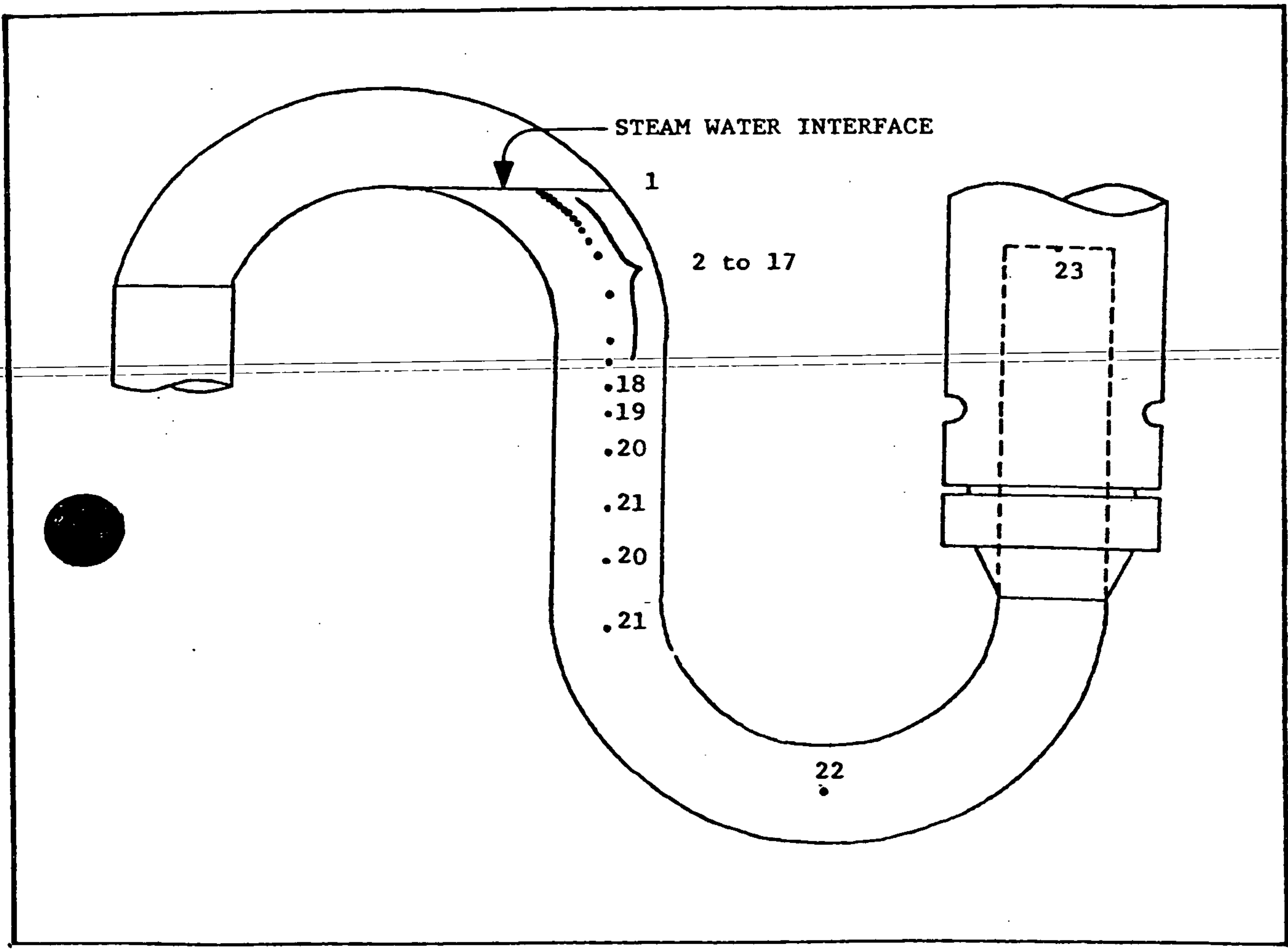
Outside Wall Temperatures

LS1 - 633.5°F
LS2 - 619.0°F
LS3 - 224.5°F
LS4 - 157.5°F
LS5 - 160.0°F
LS6 - 149.0°F
LS7 - 119.0°F
LS8 - 114.5°F
LS9 - 104.5°F

Fluid Temperatures

TE19 - 155°F
TE20 - 109°F

TEST 908 LOOP SEAL TEMPERATURE PROFILE[19]
FIGURE 6-12



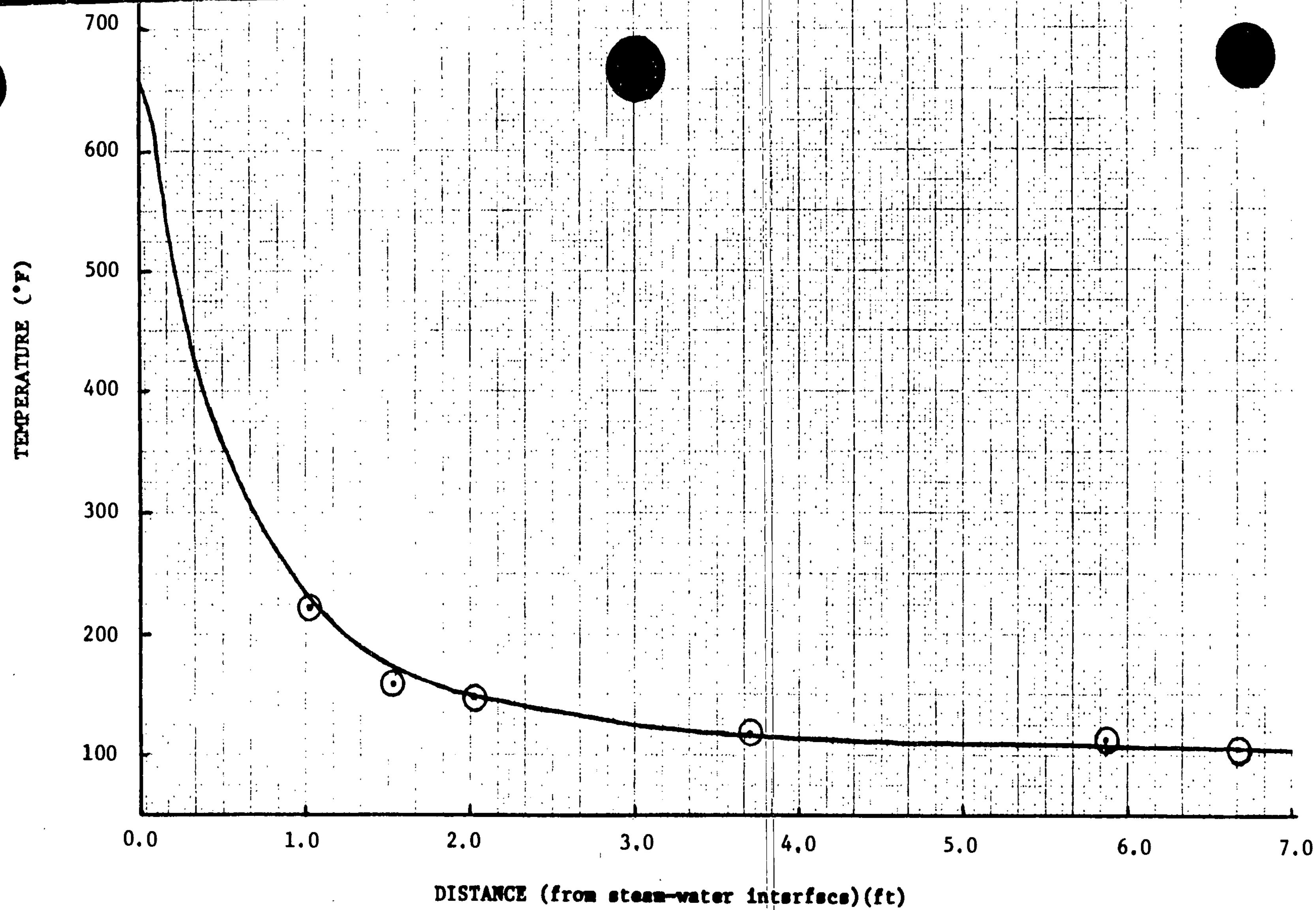
CE 908 LOOP SEAL TAC2D MESH
FIGURE 6-13

TABLE 6-3. CE 908 LOOP SEAL TEMPERATURE DISTRIBUTION AS CALCULATED WITH TAC2D

Node*	Distance** (ft)	Temperature (F)
1	.008	652
2	.025	645
3	.042	640
4	.058	635
5	.075	630
6	.094	625
7	.115	590
8	.135	568
9	.156	555
10	.188	530
11	.229	495
12	.292	450
[illegible]	.436	380
[illegible]	.604	325
15	.75	280
16	.938	248
17	1.146	210
18	1.458	180
19	1.875	155
20	2.292	140
21	2.708	130
22	3.790	115
23	8.160	102

*Figure 6-13.

**Measured from steam-water interface.



CE 908 LOOP SEAL WATER TEMPERATURE DISTRIBUTION
USING TAC2D
FIGURE 6-14

water slug downstream of the safety valve. The second simulation was to [illegible]p" the valve open with the water still in the loop seal, and only air at 82 F located downstream of the valve.

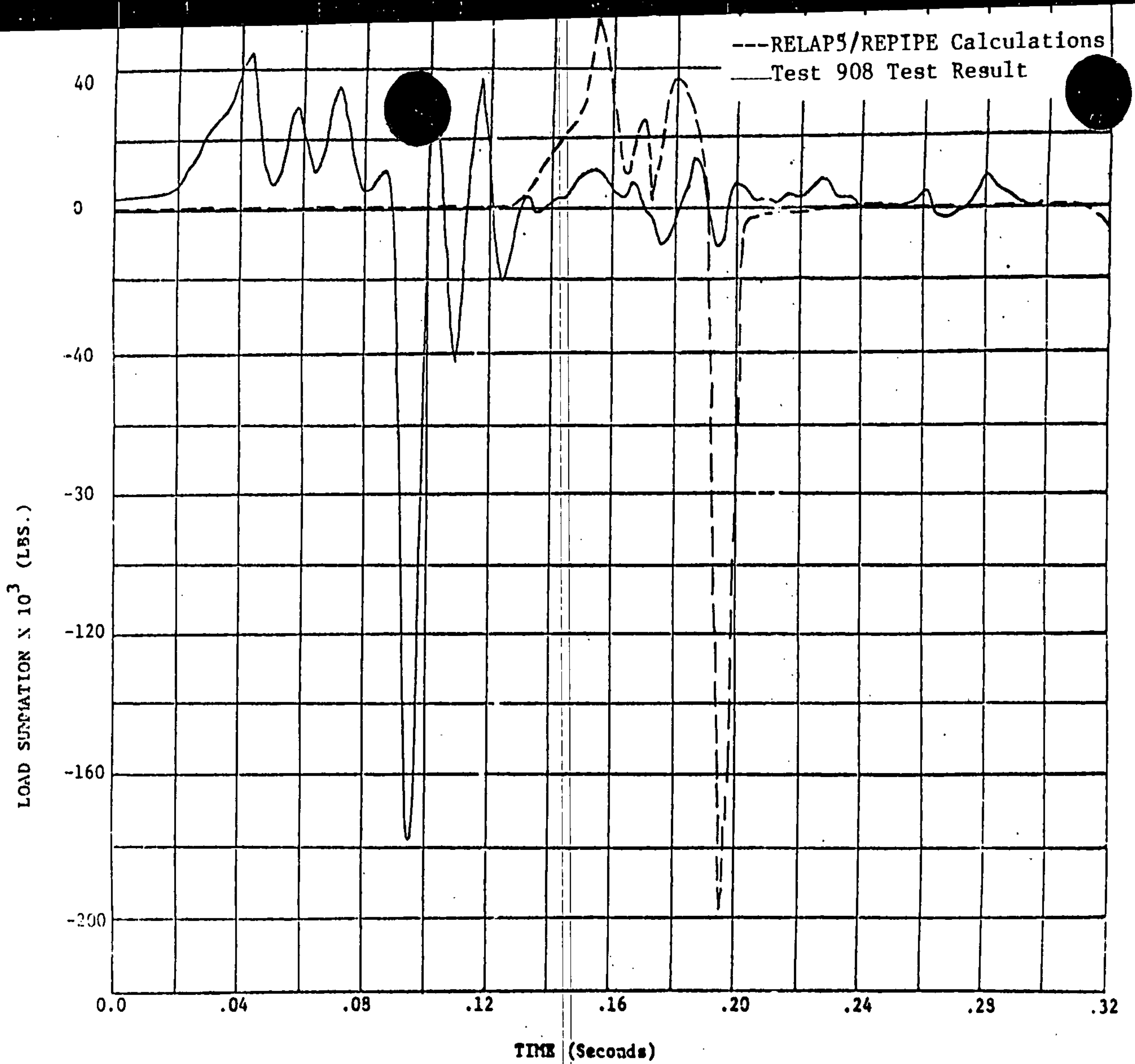
Because Segment 2 dynamic sensors (W32 and W33) produced the largest load reading for the CE Test 908, Segment 2 loads are the only loads presented for comparison.

As seen on Figures 6-15 and 6-16, RELAP5/REPIPE produced good peak load response agreement for both cases.

One can see that the upstream loop seal water case produced a delayed peak load. This is to be expected because, in the actual testing, most of the loop seal water did flow through the safety valve before the valve popped open.

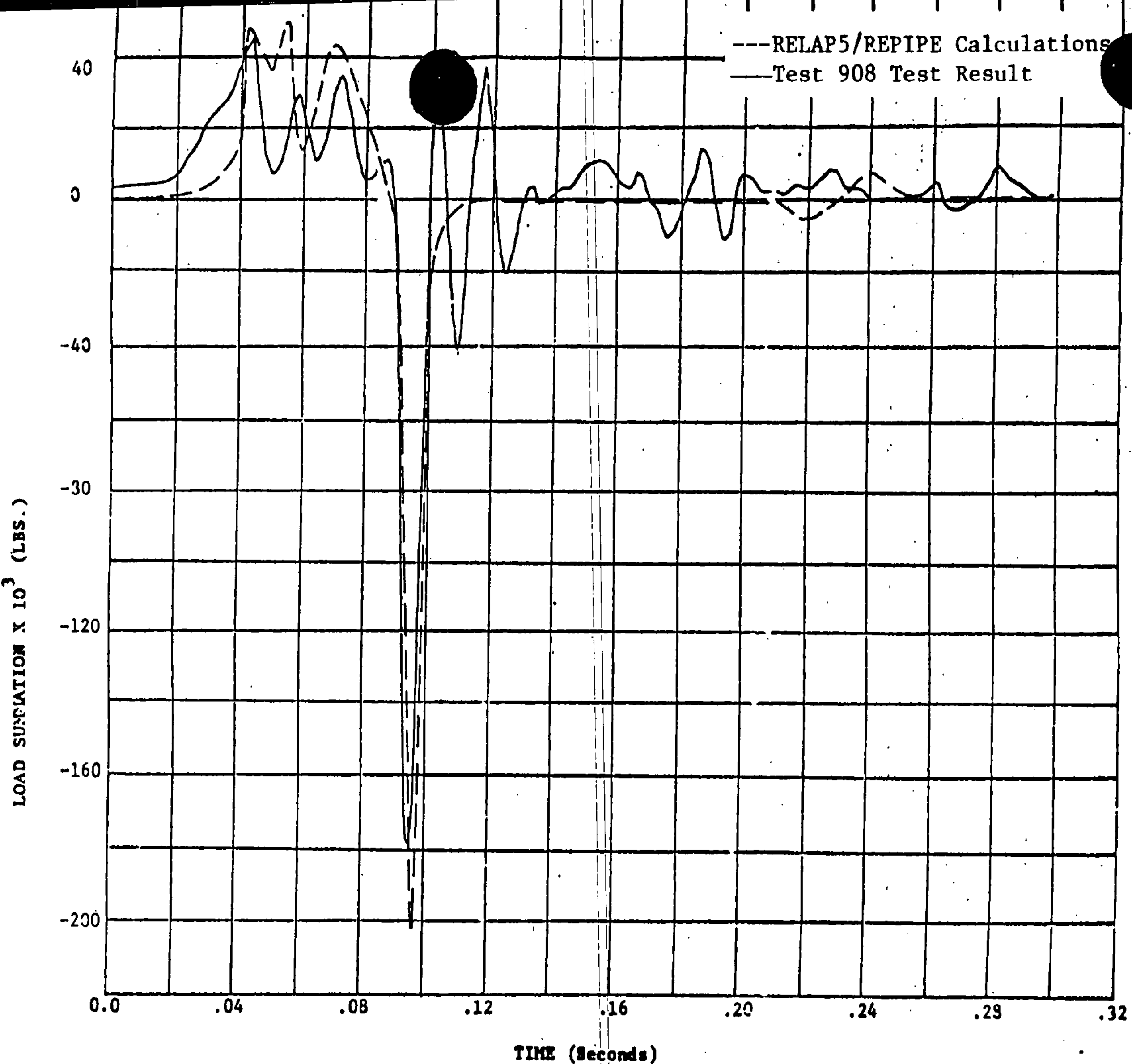
The RELAP5/REPIPE results presented here demonstrate that the modeling methods used in this report for determining safety valve discharge piping loads are adequate to determine the Kewaunee plant specific piping loads.

As stated in Section 6.3, the final analyses performed to verify the proposed S/RV modifications were done using RELAP5 with the post-processor [illegible]E. Verification of the RELAP5/FORCE computer code calculational accuracies is documented in Appendix B.



RELAP5/REPIPE CALCULATED RESULTS-WATER IN LOOP SEAL WHEN VALVE POPS-VERSUS CE TEST 908 RESULTS OF W32 AND W33[20]

FIGURE 6-15



RELAP5/REPIPE CALCULATED RESULTS-WATER IN DOWNSTREAM PIPING WHEN VALVE POPS-VERSUS CE TEST 908 RESULTS OF W32 AND W33[20]

FIGURE 6-16

7.0 DETERMINATION OF THE KEWAUNEE PLANT-SPECIFIC PIPING LOADS

The analysis of pressure relief line transients is very complex and generally involves the flow of nonequilibrium steam, water, and two-phase mixtures through the valve into a discharge pipe containing air and/or steam. The RELAP5/MOD1[16,17,18,19] computer code provides the capability to more accurately calculate the phenomena expected to occur during pressure relief system transients. A complete description of the RELAP5 computer code is presented in Appendix A.

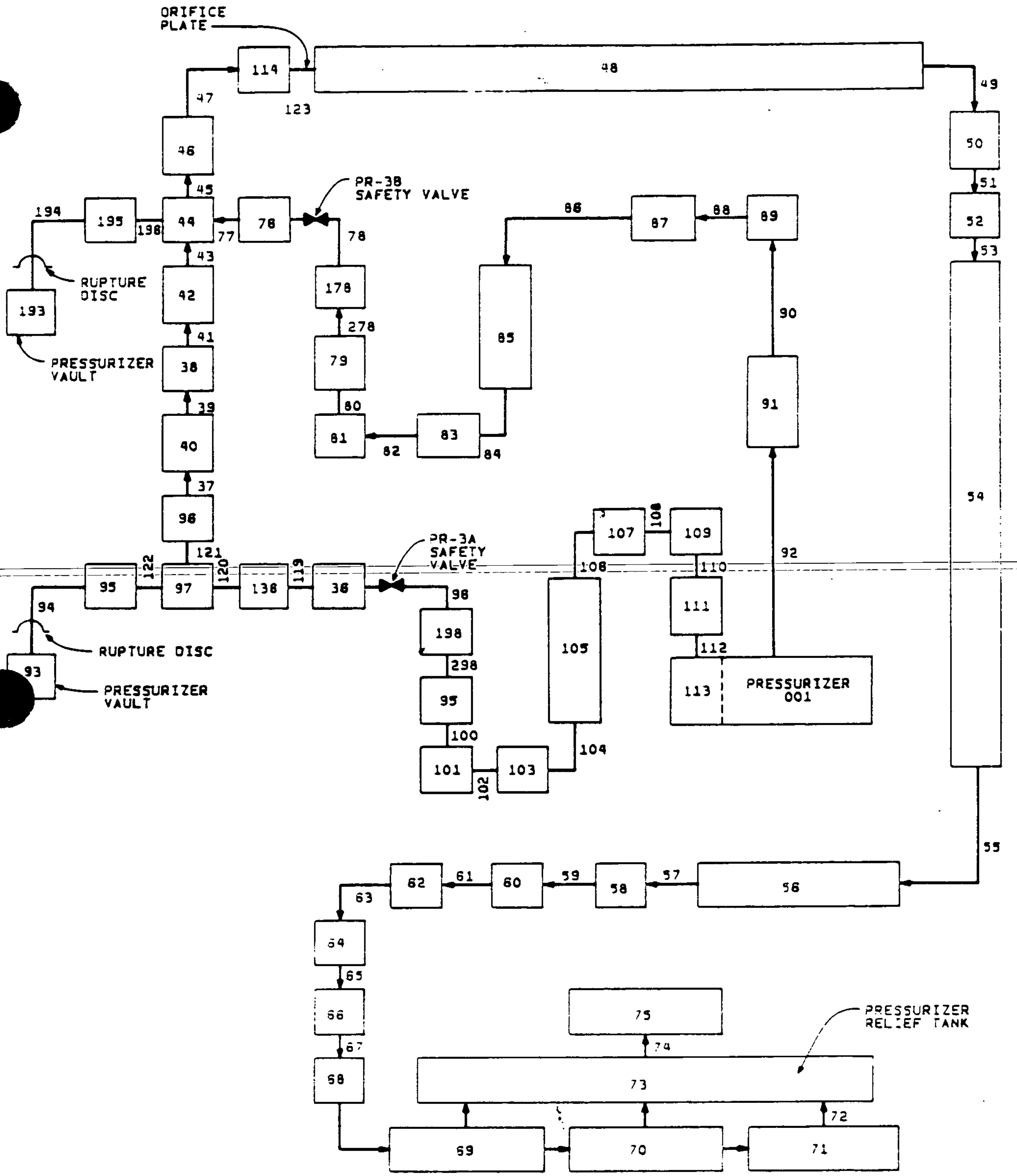
The initial RELAP5 analyses[1] were performed using the Control Data Computer Model 176. The subsequent RELAP5 analyses (the analyses presented in this report) were performed using the Boeing CRAY-1 computer.

7.1 RELAP5 PLANT-SPECIFIC MODELS FOR DETERMINATION OF PIPING LOADS

Detailed as-built Kewaunee plant-specific information concerning the safety and relief valves (S/RV) and the associated piping is presented in Section 3.0. Modifications to the as-built Kewaunee S/RV piping were required so that the thermal/hydraulic loading caused by the actuation of one or both safety valves could be reduced. The modifications consisted primarily of the addition of two rupture disk/baffle plate assemblies located at the discharge of each safety valve. More information concerning the modification is given in Section 9.0 of this report and Reference 21. This information was used to develop plant-specific RELAP5 models of the Kewaunee safety and relief valve piping network. Four cases were considered: (1) the simultaneous actuation of two safety valves without the actuation of the relief valves, (2) the actuation of safety valve PR-3A only, (3) the actuation of safety valve PR-3B only, and (4) the actuation of two relief valves.

The RELAP5 nodal diagram and associated input information for the double safety valve actuation simulation are presented on Figure 7-1 and Table 7-1, respectively.

The RELAP5 nodal diagram and associated input information for the single safety valve PR-3A actuation simulation are presented on Figure 7-2 and Table 7-2, respectively.



RELAP5 NODALIZATION FOR
KEWAUNEE TWO-SAFETY VALVE
SIMULATION
FIGURE 7-1

TABLE 7-1. RELAP5 INPUT PARAMETERS FOR THE KEWAUNEE TWO SAFETY VALVE SIMULATION--TWO RUPTURE DISKS--75 PERCENT ORIFICE PLATE--COLD LOOPS (120 F)*

Component**	Component Type	Volume or Junction Number	Area sq ft	Length of Each Volume ft	Vertical Angle degrees	Initial Conditions***	Forward Loss	Reverse Loss	Description
001	TMDPVOL	V1	38.48	25.98	90.0	Table: Time-P-Q_S	--	--	Pressurizer vessel (this is represented as a time dependent volume).
036	PIPE	V1-3	0.201	0.700	0.0	P=14.7 T=120			Horizontal segment downstream from PSV/PR-3A.
		J1-2	0.201	--	--	--	0.0	0.0	
037	SNGLJUN	J1	0.201	--	--	--	0.15	0.15	First elbow downstream from PSV/PR-3A.
038	PIPE	V1-7	0.548	0.64	0.0	P=14.7 T=120 Q_N=0.948	--	--	Horizontal 10-inch pipe between safety valves.
		J1-6	0.548	--	--	--	0.0	0.0	
039	SNGLJUN	J1	0.375	--	--		0.94	0.348	Junction of reducer and 10-inch pipe.
040	SNGLVOL	V1	0.375	0.583	0.0	P=14.7 T=120 Q_N=0.948	--	--	Reducer (6 by 10 inches).
041	SNGLJUN	JI	0.548	--	--	--	0.0	0.0	Junction at 10-inch horizontal run to 10-inch by 6-inch tee.
042	SNGLVOL	V1	0.548	0.60	0.0	P=14.7 T=120 Q_N=0.948	--	--	Horizontal segment downstream from 10-inch horizontal run.
043	SNGLJUN	J1	0.201	--	--	--	(Abrupt Area Change)		Connects horizontal 10-inch piping run to 10-inch by 6-inch tee.
044	BRANCH	V1	0.201	0.83	0.0	P=14.7 T=120	--	--	10-inch by 6-inch piping cross connecting PSV PR-3B to 10-inch pipe.
		J=0							
045	SNGLJUN	J1	0.201	--	--	--	0.0	0.0	Connects 10-inch by 6-inch cross to downstream piping.
046	PIPE	V1-3	0.548	0.38-1	0.0	P=14.7 T=120 (1V)	--	--	Horizontal segment upstream of 10-inch elbow.
		J1-2	0.548	0.65-3	--	P=14.7 T=120 Q_N=0.948 (2V)	0.0	0.0	
047	SNGLJUN	J1	0.548	--	--	--	0.171	0.171	10-inch elbow in downstream piping.
114	PIPE	V1-3	0.548	0.574	0.0	P=14.7 T=120 Q_N=0.948	--	--	10-inch pipe segment between 10-inch elbow and orifice plate.
		J1-2	0.548	--	--	--	0.0	0.0	
048	PIPE	V1-9	0.548	0.51	0.0	P=14.7 T=120 Q_N=0.948	--	--	Horizontal pipe between orifice plate and second 10-inch elbow.
		J1-8	0.548	--	--	--	0.0	0.0	
049	SNGLJUN	J1	0.548	--	--	--	0.172	0.172	Second 10-inch elbow in downstream piping.

/-1 (Continued). RELAP5 INPUT PARAMETERS FOR THE KEWAUNEE TWO SAFETY VAL ULATION--TWO RUPTURE DISKS--75 PERCENT ORIFICE PLATE--COLD LOOPS (120 F)*

Component**	Component Type	Volume or Junction Number	Area sq ft	Length of Each Volume ft	Vertical Angle degrees	Initial Conditions***			Forward Loss	Reverse Loss	Description
050	PIPE	V1-5	0.548	0.526	-90.0	P=14.7	T=120	Q_N=0.948	--	--	10-inch vertical piping segment between second 10-inch elbow and PORV connection.
		J1-4	0.548	--	--		--		0.0	0.0	
051	SNGLJUN	J1	0.548	--	--		--		0.0	0.0	
052	SNGLVOL	V1	0.548	0.5	-90.0	P=14.7	T=120	Q_N=0.948	--	--	Vertical 10-inch piping segment.
053	SNGLJUN	J1	0.548	--	--		--		0.55	0.55	
054	PIPE	V1-95	0.548	0.558	-90.0	P=14.7	T=120	Q_N=0.948	--	--	
		J1-94	0.548	--	--		--		0.0	0.0	Vertical segment to third 10-inch piping elbow.
055	SNGLJUN	J1	0.548	--	--		--		0.172	0.172	Third 10-inch elbow in downstream piping.
056	PIPE	VI-35	0.548	0.897	0.0	P=14.7	T=120	Q_N=0.948	--	--	Horizontal segment.
		J1-34	0.548	--	--		--		0.0	0.0	
057	SNGLJUN	J1	0.548	--	--		--		0.060	0.060	16.6-degree bend in downstream piping.
058	PIPE	V1-7	0.548	0.997	0.0	P=14.7	T=120	Q_N=0.948	--	--	Horizontal segment.
		J1-6	0.548	--	--		--		0.0	0.0	
059	SNGLJUN	J1	0.548	--	--		--		0.172	0.172	Fifth 10-inch elbow in downstream piping.
060	PIPE	V1-3 J1-2	0.548 0.548	1.11 --	-45.0 --	P=14.7	T=120 --	Q_N=0.948	--	--	Volume from relief tank entrance to air/water interface within tank discharge pipe.
061	SNGLJUN	J1	0.548	--	--		--		0.0	0.0	Air/water interface within tank discharge pipe.
062	PIPE	V1-2	0.548	1.00	-45.0	P=14.7	T=120		--	--	Volume below water surface to 45-degree bend in relief tank.
063	SNGLJUN	J1	0.548	--	--		--		0.103	0.103	45-degree bend in relief tank discharge pipe.
064	SNGLVOL	V1	0.548	1.650	-90.0	P=14.7	T=120		--	--	Piping in relief tank.
065	SNGLJUN	J1	0.548	--	--		--		0.0	0.0	Connects vertical segment of discharge pipe.
066	SNGLVOL	V1	0.548	1.500	-90.0	P=14.7	T=120		--	--	Piping in relief tank.
067	SNGLJUN	J1	0.548	--	--		--		0.172	0.172	90-degree bend in relief tank discharge pipe.
068	SNGLVOL	V1	0.548	1.500	0.0	P=14.7	T=120		0.0	0.0	Bend volume in relief tank.
069	BRANCH	V1	0.548	4.080	0.0	P=14.7	T=120		--	--	Horizontal discharge pipe in relief tank.
		J1	0.548	--	--		--		0.0	0.0	
		J2	0.273	--	--		--		1.89	1.71	
		J3	0.548	--	--		--		0.0	0.0	

7-1 (Continued). RELAP5 INPUT PARAMETERS FOR THE KEWAUNEE TWO SAFETY VALVE SIMULATION--TWO RUPTURE DISKS--75 PERCENT ORIFICE PLATE--COLD LOOPS (120 F)*

Component**	Component Type	Volume or Junction Number	Area sq ft	Length of Each Volume ft	Vertical Angle degrees	Initial Conditions***	Forward Loss	Reverse Loss	Description
070	BRANCH	V1	0.548	4.080	0.0	P=14.7 T=120	--	--	Horizontal discharge pipe in pressurizer relief tank.
		J1	0.273	--	--	--	1.89	1.71	
		J2	0.548	--	--	--	0.0	0.0	
071	SNGLVOL	V1	0.548	4.080	0.0	P=14.7 T=120	--	--	Horizontal discharge pipe in pressurizer relief tank.
072	SNGLJUN	J1	0.285	--	--	--	1.89	1.71	
073	BRANCH	V1	106.65	5.629	90.0	P=14.7 T=120	--	--	Volume of water in 75 percent full relief tank.
		J=0	--	--	--	--	--	--	
074	SNGLJUN	J1	106.6	--	--	--	0.0	0.0	Air/water interface within relief tank.
075	SNGLVOL	V1-4	106.6	1.876	90.0	P=14.7 T=120 Q_N=0.948	--	--	Volume of air in 75 percent water-filled relief tank.
076	PIPE	VI-4	0.201	0.500	0.0	P=14.7 T=120 (water)			Horizontal segment downstream from PSV/PR-3B.
		J1-3	0.201	--	--	--	0.0	0.0	
077	SNGLJUN	J1	0.201	--	--	--	0.36	0.36	Junction from PSV/PR-3B discharge pipe to 10-inch by 6-inch tee.
078	VALVE-SRVVLV	J1	0.017	--	--	--	(Abrupt Area Change)		Pressurizer safety valve (PSV)/PR-3B flow path.
079	PIPE	VI	0.147	0.800	0.0	P=2686.0 T=120 (water)	--	--	Vertical loop seal 6-inch segment upstream from PSV/PR-3B.
080	SNGLJUN	JI	0.147	--	--	--	0.160	0.160	Connects lower loop seal of PSV/PR-3B to vertical segment.
081	SNGLVOL	V1	0.147	0.589	0.0	P=2686.0 T=120 (water)	--	--	Lower loop seal piping of PSV/PR-3B.
082	SNGLJUN	J1	0.147	--	--	--	0.0	0.0	Connects lower loop seal piping of PSV/PR-3B.
083	PIPE	V1-2	0.147	0.638 0.54	0.0	P=2686.0 T=275 P=2686.0 Q_S=1.0	--	--	Horizontal pipe of lower loop seal piping of PSV/PR-3B.
		J1	0.147	--	--	--	0.0	0.0	
084	SNGLJUN	J1	0.147	--	--	--	0.160	0.160	Connects lower loop seal of PSV/PR-3B to vertical loop seal segment.
085	PIPE	V1-2	0.147	0.703	-90.0	P=2686.0 Q_S=1.0	--	--	Second loop seal elbow volume and vertical segment of PSV/PR-3B.
		J1	0.147	--	--	--	0.0	0.0	

-1 (Continued). RELAP5 INPUT PARAMETERS FOR THE KEWAUNEE TWO SAFETY VA[illegible]LATION--TWO RUPTURE DISKS--75 PERCENT ORIFICE PLATE--COLD LOOPS (1[illegible]

Component**	Component Type	Volume or Junction Number	Area sq ft	Length of Each Volume ft	Vertical Angle degrees	Initial Conditions***	Forward Loss	Reverse Loss	Description
086	SNGLJUN	J1	0.147	--	--	--	0.0	0.0	Connects vertical loop seal segment of PSV/PR-3B to top of loop seal.
087	PIPE	VI	0.147	0.584	0.0	P=2686.0 Q_S=1.0	--	--	Top of loop seal for PSV/PR-3B.
088	SNGLJUN	J1	0.147	--	--	--	0.195	0.195	Connects top of loop seal for PSV/PR-3B to piping going to pressurizer.
089	SNGLVOL	V1	0.147	0.785	0.0	P=2686.0 Q_S=1.0	--	--	Loop seal segment of PSV/PR-3B.
090	SNGLJUN	J1	0.147	--	--	--	0.0	0.0	Connects loop seal piping segments of PSV/PR-3B.
091	PIPE	V1-3	0.147	1.074	90.0	P=2686.0 Q_S=1.0	--	--	Vertical pipe from pressurizer to first loop seal elbow volume (Loop Seal B).
		J1-2	0.147	--	--	--	0.0	0.0	
092	SNGLJUN	J1	0.147	--	--	--	0.594	0.992	Connects pressurizer to loop seal piping.
093	SNGLVOL	V1	90.0	100.0	-90.0	P=14.7 T=120 Q_N=0.948	--	--	Pressurizer vault.
094	VALVE-MTRVLV	J1	0.163	--	--	--	(Abrupt Area Change)		Rupture disk to open in 20 msec after 285 psia set point pressure is reached.
095	SNGLVOL	V1	0.201	0.51	0.0	P=14.7 T=120	--	--	Represents cavity upstream of rupture disk.
096	SNGLVOL	V1	0.201	0.843	0.0	P=14.7 T=120 Q_N=0.948	--	--	45-degree, 6-inch elbow connecting rupture disk tee to 10-inch by 6-inch reducer.
097	BRANCH	V1	0.201	0.604	0.0	P=14.7 T=120	--	--	Discharge leg of rupture disk tee.
		J1	0.201	--	--	--	0.0	0.0	
		J2	0.201	--	--	--	0.0	0.0	
098	VALVE-SRVVLV	JI	0.017	--	--	--	(Abrupt Area Change)		Pressurizer Safety Valve PSV/PR-3A.
099	SNGLVOL	V1	0.147	0.8	0.0	P=2686.0 T=120	--	--	Vertical loop seal 6-inch segment upstream from PSV/PR-3A.
100	SNGLJUN	J1	0.147	--	--	--	0.0	0.0	Connects lower loop seal of PSV/PR-3A to vertical segment.
101	SNGLVOL	VI	0.147	0.589	0.0	P=2686.0 T=120	--	--	Lower loop seal piping of PSV/PR-3A.
102	SNGLJUN	J1	0.147	--	--	--	0.16	0.16	Connects lower loop seal piping of PSV/PR-3A.
103	PIPE	V1-2	0.147	0.638 0.684	0.0	P=2686.0 T=275 P=2686.0 Q_S=1.0	--	--	Horizontal piping of lower loop seal piping of PSV/PR-3A.
		J1	0.147	--	--	--	0.0	0.0	
104	SNGLJUN	J1	0.147	--	--	--	0.160	0.160	Connects lower loop seal of PSV/PR-3B to vertical loop seal segment.

TABLE 7-1 (Continued). RELAP5 INPUT PARAMETERS FOR THE KEWAUNEE TWO SAFETY VAL[illegible]ULATION--TWO RUPTURE DISKS--75 PERCENT ORIFICE PLATE--COLD LOOPS (1[illegible]

Component**	Component Type	Volume or Junction Number	Area sq ft	Length of Each Volume ft	Vertical Angle degrees	Initial Conditions***	Forward Loss	Reverse Loss	Description
105	PIPE	V1	0.147	1.031	90.0	P=2686.0 Q_S=1.0	--	--	Second loop seal elbow volume and vertical segment of PSV/PR-3A.
106	SNGLJUN	J1	0.147	--	--	--	0.0	0.0	Connects vertical loop seal segment of PSV/PR-3B to top of loop seal.
107	PIPE	V1	0.147	0.584	0.0	P=2686.0 Q_S=1.0	--	--	Top of loop seal for PSV/PR-3A.
108	SNGLJUN	J1	0.147	--	--	--	0.195	0.195	Connects top of loop seal for PSV/PR-3A to piping going to pressurizer.
109	SNGLVOL	V1	0.147	0.785	0.0	P=2686.0 Q_S=1.0	--	--	Loop seal segment of PSV/PR-3A.
110	SNGLJUN	J1	0.147	--	--	--	0.0	0.0	Connects loop seal piping segments of PSV/PR-3A.
111	PIPE	V1-3	0.147	1.074	90.0	P=2686.0 Q_S=1.0	--	--	Vertical pipe from pressurizer to first loop seal elbow volume (Loop Seal A).
		J1-2	0.147	--	--	--	0.0	0.0	
112	SNGLJUN	J1	0.147	--	--	--	0.594	0.992	
113	TMDPVOL	V1	38.48	25.98	90.0	Table: Time - P - Q_S	--	--	Pressurizer Vault - Volume = 1,000 cu ft (this is represented as a time-dependent volume).
114	PIPE	V1-3	0.548	0.574	0.0	P=14.7 T=120 Q_N=0.948	--	--	10-inch piping upstream of orifice plate.
119	SNGLJUN	J1	0.201	--	--	--	0.15	0.15	
120	SNGLJUN	J1	0.201	--	--	--	0.42	0.42	
121	SNGLJUN	J1	0.201	--	--	--	3.02	0.0	Junctions connecting rupture disk configuration.
122	SNGLJUN	J1	0.185	--	--	--	0.0	0.0	Connects 6-inch tee to outlet leg to rupture disk.
123	SNGLJUN	J1	0.137	--	--	--	0.963	0.963	Represents opening in orifice plate.
136	SNGLVOL	V1	0.201	0.854	0.0	P=14.7 T=120	--	--	6-inch piping segment at horizontal pipe discharge from PSV/PR-3A.
178	SNGLVOL	V1	0.017	0.92	90.0	P=2686.0 Q_S=1.0	--	--	Inlet valve nozzle to PSV/PR-3B.
193	SNGLVOL	VI	90.0	100.0	-90.0	P=14.7 T=120 Q_N=0.948	--	--	Pressurizer vault.
194	VALVE-MTRVLV	J1	0.163	--	--	--	(Abrupt Area Change)		Rupture disk to open in 20 msec after 285 psia set point pressure is reached.
195	PIPE	V1	0.201	0.62	0.0	P=14.7 T=120	--	--	Piping outlet from main branch of 10-inch by 6-inch tee to rupture disk.
		J1	0.188	--	--	-- --	0.15	0.15	
		V2	0.188	0.62	0.0	P=14.7 T=120 Q_N=0.948	--	--	

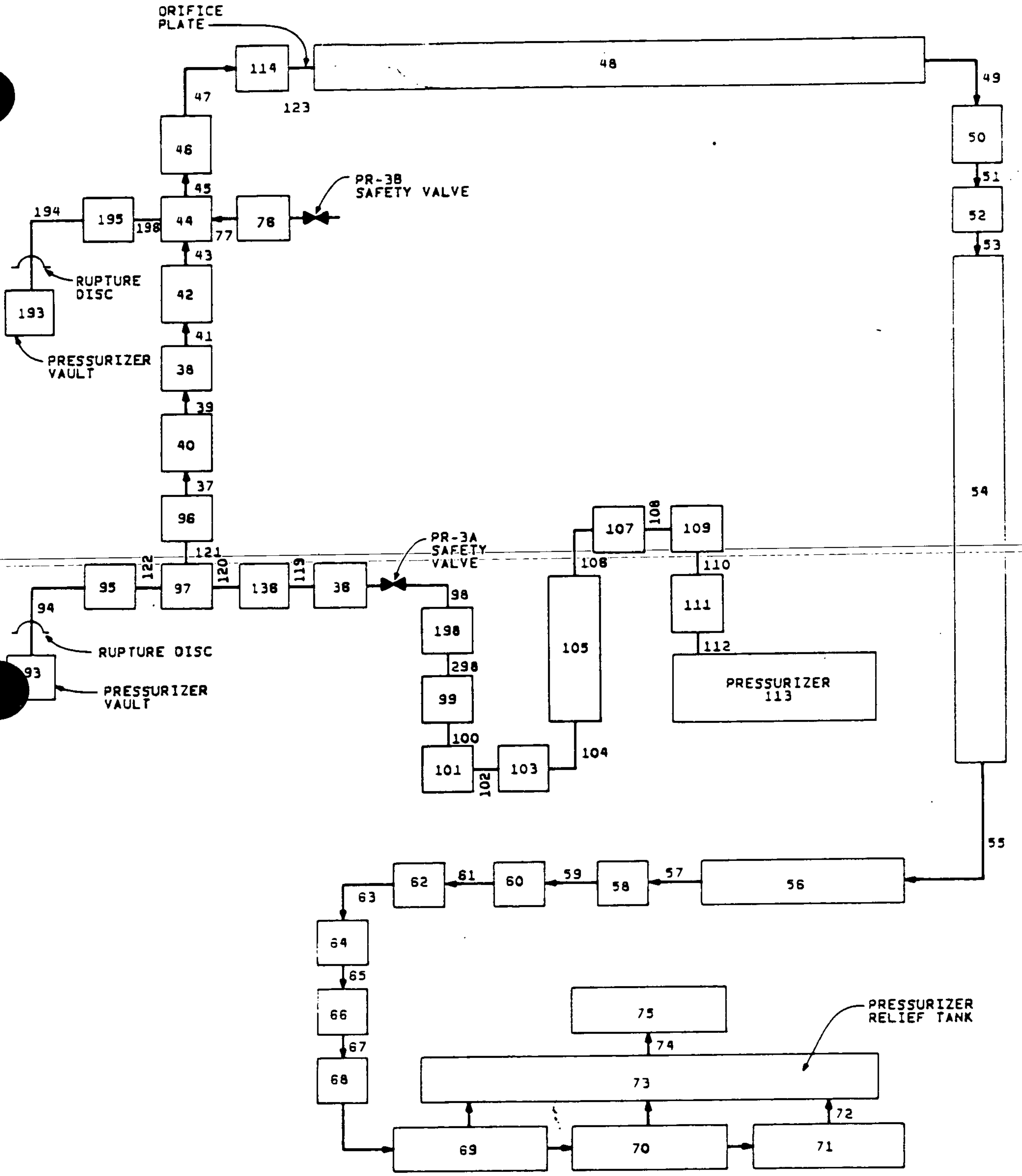
7-1 (Continued). RELAP5 INPUT PARAMETERS FOR THE KEWAUNEE TWO SAFETY VAL ATION--TWO RUPTURE DISKS--75 PERCENT ORIFICE PLATE--COLD LOOPS (12

Component**	Component Type	Volume or Junction Number	Area sq ft	Length of Each Volume ft	Vertical Angle degrees	Initial Conditions***	Forward Loss	Reverse Loss	Description
196	SNGLJUN	J1	0.185	--	--	--	(Abrupt Area Change)		Connects 10-inch by 6-inch cross to outlet leg to rupture disk.
198	SNGLVOL	V1	0.017	0.92	90.0	P=2686.0 Q_S=1.0	--	--	Inlet valve nozzle to PSV/PR-3A.
278	SNGLJUN	J1	0.017	--	--	--	(Abrupt Area Change)		Connects PSV/PR-3B upstream piping to inlet valve nozzle.
298	SNGLJUN	J1	0.017	--	--	--	(Abrupt Area Change)		Connects PSV/PR-3A upstream piping to inlet valve nozzle.

*Assumptions: No choking was assumed to occur in pipe except at orifice plate.
Wall friction was computed.
Nonequilibrium calculations were made (unequal phase temperatures).
Pipe roughness was assumed to be 0.00015.

**Figure 7-1 shows nodal diagram.

*** P = Pressure (psia)
T = Temperature (degrees F)
Q_N = Noncondensable quality (air)
Q_S = Static or equilibrium quality (steam)
Flag 2 has P, Q_S
Flag 3 has P, T
Flag 4 has P, T, Q_N



RELAP5 NODALIZATION FOR
KEWAUNEE ONE SAFETY VALVE PR-3A
SIMULATION
FIGURE 7-2

2. RELAP5 INPUT PARAMETERS FOR THE KEWAUNEE SAFETY VALVE PR-3A SIMULATI RUPTURE DISKS--75 PERCENT ORIFICE PLATE--COLD LOOPS (120 F)*

Component**	Component Type	Volume or Junction Number	Area sq ft	Length of Each Volume ft	Vertical Angle degrees	Initial Conditions***			Forward Loss	Reverse Loss	Description
036	PIPE	V1-3	0.201	0.700	0.0	P=14.7	T=120				Horizontal segment downstream from PSV/PR-3A.
		J1-2	0.201	--	--		--		0.0	0.0	
037	SNGLJUN	J1	0.201	--	--		--		0.15	0.15	First elbow downstream from PSV/PR-3A.
038	PIPE	V1-7	0.548	0.64	0.0	P=14.7	T=120	Q_N=0.948	--	--	Horizontal 10-inch pipe between safety valves.
		J1-6	0.548	--	--		--		0.0	0.0	
039	SNGLJUN	J1	0.375	--	--				0.94	0.348	Junction of reducer and 10-inch pipe.
040	SNGLVOL	V1	0.375	0.583	0.0	P=14.7	T=120	Q_N=0.948	--	--	Reducer (6 by 10 inches).
041	SNGLJUN	J1	0.548	--	--		--		0.0	0.0	Junction at 10-inch horizontal run to 10-inch by 6-inch tee.
042	SNGLVOL	V1	0.548	0.60	0.0	P=14.7	T=120	Q_N=0.948	--	--	Horizontal segment downstream from 10-inch horizontal run.
043	SNGLJUN	J1	0.548	--	--		--		(Abrupt Area Change)		Connects horizontal 10-inch piping run to 10-inch by 6-inch tee.
044	BRANCH	V1	0.548	0.500	0.0	P=14.7	T=120	Q_N=0.948	--	--	10-inch by 6-inch piping cross connecting PSV PR-3B to 10-inch pipe.
		J=0									
045	SNGLJUN	J1	0.548	--	--		--		0.0	0.0	Connects 10-inch by 6-inch cross to downstream piping.
046	PIPE	V1-3	0.548	0.4-1	0.0	P=14.7	T=120	Q_N=0.948 (1V)	--	--	Horizontal segment upstream of 10-inch elbow.
		J1-2	0.548	0.54-3	--	P=14.7	T=120	Q_N=0.948 (2V)	0.0	0.0	
047	SNGLJUN	J1	0.548	--	--		--		0.171	0.171	10-inch elbow in downstream piping.
114	PIPE	V1-3	0.548	0.574	0.0	P=14.7	T=120	Q_N=0.948	--	--	10-inch pipe segment between 10-inch elbow and orifice plate.
		J1-2	0.548	--	--		--		0.0	0.0	
048	PIPE	V1-9	0.548	0.51	0.0	P=14.7	T=120	Q_N=0.948	--	--	Horizontal pipe between orifice plate and second 10-inch elbow.
		J1-8	0.548	--	--		--		0.0	0.0	
049	SNGLJUN	J1	0.548	--	--		--		0.172	0.172	Second 10-inch elbow in downstream piping.

7-2 (Continued). RELAP5 INPUT PARAMETERS FOR THE KEWAUNEE SAFETY VALVE MULATION--TWO RUPTURE DISKS--75 PERCENT ORIFICE PLATE--COLD LOOPS

Component**	Component Type	Volume or Junction Number	Area sq ft	Length of Each Volume ft	Vertical Angle degrees	Initial Conditions***			Forward Loss	Reverse Loss	Description
050	PIPE	V1-5	0.548	0.526	-90.0	P=14.7	T=120	Q_N=0.948	--	--	10-inch vertical piping segment between second 10-inch elbow and PORV connection.
		J1-4	0.548	--	--		--		0.0	0.0	
051	SNGLJUN	J1	0.548	--	--		--		0.0	0.0	
052	SNGLVOL	V1	0.548	0.5	-90.0	P=14.7	T=120	Q_N=0.948	--	--	Vertical 10-inch piping segment.
053	SNGLJUN	J1	0.548	--	--		--		0.55	0.55	
054	PIPE	V1-95	0.548	0.558	-90.0	P=14.7	T=120	Q_N=0.948	--	--	
		J1-94	0.548	--	--		--		0.0	0.0	Vertical segment to third 10-inch piping elbow.
055	SNGLJUN	J1	0.548	--	--		--		0.172	0.172	Third 10-inch elbow in downstream piping.
056	PIPE	V1-35	0.548	0.897	0.0	P=14.7	T=120	Q_N=0.948	--	--	Horizontal segment.
		J1-34	0.548	--	--		--		0.0	0.0	
057	SNGLJUN	J1	0.548	--	--		--		0.060	0.060	16.6-degree bend in downstream piping.
058	PIPE	V1-7	0.548	0.997	0.0	P=14.7	T=120	Q_N=0.948	--	--	Horizontal segment.
		J1-6	0.548	--	--		--		0.0	0.0	
059	SNGLJUN	J1	0.548	--	--		--		0.172	0.172	Fifth 10-inch elbow in downstream piping.
060	PIPE	V1-3 J1-2	0.548 0.548	1.11 --	-45.0 --	P=14.7	T=120 --	Q_N=0.948	--	--	Volume from relief tank entrance to air/water interface within tank discharge pipe.
061	SNGLJUN	J1	0.548	--	--		--		0.0	0.0	Air/water interface within tank discharge pipe.
062	PIPE	V1-2	0.548	1.00	-45.0	P=14.7	T=120		--	--	Volume below water surface to 45-degree bend in relief tank.
063	SNGLJUN	J1	0.548	--	--		--		0.103	0.103	45-degree bend in relief tank discharge pipe.
064	SNGLVOL	V1	0.548	1.650	-90.0	P=14.7	T=120		--	--	Piping in relief tank.
065	SNGLJUN	J1	0.548	--	--		--		0.0	0.0	Connects vertical segment of discharge pipe.
066	SNGLVOL	V1	0.548	1.500	-90.0	P=14.7	T=120		--	--	Piping in relief tank.
067	SNGLJUN	J1	0.548	--	--		--		0.172	0.172	90-degree bend in relief tank discharge pipe.
068	SNGLVOL	V1	0.548	1.500	0.0	P=14.7	T=120		0.0	0.0	Bend volume in relief tank.
069	BRANCH	V1	0.548	4.080	0.0	P=14.7	T=120		--	--	Horizontal discharge pipe in relief tank.
		J1	0.548	--	--		--		0.0	0.0	
		J2	0.273	--	--		--		1.89	1.71	
		J3	0.548	--	--		--		0.0	0.0	

[illegible]2 (Continued). RELAP5 INPUT PARAMETERS FOR THE KEWAUNEE SAFETY VALVE P[illegible]ULATION--TWO RUPTURE DISKS--75 PERCENT ORIFICE PLATE--COLD LOOPS (1[illegible]

Component**	Component Type	Volume or Junction Number	Area sq ft	Length of Each Volume ft	Vertical Angle degrees	Initial Conditions***			Forward Loss	Reverse Loss	Description
070	BRANCH	V1	0.548	4.080	0.0	P=14.7	T=120		--	--	Horizontal discharge pipe in pressurizer relief tank.
		J1	0.273	--	--		--		1.89	1.71	
		J2	0.548	--	--		--		0.0	0.0	
071	SNGLVOL	V1	0.548	4.080	0.0	P=14.7	T=120		--	--	Horizontal discharge pipe in pressurizer relief tank.
072	SNGLJUN	J1	0.285	--	--		--		1.89	1.71	
073	BRANCH	V1	106.65	5.629	90.0	P=14.7	T=120		--	--	Volume of water in 75 percent full relief tank.
		J=0	--	--	--		--		--	--	
074	SNGLJUN	J1	106.6	--	--		--		0.0	0.0	Air/water interface within relief tank.
075	SNGLVOL	V1-4	106.6	1.876	90.0	P=14.7	T=120	Q_N=0.948	--	--	Volume of air in 75 percent water-filled relief tank.
076	PIPE	V1-4	0.201	0.500	0.0	P=14.7	T=120	Q_N=0.948			Horizontal segment downstream from PSV/PR-3B.
		J1-3	0.201	--	--		--		0.0	0.0	
077	SNGLJUN	J1	0.201	--	--		--		0.36	0.36	Junction from PSV/PR-3B discharge pipe to 10-inch by 6-inch tee.
093	SNGLVOL	V1	90.0	100.0	-90.0	P=14.7	T=120	Q_N=0.948	--	--	Pressurizer vault.
094	VALVE-MTRVLV	J1	0.163	--	--		--		(Abrupt Area Change)		Rupture disk to open in 20 msec after 285 psia set point pressure is reached.
095	SNGLVOL	V1	0.201	0.51	0.0	P=14.7	T=120		--	--	Represents cavity upstream of rupture disk.
096	SNGLVOL	V1	0.201	0.843	0.0	P=14.7	T=120	Q_N=0.948	--	--	45-degree, 6-inch elbow connecting rupture disk tee to 10-inch by 6-inch reducer.
097	BRANCH	V1	0.201	0.604	0.0	P=14.7	T=120		--	--	Discharge leg of rupture disk tee.
		J1	0.201	--	--		--		0.0	0.0	
		J2	0.201	--	--		--		0.0	0.0	
098	VALVE-SRVVLV	J1	0.017	--	--		--		(Abrupt Area Change)		Pressurizer Safety Valve PSV/PR-3A.
099	SNGLVOL	V1	0.147	0.8	0.0	P=2686.0	T=120		--	--	Vertical loop seal 6-inch segment upstream from PSV/PR-3A.
100	SNGLJUN	JI	0.147	--	--		--		0.0	0.0	Connects lower loop seal of PSV/PR-3A to vertical segment.
101	SNGLVOL	V1	0.147	0.589	0.0	P=2686.0	T=120		--	--	Lower loop seal piping of PSV/PR-3A.
102	SNGLJUN	J1	0.147	--	--		--		0.16	0.16	Connects lower loop seal piping of PSV/PR-3A.

[illegible] 2 (Continued). RELAP5 INPUT PARAMETERS FOR THE KEWAUNEE SAFETY VALVE PR[illegible]MULATION--TWO RUPTURE DISKS--75 PERCENT ORIFICE PLATE--COLD LOOPS (12[illegible])*
R[illegible]M

Component**	Component Type	Volume or Junction Number	Area sq ft	Length of Each Volume ft	Vertical Angle degrees	Initial Conditions***	Forward Loss	Reverse Loss	Description
103	PIPE	V1-2	0.147	0.638 0.684	0.0	P=2686.0 T=275 P=2686.0 Q_S=1.0	--	--	Horizontal piping of lower loop seal piping of PSV/PR-3A.
		J1	0.147	--	--	--	0.0	0.0	
104	SNGLJUN	J1	0.147	--	--	--	0.160	0.160	Connects lower loop seal of PSV/PR-3B to vertical loop seal segment.
105	PIPE	V1	0.147	1.031	90.0	P=2686.0 Q_S=1.0	--	--	Second loop seal elbow volume and vertical segment of PSV/PR-3A.
106	SNGLJUN	J1	0.147	--	--	--	0.0	0.0	Connects vertical loop seal segment of PSV/PR-3B to top of loop seal.
107	PIPE	V1	0.147	0.584	0.0	P=2686.0 Q_S=1.0	--	--	Top of loop seal for PSV/PR-3A.
108	SNGLJUN	J1	0.147	--	--	--	0.195	0.195	Connects top of loop seal for PSV/PR-3A to piping going to pressurizer.
109	SNGLVOL	V1	0.147	0.785	0.0	P=2686.0 Q_S=1.0	--	--	Loop seal segment of PSV/PR-3A.
110	SNGLJUN	J1	0.147	--	--	--	0.0	0.0	Connects loop seal piping segments of PSV/PR-3A.
111	PIPE	V1-3	0.147	1.074	90.0	P=2686.0 Q_S=1.0	--	--	Vertical pipe from pressurizer to first loop seal elbow volume (Loop Seal A).
		J1-2	0.147	--	--	--	0.0	0.0	
112	SNGLJUN	J1	0.147	--	--	--	0.594	0.992	
113	TMDPVOL	V1	38.48	25.98	90.0	Table: Time - P - Q_S	--	--	Pressurizer Vault - Volume = 1,000 cu ft (this is represented as a time-dependent volume).
114	PIPE	V1-3	0.548	0.574	0.0	P=14.7 T=120 Q_N=0.948	--	--	10-inch piping upstream of orifice plate.
119	SNGLJUN	J1	0.201	--	--	--	0.15	0.15	
120	SNGLJUN	J1	0.201	--	--	--	0.42	0.42	
121	SNGLJUN	J1	0.201	--	--	--	3.02	0.0	Junctions connecting rupture disk configuration.
122	SNGLJUN	J1	0.185	--	--	--	0.0	0.0	Connects 6-inch tee to outlet leg to rupture disk.
123	SNGLJUN	J1	0.137	--	--	--	0.963	0.963	Represents opening in orifice plate.
136	SNGLVOL	V1	0.201	0.854	0.0	P=14.7 T=120	--	--	6-inch piping segment at horizontal pipe discharge from PSV/PR-3A.
193	SNGLVOL	V1	90.0	100.0	-90.0	P=14.7 T=120 Q_N=0.948	--	--	Pressurizer vault.
194	VALVE-MTRVLV	J1	0.163	--	--	--	(Abrupt Area Change)		Rupture disk to open in 20 msec after 285 psia set point pressure is reached.

[illegible] 7-2 (Continued). RELAP5 INPUT PARAMETERS FOR THE KEWAUNEE SAFETY VALVE P[illegible] SIMULATION--TWO RUPTURE DISKS--75 PERCENT ORIFICE PLATE--COLD LOOPS ([illegible])*

Component**	Component Type	Volume or Junction Number	Area sq ft	Length of Each Volume ft	Vertical Angle degrees	Initial Conditions***			Forward Loss	Reverse Loss	Description
195	PIPE	V1	0.201	0.62	0.0	P=14.7	T=120	Q_N=0.948	--	--	Piping outlet from main branch of 10-inch by 6-inch tee to rupture disk.
		J1	0.188	--	--	--	--	--	0.15	0.15	
		V2	0.188	0.62	0.0	P=14.7	T=120	Q_N=0.948	--	--	
196	SNGLJUN	J1	0.185	--	--		--		(Abrupt Area Change)		Connects 10-inch by 6-inch cross to outlet leg to rupture disk.
198	SNGLVOL	V1	0.017	0.92	90.0	P=2686.0		Q_S=1.0	--	--	Inlet valve nozzle to PSV/PR-3A.
278	SNGLJUN	J1	0.017	--	--		--		(Abrupt Area Change)		Connects PSV/PR-3B upstream piping to inlet valve nozzle.
298	SNGLJUN	J1	0.017	--	--		--		(Abrupt Area Change)		Connects PSV/PR-3A upstream piping to inlet valve nozzle.

*Assumptions: No choking was assumed to occur in pipe except at orifice plate.
Wall friction was computed.
Nonequilibrium calculations were made (unequal phase temperatures).
Pipe roughness was assumed to be 0.00015.

**Figure 7-2 shows nodal diagram.

*** P = Pressure (psia)
T = Temperature (degrees F)
Q_N = Noncondensable quality (air)
Q_S = Static or equilibrium quality (steam)
Flag 2 has P, Q_S
Flag 3 has P, T
Flag 4 has P, T, Q_N

The RELAP5 nodal diagram and associated input information for the single safety valve PR-3B actuation simulation are presented on Figure 7-3 and Table 7-3, respectively.

The RELAP5 nodal diagram and associated input information for the double-relief valve actuation simulation are presented on Figure 7-4 and Table 7-4, respectively.

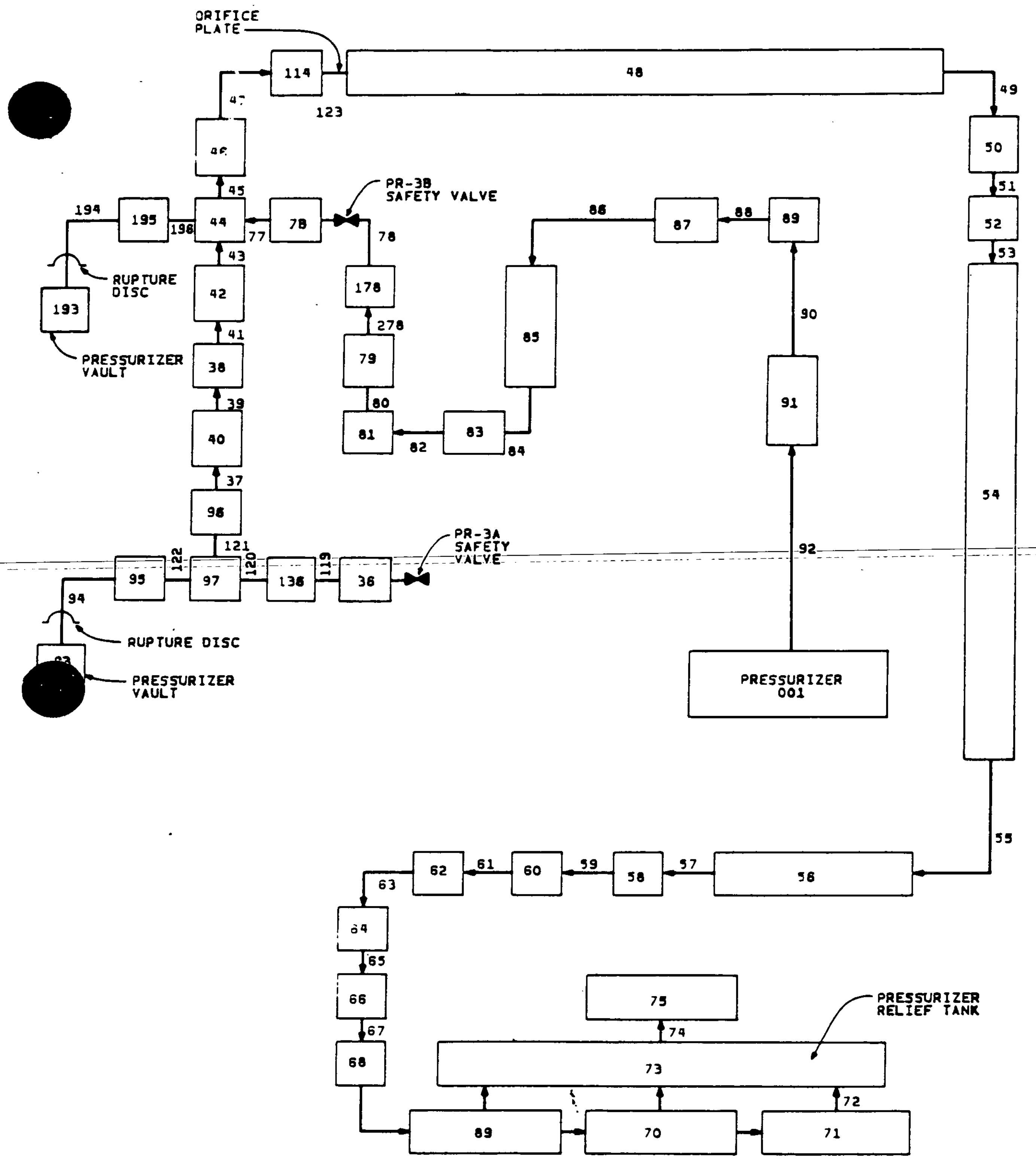
These four S/RV actuations were simulated using RELAP5. The modeling procedures, assumptions used, and model descriptions are given in the following subsections.

7.1.1 <u>Conditions Which May Cause Kewaunee Safety Valve or Relief Valve Actuation</u>

As part of the final safety analysis report (FSAR), many potential primary system transient situations were considered. These transients were evaluated for the Kewaunee NPP and are presented in the Kewaunee FSAR[8] in Section 14. Some evaluations (locked rotor and loss of load accidents) assumed that the relief valves did not actuate. Of these two, the locked rotor accident produced the greater pressure and pressure rise, 2,737 psia and 280 psi/second, respectively. The locked rotor transient was done using very conservative assumptions and is considered the upper bound transient for the safety valve actuation.

To duplicate the locked rotor transient, the pressure transient was extracted from the Kewaunee FSAR, Figure 14.1-34. Since for the RELAP5 simulation, the loop seal water was placed downstream of the safety valve, it was necessary that the RELAP5 simulated transient begin (time = 0.0) at the end of valve simmer period. (As shown during CE Test 908, the safety valve seat moves up and down until all the subcooled water in the loop seal clears the valve; this is referred to as the "simmer" time.)

Because the CE Test 908 test conditions and test valve are similar to the Kewaunee simulated conditions and safety valve, the Kewaunee locked rotor simulated "pop" pressure was based on the CE 908 Test information. Therefore, for the RELAP5 simulation, the pressurizer pressure was 2,686 psia at the beginning of the transient (when the valve "pops" open).



RELAP5 NODALIZATION FOR
KEWAUNEE ONE SAFETY
VALVE PR-3B SIMULATION
FIGURE 7-3

-3. RELAP5 INPUT PARAMETERS FOR THE KEWAUNEE SAFETY VALVE PR-3B SIMULAT RUPTURE DISKS--75 PERCENT ORIFICE PLATE--COLD LOOPS (120 F)*

Component**	Component Type	Volume or Junction Number	Area (sq ft)	Length of Each Volume (ft)	Vertical Angle (degrees)	Initial Conditions***	Forward Loss	Reverse Loss	Description
001	TMDPVOL	V1	38.48	25.98	90.0	Table: Time-P-Q_S	--	--	Pressurizer vessel (this is represented as a time dependent volume).
036	PIPE	V1-3	0.201	0.700	0.0	P=14.7 T=120 Q_N=0.948			Horizontal segment downstream from PSV/PR-3A.
		J1-2	0.201	--	--	--	0.0	0.0	
037	SNGLJUN	J1	0.201	--	--	--	0.15	0.15	First elbow downstream from PSV/PR-3A.
038	PIPE	V1-7	0.548	0.64	0.0	P=14.7 T=120 Q_N=0.948	--	--	Horizontal 10-inch pipe between safety valves.
		J1-6	0.548	--	--	--	0.0	0.0	
039	SNGLJUN	J1	0.375	--	--		0.94	0.348	Junction of reducer and 10-inch pipe.
040	SNGLVOL	V1	0.375	0.583	0.0	P=14.7 T=120 Q_N=0.948	--	--	Reducer (6 by 10 inches).
041	SNGLJUN	J1	0.548	--	--	--	0.0	0.0	Junction at 10-inch horizontal run to 10-inch by 6-inch tee.
042	SNGLVOL	V1	0.548	0.60	0.0	P=14.7 T=120 Q_N=0.948	--	--	Horizontal segment downstream from 10-inch horizontal run.
043	SNGLJUN	J1	0.201	--	--	--	(Abrupt Area Change)		Connects horizontal 10-inch piping run to 10-inch by 6-inch tee.
044	BRANCH	V1	0.201	0.83	0.0	P=14.7 T=120	--	--	10-inch by 6-inch piping cross connecting PSV PR-3B to 10-inch pipe.
		J=0							
045	SNGLJUN	J1	0.201	--	--	--	0.0	0.0	Connects 10-inch by 6-inch cross to downstream piping.
046	PIPE	V1	0.548	0.38	0.0	P=14.7 T=120	--	--	Horizontal segment upstream of 10-inch elbow.
		V2-3	0.548	0.65	0.0	P=14.7 T=120 Q_N=0.948	--	--	
		J1-2	0.548	--	0.0	-- --	0.0	0.0	
047	SNGLJUN	J1	0.548	--	--	--	0.171	0.171	10-inch elbow in downstream piping.
114	PIPE	V1-3	0.548	0.574	0.0	P=14.7 T=120 Q_N=0.948	--	--	10-inch pipe segment between 10-inch elbow and orifice plate.
		J1-2	0.548	--	--	--	0.0	0.0	
048	PIPE	V1-9	0.548	0.51	0.0	P=14.7 T=120 Q_N=0.948	--	--	Horizontal pipe between orifice plate and second 10-inch elbow.
		J1-8	0.548	--	--	--	0.0	0.0	
049	SNGLJUN	J1	0.548	--	--	--	0.172	0.172	Second 10-inch elbow in downstream piping.

-3 (Continued). RELAP5 INPUT PARAMETERS FOR THE KEWAUNEE SAFETY VALVE P TI LATION--TWO RUPTURE DISKS--75 PERCENT ORIFICE PLATE--COLD LOOPS (I

Component**	Component Type	Volume or Junction Number	Area sq ft	Length of Each Volume ft	Vertical Angle degrees	Initial Conditions***			Forward Loss	Reverse Loss	Description
050	PIPE	V1-5	0.548	0.526	-90.0	P=14.7	T=120	Q_N=0.948	--	--	10-inch vertical piping segment between second 10-inch elbow and PORV connection.
		J1-4	0.548	--	--		--		0.0	0.0	
051	SNGLJUN	J1	0.548	--	--		--		0.0	0.0	
052	SNGLVOL	V1	0.548	0.5	-90.0	P=14.7	T=120	Q_N=0.948	--	--	Vertical 10-inch piping segment.
053	SNGLJUN	J1	0.548	--	--		--		0.55	0.55	
054	PIPE	V1-95	0.548	0.558	-90.0	P=14.7	T=120	Q_N=0.948	--	--	
		J1-94	0.548	--	--		--		0.0	0.0	Vertical segment to third 10-inch piping elbow.
055	SNGLJUN	J1	0.548	--	--		--		0.172	0.172	Third 10-inch elbow in downstream piping.
056	PIPE	V1-35	0.548	0.897	0.0	P=14.7	T=120	Q_N=0.948	--	--	Horizontal segment.
		J1-34	0.548	--	--		--		0.0	0.0	
057	SNGLJUN	JI	0.548	--	--		--		0.060	0.060	16.6-degree bend in downstream piping.
058	PIPE	V1-7	0.548	0.997	0.0	P=14.7	T=120	Q_N=0.948	--	--	Horizontal segment.
		J1-6	0.548	--	--		--		0.0	0.0	
059	SNGLJUN	J1	0.548	--	--		--		0.172	0.172	Fifth 10-inch elbow in downstream piping.
060	PIPE	V1-3 J1-2	0.548 0.548	1.11 --	-45.0 --	P=14.7	T=120 --	Q_N=0.948	--	--	Volume from relief tank entrance to air/water interface within tank discharge pipe.
061	SNGLJUN	J1	0.548	--	--		--		0.0	0.0	Air/water interface within tank discharge pipe.
062	PIPE	V1-2	0.548	1.00	-45.0	P=14.7	T=120		--	--	Volume below water surface to 45-degree bend in relief tank.
063	SNGLJUN	J1	0.548	--	--		--		0.103	0.103	45-degree bend in relief tank discharge pipe.
064	SNGLVOL	V1	0.548	1.650	-90.0	P=14.7	T=120		--	--	Piping in relief tank.
065	SNGLJUN	J1	0.548	--	--		--		0.0	0.0	Connects vertical segment of discharge pipe.
066	SNGLVOL	V1	0.548	1.500	-90.0	P=14.7	T=120		--	--	Piping in relief tank.
067	SNGLJUN	J1	0.548	--	--		--		0.172	0.172	90-degree bend in relief tank discharge pipe.
068	SNGLVOL	V1	0.548	1.500	0.0	P=14.7	T=120		0.0	0.0	Bend volume in relief tank.
069	BRANCH	V1	0.548	4.080	0.0	P=14.7	T=120		--	--	Horizontal discharge pipe in relief tank.
		J1	0.548	--	--		--		0.0	0.0	
		J2	0.273	--	--		--		1.89	1.71	
		J3	0.548	--	--		--		0.0	0.0	

T[illegible]7-3 (Continued). RELAP5 INPUT PARAMETERS FOR THE KEWAUNEE SAFETY VALVE P[illegible]MULATION--TWO RUPTURE DISKS--75 PERCENT ORIFICE PLATE--COLD LOOPS ([illegible]

Component**	Component Type	Volume or Junction Number	Area sq ft	Length of Each Volume ft	Vertical Angle degrees	Initial Conditions***	Forward Loss	Reverse Loss	Description
070	BRANCH	V1	0.548	4.080	0.0	P=14.7 T=120	--	--	Horizontal discharge pipe in pressurizer relief tank.
		J1	0.273	--	--	--	1.89	1.71	
		J2	0.548	--	--	--	0.0	0.0	
071	SNGLVOL	V1	0.548	4.080	0.0	P=14.7 T=120	--	--	Horizontal discharge pipe in pressurizer relief tank.
072	SNGLJUN	J1	0.285	--	--	--	1.89	1.71	
073	BRANCH	V1	106.65	5.629	90.0	P=14.7 T=120	--	--	Volume of water in 75 percent full relief tank.
		J=0	--	--	--	--	--	--	
074	SNGLJUN	J1	106.6	--	--	--	0.0	0.0	Air/water interface within relief tank.
075	SNGLVOL	V1-4	106.6	1.876	90.0	P=14.7 T=120 Q_N=0.948	--	--	Volume of air in 75 percent water-filled relief tank.
076	PIPE	V1-4	0.201	0.500	0.0	P=14.7 T=120 (water)			Horizontal segment downstream from PSV/PR-3B.
		J1-3	0.201	--	--	--	0.0	0.0	
077	SNGLJUN	J1	0.201	--	--	--	0.36	0.36	Junction from PSV/PR-3B discharge pipe to 10-inch by 6-inch tee.
078	VALVE-SRVVLV	J1	0.017	--	--	--	(Abrupt Area Change)		Pressurizer safety valve (PSV)/PR-3B flow path.
079	PIPE	V1	0.147	0.800	0.0	P=2686.0 T=120 (water)	--	--	Vertical loop seal 6-inch segment upstream from PSV/PR-3B.
080	SNGLJUN	J1	0.147	--	--	--	0.160	0.160	Connects lower loop seal of PSV/PR-3B to vertical segment.
081	SNGLVOL	V1	0.147	0.589	0.0	P=2686.0 T=120 (water)	--	--	Lower loop seal piping of PSV/PR-3B.
082	SNGLJUN	J1	0.147	--	--	--	0.0	0.0	Connects lower loop seal piping of PSV/PR-3B.
083	PIPE	V1-2	0.147	0.638 0.54	0.0	P=2686.0 T=275 P=2686.0 Q_S=1.0	--	--	Horizontal pipe of lower loop seal piping of PSV/PR-3B.
		J1	0.147	--	--	--	0.0	0.0	
084	SNGLJUN	J1	0.147	--	--	--	0.160	0.160	Connects lower loop seal of PSV/PR-3B to vertical loop seal segment.
085	PIPE	V1-2	0.147	0.703	-90.0	P=2686.0 Q_S=1.0	--	--	Second loop seal elbow volume and vertical segment of PSV/PR-3B.
		J1	0.147	--	--	--	0.0	0.0	
086	SNGLJUN	J1	0.147	--	--	--	0.0	0.0	Connects vertical loop seal segment of PSV/PR-3B to top of loop seal.
087	PIPE	V1	0.147	0.584	0.0	P=2686.0 Q_S=1.0	--	--	Top of loop seal for PSV/PR-3B.

-3 (Continued). RELAP5 INPUT PARAMETERS FOR THE KEWAUNEE SAFETY VALVE MULATION--TWO RUPTURE DISKS--75 PERCENT ORIFICE PLATE--COLD LOOPS (
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Component **	Component Type	Volume or Junction Number	Area sq ft	Length of Each Volume ft	Vertical Angle degrees	Initial Conditions***	Forward Loss	Reverse Loss	Description
088	SNGLJUN	J1	0.147	--	--	--	0.195	0.195	Connects top of loop seal for PSV/PR-3B to piping going to pressurizer.
089	SNGLVOL	V1	0.147	0.785	0.0	P=2686.0 Q_S=1.0	--	--	Loop seal segment of PSV/PR-3B.
090	SNGLJUN	J1	0.147	--	--	--	0.0	0.0	Connects loop seal piping segments of PSV/PR-3B.
091	PIPE	V1-3	0.147	1.074	90.0	P=2686.0 Q_S=1.0	--	--	Vertical pipe from pressurizer to first loop seal elbow volume (Loop Seal B).
		J1-2	0.147	--	--	--	0.0	0.0	
092	SNGLJUN	J1	0.147	--	--	--	0.594	0.992	Connects pressurizer to loop seal piping.
093	SNGLVOL	V1	90.0	100.0	-90.0	P=14.7 T=120 Q_N=0.948	--	--	Pressurizer vault.
094	VALVE-MTRVLV	J1	0.163	--	--	--	(Abrupt Area Change)		Rupture disk to open in 20 msec after 285 psia set point pressure is reached.
095	SNGLVOL	V1	0.201	0.51	0.0	P=14.7 T=120 Q_N=0.948	--	--	Represents cavity upstream of rupture disk.
096	SNGLVOL	V1	0.201	0.843	0.0	P=14.7 T=120 Q_N=0.948	--	--	45-degree, 6-inch elbow connecting rupture disk tee to 10-inch by 6-inch reducer.
097	BRANCH	V1	0.201	0.604	0.0	P=14.7 T=120 Q_N=0.948	--	--	Discharge leg of rupture disk tee.
		J1	0.201	--	--	--	0.0	0.0	
		J2	0.201	--	--	--	0.0	0.0	
114	PIPE	V1-3	0.548	0.574	0.0	P=14.7 T=120 Q_N=0.948	--	--	10-inch piping upstream of orifice plate.
119	SNGLJUN	J1	0.201	--	--	--	0.15	0.15	
120	SNGLJUN	J1	0.201	--	--	--	0.42	0.42	
121	SNGLJUN	J1	0.201	--	--	--	3.02	0.0	Junctions connecting rupture disk configuration.
122	SNGLJUN	J1	0.185	--	--	--	0.0	0.0	Connects 6-inch tee to outlet leg to rupture disk.
123	SNGLJUN	J1	0.137	--	--	--	0.963	0.963	Represents opening in orifice plate.
136	SNGLVOL	V1	0.201	0.854	0.0	P=14.7 T=120 Q_N=0.948	--	--	6-inch piping segment at horizontal pipe discharge from PSV/PR-3A.
178	SNGLVOL	V1	0.017	0.92	90.0	P=2686.0 Q_S=1.0	--	--	Inlet valve nozzle to PSV/PR-3B.
193	SNGLVOL	V1	90.0	100.0	-90.0	P=14.7 T=120 Q_N=0.948	--	--	Pressurizer vault.
194	VALVE-MTRVLV	J1	0.163	--	--	--	(Abrupt Area Change)		Rupture disk to open in 20 msec after 285 psia set point pressure is reached.

[redacted]-3 (Continued). RELAP5 INPUT PARAMETERS FOR THE KEWAUNEE SAFETY VALVE P[redacted]ULATION--TWO RUPTURE DISKS--75 PERCENT ORIFICE PLATE--COLD LOOPS ([redacted]

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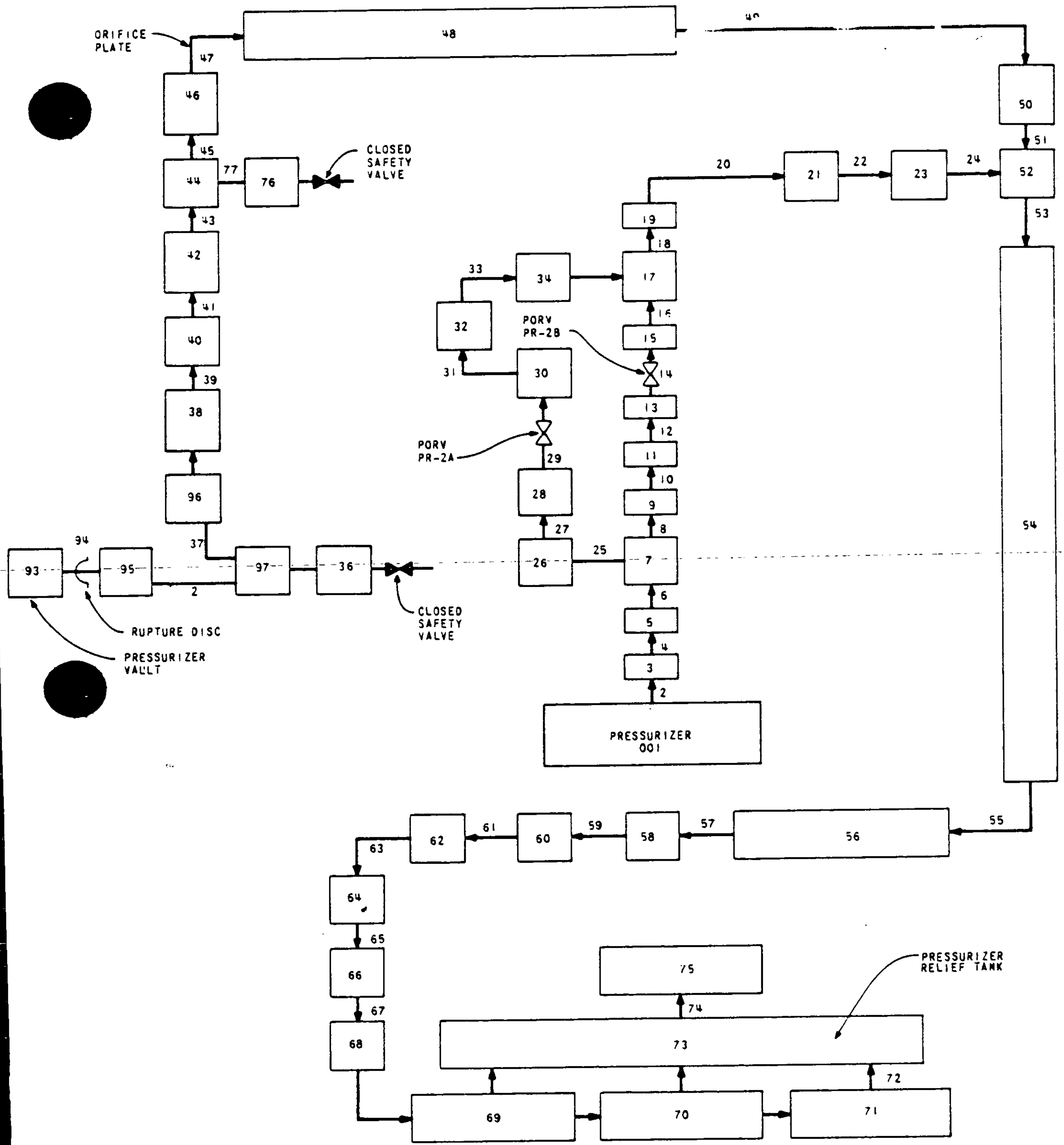
Component**	Component Type	Volume or Junction Number	Area sq ft	Length of Each Volume ft	Vertical Angle degrees	Initial Conditions***			Forward Loss	Reverse Loss	Description
195	PIPE	V1	0.201	0.62	0.0	P=14.7	T=120		--	--	Piping outlet from main branch of 10-inch by 6-inch tee to rupture disk.
		J1	0.188	--	0.0	--	--		0.15	0.15	
		V2	0.188	0.62	0.0	P=14.7	T=120	Q_N=0.948	--	--	
196	SNGLJUN	J1	0.185	--	--		--		(Abrupt Area Change)		Connects 10-inch by 6-inch cross to outlet leg to rupture disk.
278	SNGLJUN	J1	0.017	--	--		--		(Abrupt Area Change)		Connects PSV/PR-3B upstream piping to inlet valve nozzle.

*Assumptions: No choking was assumed to occur in pipe except at orifice plate.
Wall friction was computed.
Nonequilibrium calculations were made (unequal phase temperatures).
Pipe roughness was assumed to be 0.00015.

**Figure 7-3 shows nodal diagram.

*** P = Pressure (psia)
T = Temperature (degrees F)
Q_N = Noncondensable quality (air)
Q_S = Static or equilibrium quality (steam)
Flag 2 has P, Q_S
Flag 3 has P, T
Flag 4 has P, T, Q_N



RELAP5 NODALIZATION FOR KEWAUNEE TWO RELIEF VALVE SIMULATION
FIGURE 7-4

-4. RELAP5 INPUT PARAMETERS FOR THE KEWAUNEE DOUBLE PORV SIMULATION*

Component**	Component Type	Volume or Junction Number	Area sq ft	Length of Each Volume ft	Vertical Angle degrees	Initial Conditions***	Forward Loss	Reverse Loss	Description
001	TMDPVOL	V1	38.48	25.98	90.0	Table: Time-P-Q_S	--	--	Pressurizer vessel (this is represented as a time dependent volume).
002***	SNGLJUN		0.038	--	--	--	0.0	0.0	
003	PIPE	V1-5	0.038	0.508	90.0	P=2472.0 Q_S=1.0	--	--	Vertical pipe from pressurizer.
		J1-4	0.038	--	--	--	0.0	0.0	
004	SNGLJUN	J1	0.038	--	--	--	0.160	0.160	First 90 degree elbow from pressurizer.
005	PIPE	V1-6	0.038	0.528	0.0	P=2472.0 Q_S=1.0	--	--	Horizontal pipe from elbow to PORV PR-2B branch.
		J1-5	0.038	--	--	--	0.0	0.0	
006	SNGLJUN	J1	0.038	--	--	--	0.0	0.0	
007	BRANCH	V1/J=0	0.038	0.500	0.0	P=2472.0 Q_S=1.0	--	--	Branch volume to PORV PR-2B.
008	SNGLJUN	J1	0.038	--	--	--	0.0	0.0	
009	PIPE	V1-5	0.038	0.484	0.0	P=2472.0 Q_S=1.0	--	--	Horizontal pipe from Branch Volume 007 to second elbow.
		J1-4	0.038	--	--	--	0.0	0.0	
010	SNGLJUN	J1	0.038	--	--	--	0.160	0.160	Second elbow in first branch.
011	SNGLVOL	V1	0.038	0.801	0.0	P=2472.0 Q_S=1.0	--	--	
012	SNGLJUN	J1	0.038	--	--	--	0.0	0.0	Open Gate Valve PR-1A.
013	PIPE	V1-5	0.038	0.543	0.0	P=2472.0 Q_S=1.0	--	--	
		J1-4	0.038	--	--	--	0.0	0.0	
014	VALVE-MTRVLV	J1	0.038	--	--	--	3.250	5.730	PORV PR-2A.
015	PIPE	V1-3	0.088	0.497	0.0	P=14.7 T=120 Q_N=0.948	--	--	Volume from PORV PR-2A to Branch Volume 017 in first branch.
		J1-2	0.088	--	--	--	0.0	0.0	
016	SNGLJUN	J1	0.088	--	--	--	0.0	0.0	
017	BRANCH	V1/J=0	0.088	0.500	0.0	P=14.7 T=120 Q_N=0.948	--	--	Branch volume from PORV PR-2B.
018	SNGLJUN	J1	0.088	--	--	--	0.0	0.0	
019	SNGLVOL	V1	0.088	0.493	0.0	P=14.7 T=120 Q_N=0.948	--	--	Horizontal pipe from Branch Volume 017 to third elbow.
020	SNGLJUN	J1	0.088	--	--	--	0.172	0.172	Third 90 degree elbow.
021	PIPE	V1-2	0.088	0.493	-90.0	P=14.7 T=120 Q_N=0.948	--	--	Vertical segment downstream pipe.
		J1	0.088	--	--	--	0.0	0.0	

TABLE 7-4 (Continued). RELAP5 INPUT PARAMETERS FOR THE KEWAUNEE DOUBLE PORV SIMULATION*

Component**	Component Type	Volume or Junction Number	Area sq ft	Length of Each Volume ft	Vertical Angle degrees	Initial Conditions***	Forward Loss	Reverse Loss	Description
022	SNGLJUN	J1	0.088	--	--	--	0.103	0.103	45 degree elbow.
023	PIPE	V1-4	0.088	0.477	-45.0	P=14.7 T=120 Q_N=0.948	--	--	Pipe segment inclined at 45 degrees.
		J1-3	0.088	--	--	--	0.0	0.0	
024	SNGLJUN	J1	0.088	--	--	--	1.43	0.806	Tee junction.
025	SNGLJUN	J1	0.038	--	--	--	0.0	0.0	
026	SNGLVOL	V1	0.038	0.785	0.0	P=2472.0 Q_S=1.0	--	--	Horizontal pipe from Branch Volume 007 to Gate Valve PR-1B.
027	SNGLJUN	J1	0.038	--	--	--	0.0	0.0	Open Gate Valve PR-1B.
028	PIPE	V1-6	0.038	0.489	0.0	P=2472.0 Q_S=1.0	--	--	Horizontal pipe from gate valve to PORV PR-2B.
		J1-5	0.038	--	--	--	0.0	0.0	
029	VALVE-MTRVLV	J1	0.038	--	--	--	(Abrupt Area Change)		PORV PR-2B.
030	PIPE	V1-2	0.051	0.450	0.0	P=14.7 T=120 Q_N=0.948	--	--	Horizontal pipe from PORV PR-2B to second elbow in second branch.
		J1	0.051	--	--	--	0.0	0.0	
031	SNGLJUN	J1	0.051	--	--	--	0.173	0.173	Second elbow in Branch B.
032	PIPE	V1-3	0.051	0.614	0.0	P=14.7 T=120 Q_N=0.948	--	--	Pipe from second elbow to 45 degree elbow in Branch B.
		J1-2	0.051	--	--	--	0.0	0.0	
033	SNGLJUN	J1	0.051	--	--	--	0.104	0.104	45 degree elbow in Branch B.
034	PIPE	V1-2	0.051	0.576	0.0	P=14.7 T=120 Q_N=0.948	--	--	Pipe from 45 degree elbow to Branch Volume 017 in Branch B.
		J1	0.051	--	--	--	0.0	0.0	
035	SNGLJUN	J1	0.051	--	--	--	0.0	0.0	
036	PIPE	V1-3	0.201	0.700	0.0	P=14.7 T=120 Q_N=0.948			Horizontal segment downstream from PSV/PR-3A.
		J1-2	0.201	--	--	--	0.0	0.0	
037	SNGLJUN	J1	0.201	--	--	--	0.15	0.15	First elbow downstream from PSV/PR-3A.
038	PIPE	V1-10	0.201	0.53	0.0	P=14.7 T=120 Q_N=0.948	--	--	Horizontal pipe from first elbow to reducer.
		J1-7	0.201	--	--	--	0.0	0.0	
039	SNGLJUN	J1	0.201	--	--		0.0	0.1	Junction at 6-inch end of reducer.
040	SNGLVOL	V1	0.375	0.50	0.0	P=14.7 T=120 Q_N=0.948	--	--	Reducer (6 by 10 inches).
041	SNGLJUN	J1	0.375	--	--	--	0.94	0.0	Junction at 10-inch end of reducer.
042	PIPE	V1-3	0.548	0.577	0.0	P=14.7 T=120 Q_N=0.948	--	--	Horizontal segment downstream from 10-inch horizontal run.
		J1-2	0.548	--	--		0.0	0.0	

TABLE 7-4 (Continued). RELAP5 INPUT PARAMETERS FOR THE KEWAUNEE DOUBLE PORV SIM[illegible]ON *

Component**	Component Type	Volume or Junction Number	Area sq ft	Length of Each Volume ft	Vertical Angle degrees	Initial Conditions***	Forward Loss	Reverse Loss	Description
043	SNGLJUN	J1	0.548	--	--	--	1.78	1.78	Connects horizontal 10-inch piping run to 10-inch by 6-inch tee.
044	BRANCH	V1	0.548	0.500	0.0	P=14.7 T=120 Q_N=0.948	--	--	10-inch by 6-inch piping tee connecting PSV PR-3B to 10-inch pipe.
		J=0							
045	SNGLJUN	J1	0.548	--	--	--	0.934	0.934	Connects 10-inch by 6-inch tee to downstream piping.
046	PIPE	V1-5	0.548	0.576	0.0	P=14.7 T=120 Q_N=0.948	--	--	Horizontal segment upstream of 10-inch elbow.
		J1-4	0.548	--	--	--	0.0	0.0	
047	SNGLJUN	J1	0.137	--	--	--	0.900	0.900	Orifice plate.
048	PIPE	V1-10	0.548	0.621	0.0	P=14.7 T=120 Q_N=0.948	--	--	Horizontal pipe between orifice plate and second 10-inch elbow.
		J1-9	0.548	--	--	--	0.0	0.0	
049	SNGLJUN	J1	0.548	--	--	--	0.172	0.172	Second 10-inch elbow in downstream piping.
050	PIPE	V1-5	0.548	0.526	-90.0	P=14.7 T=120 Q_N=0.948	--	--	10-inch vertical piping segment between second 10-inch elbow and PORV connection.
		J1-4	0.548	--	--	--	0.0	0.0	
051	SNGLJUN	J1	0.548	--	--	--	0.0	0.0	
052	SNGLVOL	V1	0.548	0.5	-90.0	P=14.7 T=120 Q_N=0.948	--	--	Vertical 10-inch piping segment.
053	SNGLJUN	J1	0.548	--	--	--	0.55	0.55	
054	PIPE	V1-95	0.548	0.558	-90.0	P=14.7 T=120 Q_N=0.948	--	--	
		J1-94	0.548	--	--	--	0.0	0.0	Vertical segment to third 10-inch piping elbow.
055	SNGLJUN	J1	0.548	--	--	--	0.172	0.172	Third 10-inch elbow in downstream piping.
056	PIPE	V1-35	0.548	0.897	0.0	P=14.7 T=120 Q_N=0.948	--	--	Horizontal segment.
		J1-34	0.548	--	--	--	0.0	0.0	
057	SNGLJUN	J1	0.548	--	--	--	0.060	0.060	16.6-degree bend in downstream piping.
058	PIPE	V1-7	0.548	0.997	0.0	P=14.7 T=120 Q_N=0.948	--	--	Horizontal segment.
		J1-6	0.548	--	--	--	0.0	0.0	
059	SNGLJUN	J1	0.548	--	--	--	0.172	0.172	Fifth 10-inch elbow in downstream piping.
060	PIPE	V1-3	0.548	1.11	-45.0	P=14.7 T=120 Q_N=0.948	--	--	Volume from relief tank entrance to air/water interface within tank discharge pipe.
		J1-2	0.548	--	--	--			
061	SNGLJUN	J1	0.548	--	--	--	0.0	0.0	Air/water interface within tank discharge pipe.

7-4 (Continued). RELAP5 INPUT PARAMETERS FOR THE KEWAUNEE DOUBLE PORV S[illegible]ON*

Component**	Component Type	Volume or Junction Number	Area sq ft	Length of Each Volume ft	Vertical Angle degrees	Initial Conditions***			Forward Loss	Reverse Loss	Description
062	PIPE	V1-2	0.548	1.00	-45.0	P=14.7	T=120		--	--	Volume below water surface to 45-degree bend in relief tank.
063	SNGLJUN	J1	0.548	--	--		--		0.103	0.103	45-degree bend in relief tank discharge pipe.
064	SNGLVOL	V1	0.548	1.650	-90.0	P=14.7	T=120		--	--	Piping in relief tank.
065	SNGLJUN	J1	0.548	--	--		--		0.0	0.0	Connects vertical segment of discharge pipe.
066	SNGLVOL	V1	0.548	1.500	-90.0	P=14.7	T=120		--	--	Piping in relief tank.
067	SNGLJUN	J1	0.548	--	--		--		0.172	0.172	90-degree bend in relief tank discharge pipe.
068	SNGLVOL	V1	0.548	1.500	0.0	P=14.7	T=120		0.0	0.0	Bend volume in relief tank.
069	BRANCH	V1	0.548	4.080	0.0	P=14.7	T=120		--	--	Horizontal discharge pipe in relief tank.
		J1	0.548	--	--		--		0.0	0.0	
		J2	0.273	--	--		--		1.89	1.71	
		J3	0.548	--	--		--		0.0	0.0	
070	BRANCH	V1	0.548	4.080	0.0	P=14.7	T=120		--	--	Horizontal discharge pipe in relief tank.
		J1	0.273	--	--		--		1.89	1.71	
		J2	0.548	--	--		--		0.0	0.0	
071	SNGLVOL	V1	0.548	4.080	0.0	P=14.7	T=120		--	--	Horizontal discharge pipe in relief tank.
072	SNGLJUN	J1	0.285	--	--		--		1.89	1.71	
073	BRANCH	V1	106.65	5.629	90.0	P=14.7	T=120		--	--	Volume of water in 75 per cent full relief tank.
		J=0	--	--	--		--		--	--	
074	SNGLJUN	J1	106.6	--	--		--		0.0	0.0	Air/water interface within relief tank.
075	SNGLVOL	V1-4	106.6	1.876	90.0	P=14.7	T=120	Q_N=0.948	--	--	Volume of air in 75 per cent water-filled relief tank.
076	PIPE	V1-4	0.201	0.500	0.0	P=14.7	T=120	Q_N=0.948			Horizontal segment downstream from PSV/PR-3B.
		J1-3	0.201	--	--		--		0.0	0.0	
077	SNGLJUN	J1	0.201	--	--		--		0.36	0.36	Junction from PSV/PR-3B discharge pipe to 10-inch by 6-inch tee.
093	SNGLVOL	V1	90.0	100.0	-90.0	P=14.7	T=120	Q_N=0.948	--	--	Pressurizer vault.
094	VALVE-MTRVLV	J1	0.19	--	--		--		(Abrupt Area Change)		Rupture disc to open in 40 msec after 285 psia set point pressure is reached.
095	BRANCH	V1	0.201	1.0	0.0	P=14.7	T=120	Q_N=0.948	--	--	Represents cavity upstream of rupture disc.

TABLE 7-4 (Continued). RELAP5 INPUT PARAMETERS FOR THE KEWAUNEE DOUBLE PORV S[illegible]ON*

Component**	Component Type	Volume or Junction Number	Area sq ft	Length of Each Volume ft	Vertical Angle degrees	Initial Conditions***			Forward Loss	Reverse Loss	Description
096	BRANCH	V1	0.201	0.529	0.0	P=14.7	T=120	Q_N=0.948	--	--	45-degree, 6-inch elbow connecting rupture disc tee to 10-inch by 6-inch reducer.
		J1	0.1005	--	--		--		0.575	0.575	
		J2	0.1005	--	--		--		0.575	0.575	
		J3	0.201	--	--		--		0.0	0.0	
097	BRANCH	V1	0.201	0.50	0.0	P=14.7	T=120	Q_N=0.948	--	--	Discharge leg of rupture disc tee.
		J1	0.201	--	--		--		0.0	0.0	
		J2	0.1005	--	--		--		24.75	24.75	

*Assumptions: No choking was assumed to occur in pipe except at orifice plate.
Wall friction was computed.
Nonequilibrium calculations were made (unequal phase temperatures).
Pipe roughness was assumed to be 0.00015.

**Figure 7-4 shows nodal diagram.

*** P = Pressure (psia)
T = Temperature (degrees F)
Q_N = Noncondensable quality (air)
Q_S = Static or equilibrium quality (steam)
Flag 2 has P, Q_S
Flag 3 has P, T
Flag 4 has P, T, Q_N

The worst case (greatest pressure rise) PORV was determined to be the loss of load at beginning-of-life, with zero moderation temperature coefficient assuming full credit for the pressurizer spray, PORVs, and automatic control rod insertion. The PORVs were assumed to actuate at 4.2 seconds into the transient or at 2,350 psia (the PORV set point).

7.2 THERMAL/HYDRAULIC MODELING TECHNIQUES

The RELAP5 modeling techniques, used for all the thermal/hydraulic calculations performed for the evaluations presented in this report, are summarized as follows.

(1) For the single and double safety valve actuation, the loop seal water was placed downstream of the safety valve(s). This procedure was shown to produce good analytical results when compared to the EPRI's CE-908 test results.[1,16]

The loop seal water temperature distribution was the same distribution used in Reference 1. The TAC2D computer code was used assuming 120 F ambient conditions in the pressurizer vault location adjacent to the loop seals. This is a conservative assumption, based on recent temperature measurements in the vault area. Subsection 7.2.1 discusses the details.

(2) The control volume length for all safety valve and PORV actuation RELAP5 simulations was less than 0.7 feet, except for those control volumes adjacent to the pressurizer relief tank. The control volume lengths used in all the analyses have been reviewed and are consistent with recommendations.[1,16]

The control volume length must be (in most cases) less than 1 foot to avoid underestimation of the thermal/hydraulic loads caused by numerical smearing of the water slug.

(3) The inlet nozzle to the safety valves was modeled as a cylinder 9 inches long and 0.017 square feet in open flow area.

(4) The safety valve will "pop" open in 0.015 second.

The time step parameters used for the RELAP5 calculations were a maximum time step of 0.001 seconds and a minimum time of 1.0 E-07 seconds. The RELAP5 computer code has an automatic time step control scheme which sets the calculational time step being used between the maximum time step specified (0.001 seconds) and the minimum time step specified (1.0 seconds). Checks are made on the mass truncating error, the Courant limit negative or zero densities, density differences, and water properties in determining if the time advancement is successful. If unsuccessful, the time step is reduced and the advancement is repeated until all acceptance criteria are met.

The use of these maximum and minimum time steps were confirmed by comparing RELAP5 calculations using these time steps with measured data from the Edwards' and Hanson's experimental measurements. These experiments were done using subcooled water, so the applicability to the loop seal simulation is good. The RELAP5 calculated results were in agreement with the measured data. Based on these comparisons it was judged that th time steps used for the Kewaunee analyses were sufficient to provide accu results.

The safety valve flow area was found by using the Kewaunee S/RV pipi RELAP5 model and setting the upstream pressure at 2,575 psia (safety valv set point plus 3 percent accumulation) with the safety valve comp y open. The valve area was adjusted leaving the upstream pressure at 2,575 psia, until the calculated flow through the valve was found to be 115 percent (or 396,700 lb/h) of rated flow. Therefore, using an area of 0.017 sq ft for the safety valve will produce 115 percent of rated flow a 3 percent accumulation. This is a conservative assumption for calculatin thermal/hydraulic piping loads because all of the tested Crosby 6M6 safet valves produced less than 115 percent rated flow at 3 percent accumulatio

The loss coefficients were calculated for all geometry changes in th discharge piping (elbows, contraction-expansions, and reducers). The los coefficients were calculated using the handbook written by Idel'chik [I. E. Idel'chik, "Handbook of Hydraulic Resistance," AEC-tr-6630, (1966

A second popping time of 0.015 was extracted from test data and was used for the Kewaunee simulation. The popping times for the Crosby 6M6 safety valve testing for loop seals ranged from 0.009 seconds to 0.019 s therefore, the popping time used for the Kewaunee safety valves is typical for that type of valve.

7.2.1 Kewaunee Loop Seal Temperature Determination

As noted in Subsection 6.3.1, the amount of subcooling in the loop seal can be an important factor in determining the downstream forces on the discharge piping. Therefore, the two-dimensional heat transfer computer code, TAC2D, was used to determine the temperature variation in the Kewaunee loop seal.

The Kewaunee safety valve loop seal was modeled using TAC2D to determine the actual temperature profile of the water in the Kewaunee loop seal. Important parameters used in the TAC2D analysis are presented in Table 7-5. The Kewaunee loop seal with the TAC2D mesh intervals is illustrated on Figure 7-5. The TAC2D calculated results are presented in Table 7-6 and are shown on Figures 7-6 and 7-7.

7.2.2 Downstream Water Distribution

A solid slug was located directly downstream of the valve. The energy profile, predicted by TAC2D, was conserved by moving the water into the downstream piping with the same energy distribution as was calculated for upstream loop seal water.

To determine the downstream energy or temperature profile, the loop seal water was expanded through the valve while the enthalpy remained constant. The first two control volumes downstream of the valve contain the water above 212 F and below the saturated steam condition of 2,250 psia (653 F). These two volumes contain two-phase water, which represents the flashing of all water in the upstream loop seal between 212 F and 653 F into the downstream piping at a pressure of 14.7 psia. All other water below 212 F was distributed in the remaining downstream volumes. The primary criterion for calculating accurate downstream loading is to keep the water slug solid (no voids) in the piping system at the time of safety valve "pop."

TABLE 7-5. TAC2D PARAMETERS USED IN THE KEWAUNEE LOOP SEAL TEMPERATURE PROFILE DETERMINATION

Problem geometry	Cylindrical
Number nodes in radial direction	21
Number nodes in axial direction	36
Steel properties	
Thermal conductivity (Btu/hr-ft-R)	10.0
Volumetric specific heat (Btu/cu ft-R)	64.1
Emissivity	0.45
Water properties	
Thermal conductivity (Btu/hr-ft-R)	0.349
Volumetric specific heat (Btu/cu ft-R)	58.3
Initial temperatures, F	
Steam	653
Piping in steam region	645
Ambient air	120
Heat conductances at material interfaces (Btu/hr-sq ft-R)	
Steam/piping	1,150
Ambient air/bottom of valve	0.443
Ambient air/top of valve	0.877

Ambient air/piping

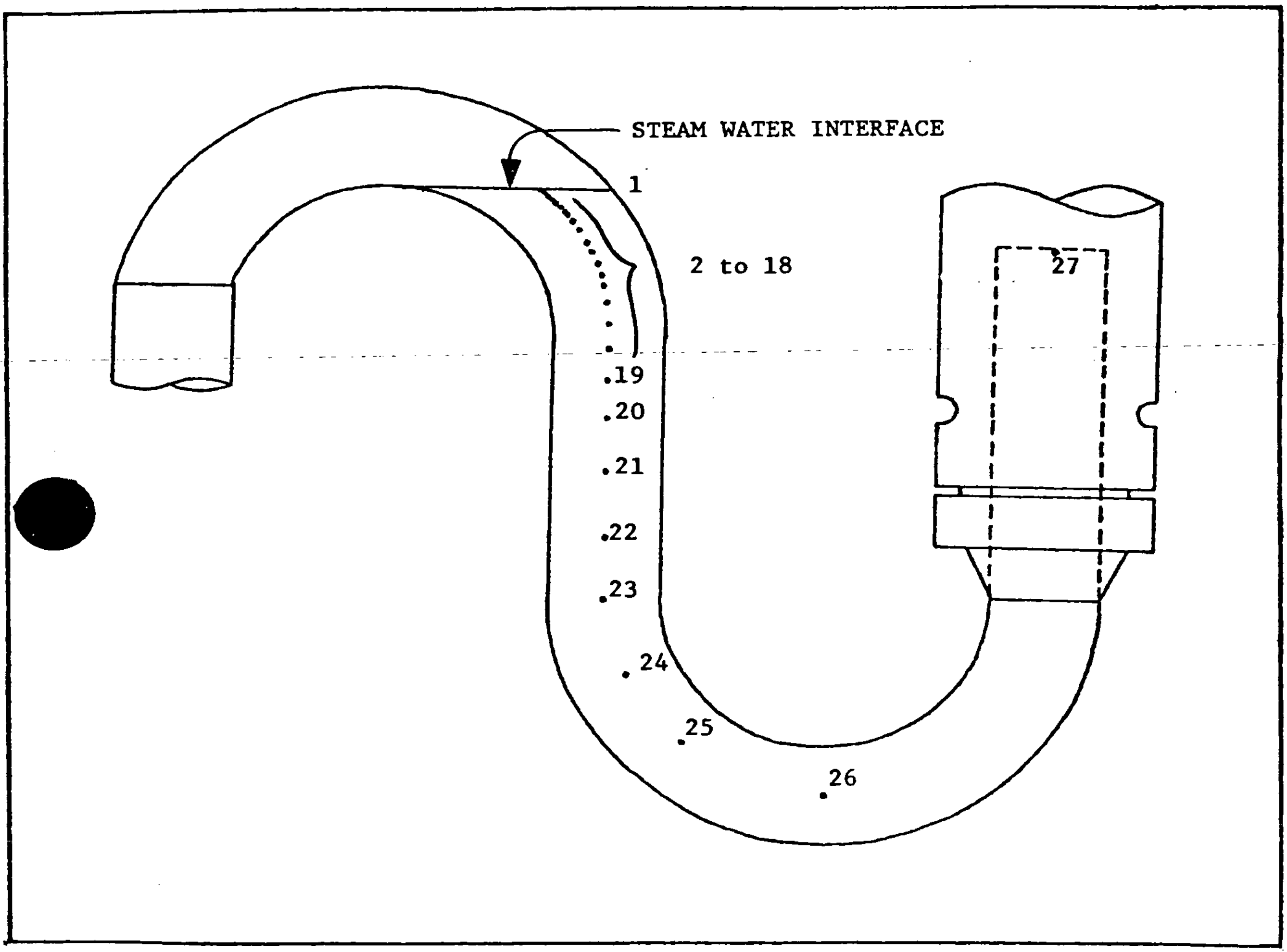
$$h_{air-pipe} = [1.0-(\left\{660.0-[2.0x(DR-460.0)-75.0]\right\}/585.0)5.0x1.39]$$

where DR is linear average of metal and air temperatures in degrees R

Water/piping

$$h_{water-pipe} = (1.0-\left\{[653.0-(DR-460.0)]/578.0\right\}0.6)x570.0$$

where DR is linear average of metal and water temperatures in degrees R



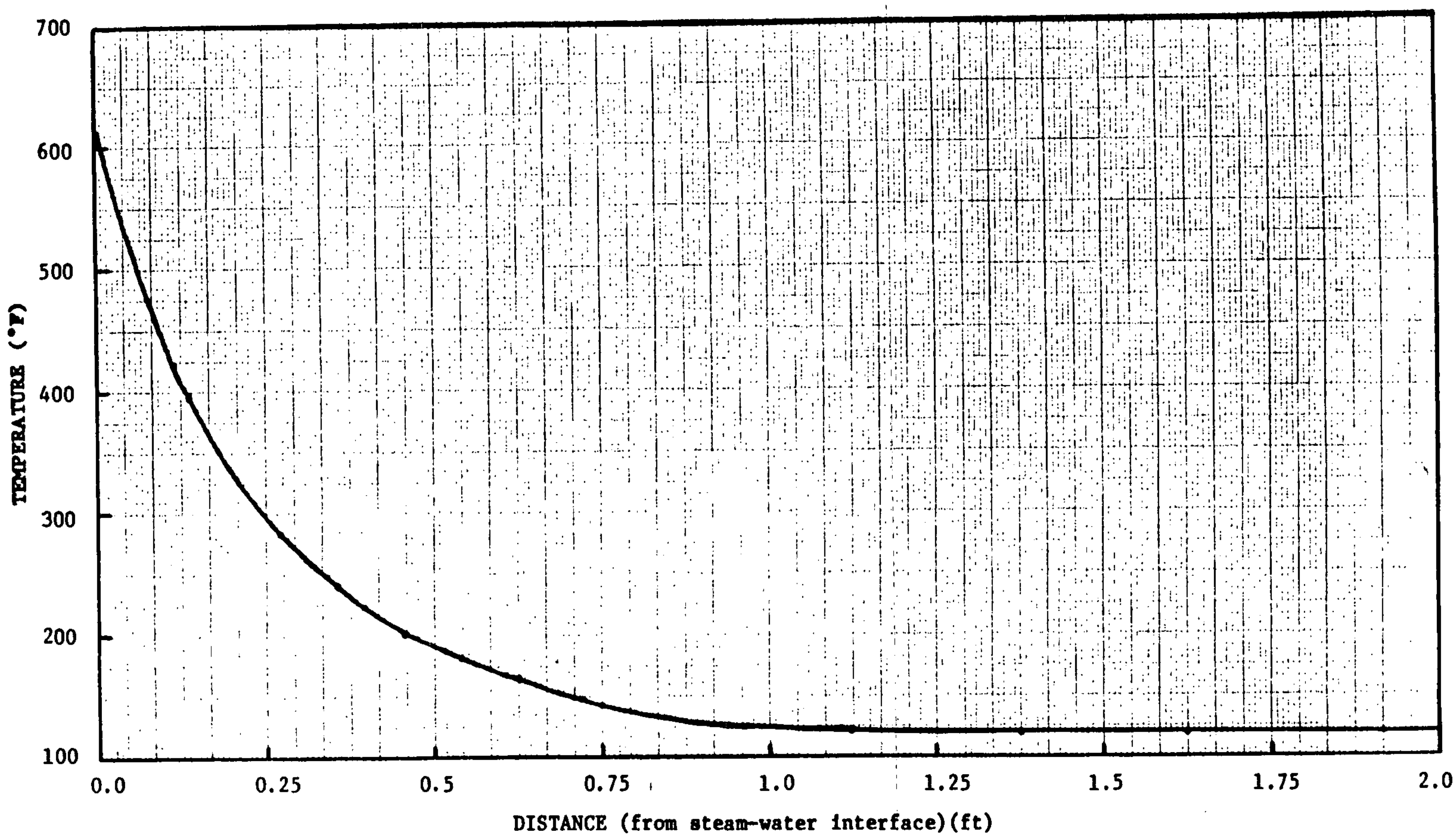
KEWAUNEE LOOP SEAL
TEMPERATURE DISTRIBUTION
FIGURE 7-5

TABLE 7-6. KEWAUNEE LOOP SEAL TEMPERATURE DISTRIBUTION

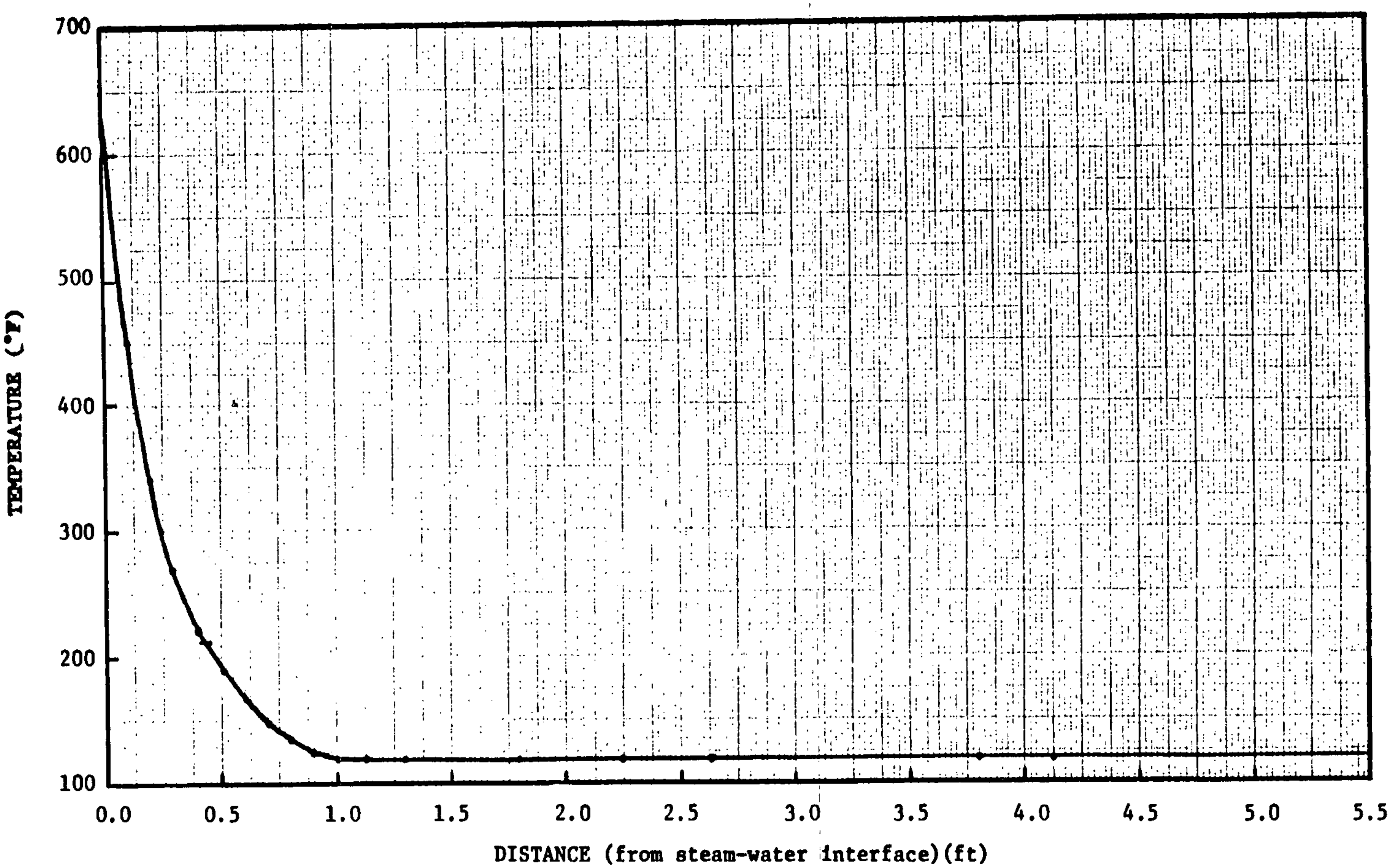
Node*	Distance** (ft)	Temperature
1	.008	618
2	.025	573
3	.042	536
4	.058	505
5	.075	478
6	.094	450
7	.115	423
8	.135	399
9	.156	377
10	.188	348
11	.229	315
12	.271	288
13	.313	264
[illegible]	.354	244
[illegible]	.396	227
16	.458	205
17	.542	183
18	.625	165
19	.75	145
20	.917	128
21	1.125	120
22	1.375	120
23	1.625	120
24	1.917	120
25	2.25	120
26	2.793	120
27	5.492	120

*Figure 7-5 shows nodes.

**Measure from steam-water interface.



KEWAUNEE LOOP SEAL WATER TEMPERATURE VARIATION (0.0 to 2.0)
FIGURE 7-6



KEWAUNEE LOOP SEAL WATER TEMPERATURE VARIATION (0.0 to 5.5)
FIGURE 7-7

This same technique of the downstream water distribution was used to determine the loads generated by the CE 908 safety valve test. These results were presented on Figure 6-16 of this report. That figure presents the calculated versus measured load data of the piping leg which experiences the largest thermal/hydraulic load tested. As seen in the comparison, the RELAP5 calculated results are in agreement with the measured results. Also, the studies done by ITI[16] for EPRI apparently used a similar method for distributing the downstream water. They also had good calculated results when compared to the test data.

Based on these comparisons, it was judged that the method for downstream water distribution used in the RELAP5 simulation provided good results in determining downstream loads on the Kewaunee S/RV piping system.

7.2.3 Pressure Conditions Used For RELAP5 Calculation

The pressure transient curve used for the Kewaunee locked rotor accident, presented on Figure 14.1-34 of the FSAR,[8] was modeled in the RELAP5 calculation as a time-dependent volume with a linear variation of saturated steam at 2,686.0 psia for time equal to 0.0 second and of saturated steam at 2,737.0 psia for time equal to 0.5 second. By using this procedure, the Kewaunee FSAR calculated lock rotor peak pressure of 2,737.0 psia was simulated by the RELAP5 calculation. This is a conservative peak pressure because the Crosby valve flow rates measured in the CE test program were in excess of the rated flow for the safety valves. Because the calculations made for the FSAR transient analyses were based on the rated flow, a more than rated flow will decrease the transient pressure rise below that which was calculated for the FSAR transient.

As a result of the conservative simulation of the CE Test 908 pressure transient (a constant ramp rate of 297 psi/second), the measured "pop" pressure for CE Test 908 (2,686 psi) was used to initiate the RELAP5 transient. Additional items relating to the conservatism included in the Kewaunee safety valve actuation analyses are as follows.

The loop seal used in the CE testing contained approximately 1.0 cu ft of water, whereas the loop seal piping at the Kewaunee plant contains only

0.7 cu ft of water. This difference amounts to 43 percent more water in the CE Test 908 loop seal than was contained in the Kewaunee loop With less water in the Kewaunee loop seal, it follows that the wate ould clear the Kewaunee valve sooner than the water would clear the CE 908 test valve, thereby producing a lower "pop" pressure for the Kewaunee safety valve.

Westinghouse (WCAP-10105) performed the original FSAR transient analy with the pressurizer safety valve modeled to open by assuming that the valve starts to open at the design set pressure (2,500 psia) and achieves rated flow at the accumulation pressure (2,575 psia). To assess the effec on reactor coolant system pressure due to valve opening delay, Westinghous (WCAP-10105, Section 4.0) ran a series of overpressure transients with various time delays inserted for the valve opening. These analyses utili the limiting overpressure FSAR transient condition. A worst case referen plant was selected for a two-loop plant which maximized the effect of the pressure rise caused by an overpressure transient condition. These simul tions revealed that, even with the delays of up to 1.0 second, the pressu transient peaks and turns around in a very short time. The Westi se calculations reveal that the CE testing apparatus simulated the effects o the loop seal delay in the pressure transient fairly well. Using the limiting transient reference plant, the calculations indicated that the 0 to 0.9 second opening delay produced a peak popping pressure which was typical of what was seen in the Crosby safety valve loop seal testing.

Other calculations done by Westinghouse proved that the locked rotor pressure rise is only slightly dependent on safety valve actuation and th the reactor coolant system pressurization is dictated mainly by heat remo (steam generators) and core feedback models. As a result, the pressuriza tion rate decreases with time until the transient pressure begins to subs even with no safety valve opening.

In summary, the following items were used in determining the Kewaune safety valve(s) popping pressure and pressurizer peak pressure which wer simulated using RELAP5.

(1) The Kewaunee locked rotor transient was simulated on RELAP5 using the Kewaunee FSAR transient. The Kewaunee FSAR transient was shown to be very conservative when compared to the Westinghouse two-loop worst case locked rotor transients.

(2) The Kewaunee loop seal has less water than the CE Test 908 loop. Therefore, when using a similar valve and pressurization rates, the CE test results are conservative relative to what would be expected at Kewaunee.

(3) The CE Test 908 popping pressure is typical of popping pressures calculated by Westinghouse when simulating a loop seal delay.

Based on this information, it was judged that the popping pressure of 2,686 psia and the peak pressure of 2,737 psia which were used to simulate the Kewaunee safety valve actuations are representative and conservative pressures.

The loss of load accident at beginning of core life with reactor control, pressurizer PORV actuation, and pressurizer spray actuation was used as the design basis accident for the double PORVs actuation. Assuming an opening time of 2.0 seconds, the PORVs are assumed fully open at 6.2 seconds into the FSAR transient.[8] The design transient was conservatively assumed to begin after the valves had opened completely. The RELAP5 simulated opening time was conservatively set at 0.5 seconds and was modeled as a time-dependent valve which was set at V_{area} = 0.0 sq ft at time = 0.0 seconds, and V_{area} = 0.11 sq ft at time = 0.5 seconds. The maximum valve area was based on the critical flow rate of 199,000 lb/h at a valve inlet pressure of 2,205 psia. The flow was based on the measured flow rate of test number 1 for the Masoneilan PORV at the Marshall test facility. This flow rate exceeds the rated flow of 179,000 lb/h at a set point pressure of 2,350 psia; therefore, it is a conservative flow rate to use in determining the thermal/hydraulic loads on the discharge piping.

7.3 DESCRIPTION OF RELAP5 MODELS

7.3.1 Description of Double PORV Model

This model was developed to maximize the thermal/hydraulic loading on the Kewaunee S/RV piping system caused by a double PORV actuation.

The following conservative assumptions were used to maximize the PORV actuation discharge pressures.

(1) The pressure in the discharge piping was initialized as air 14.7 psia, 120 F and 80 percent relative humidity.

(2) The maximum flow through a PORV was taken to be 199,000 lb/h, which was the maximum measure steam flow of the Masoneilan relie valve tested at the Marshall test facility.[22] This is approximately 11 percent greater than the rated flow of 179,000 lb/h.

(3) The opening time of the Masoneilan relief valve was assumed to b 0.5 second. This is considered a very conservative opening time since the shortest opening time measured at the Wyle test facili was 1.64 seconds.

The RELAP5 nodal diagram is presented on Figure 7-1. The des tion of the input parameters for the PORV RELAP5 model is given in Table 7-1. listing of the RELAP5 input for the double PORV actuation is presented in Appendix G.

7.3.2 Double and Single Safety Valve(s) Actuation With Two Rupture Disc Assemblies

These simulations were performed to determine the maximum thermal/hydraulic loading on the Kewaunee discharge piping system. The RELAP5 nodal diagrams for the double safety valve, the single safety valve PR-3A and the single safety valve PR-3B simulations are presented on Figures 7- 7-2, and 7-3, respectively. Descriptions of the RELAP5 input for the double safety valve actuation, the single safety valve PR-3A actuation, a the single safety valve PR-3B actuation are presented in Tables 7-1, 7-2, and 7-3, respectively.

The major assumptions used in these analyses are given as follows.

(1) The maximum flow for each safety valve was taken to be 115 percent of rated flow (397,000 lb/h steam at the set pressure of 2,500 psia). This 15 percent increase in rated flow was greater than any percent increase of measured flow over rated flow for the Crosby valves with loop seals tested at the Combustion Engineering Test Facility.[23]

(2) The orifice plate open area was assumed to be 25 percent of full open area (0.137 sq ft open flow area).

(3) The rupture disk set point was taken as 285 psia.

(4) The rupture disk was assumed to open within 20 msec after the set point had been reached.

(5) No flow impingement forces on the rupture disk surfaces were included as a means to rupture the disk.

(6) No PORV actuation was assumed.

(7) The locked rotor transient was simulated.

(8) The safety valve was assumed to "pop" in 0.015 second.

(9) The pressure in the discharge piping including the pressurizer relief tank was assumed to be 14.7 psia.

A listing of the RELAP5 input for the double safety valve actuation is presented in Appendix F.

7.4 DETERMINATION OF THE PIPING LOADS

The RELAP5 computer code determined pressures, densities, void fractions, and flow acceleration as a function of time. Some simple calculations and appropriate combinations are required to take the RELAP5 calculated parameters and provide the piping thermal/hydraulic loads for a piping system. A computer code is generally written to perform these calculations and to designate additions of junctions associated with piping legs. This computer code, which takes data from the RELAP5 calculations and transforms it through appropriate input instructions into piping loads to be used for stress calculations, is referred to as a "post processor." For the original Kewaunee piping report,[1] the post processor use is called REPIPE. Because of the change in computer facilities, the post processor used for the calculations presented in this report is referred to as FORCE.

FORCE[24] is a computer code developed by Boeing Computer Services Company. FORCE converts the thermal/hydraulic output from RELAP5 [illegible] force time histories at specified locations. The thermal/hydraulic loading time histories are generated using FORCE by summing the unbalanced forces (pressure and accelerations) between two points (usually elbows) in the RELAP5 model. The simulated piping segment between the two elbows is referred to as a piping leg.

Results from the FORCE calculations agreed with CE test results. Calculations using REPIPE and FORCE (Appendix B contains a description) produced approximately the same results.

7.5 THERMAL/HYDRAULIC AND LOAD CALCULATION RESULTS

7.5.1 Results of the Double PORV Actuation Simulation

The double PORV actuation simulation performed by RELAP5/MOD1 provide information for determining the thermal/hydraulic forces on the piping system caused by a double PORV actuation. Table 7-7 presents a summary of the peak forces calculated by RELAP5/FORCE. Plots of the PORV thermal/hydraulic loads for piping segments are presented in Appendix I and are defined in Table 7-8. Force time histories associated with the peak forces were used as input for the ADLPIPE[25] calculations. A lump mass sketch of the ADLPIPE stress model is presented on Figure 7-8. This sketch shows the location as defined in Table 7-8 of the applied piping loads which were calculated by RELAP5/FORCE.

7.5.2 Results of the Single and Double Safety Valve(s) Actuation Simulations

For the single safety valve actuation simulation, safety valves PR-[illegible] and PR-3B in two separate calculations were simulated to open. Because of the orifice plate downstream of the safety valve, the single safety actuation caused the rupture disk at the discharge of safety valve PR-3A to burst, allowing the loop seal water to exit through the burst disk.

TABLE 7-7. PEAK FORCES CAUSED BY A DOUBLE PORV ACTUATION

ADLPIPE* Lump Mass	Maximum Positive Force** kips	Maximum Negative Force** kips
52	.041	-.051
55	.047	-.071
815	.001	-.015
161	.12	-.86
265	.15	-.99
66	.16	-.31
67	.21	-.30
72	.001	-.008
174	.001	-.033
826	.0	-.0046
86	.005	-.077
91	.002	-.042
104	.001	-.024
[illegible]	.001	-.0075

*A description of associated piping segment is shown on Table 7-8.

**The forces are positive in the direction of flow.

TABLE 7-8. DESCRIPTION OF THE FORCE PIPE SEGMENTS USED IN ADLPIPE

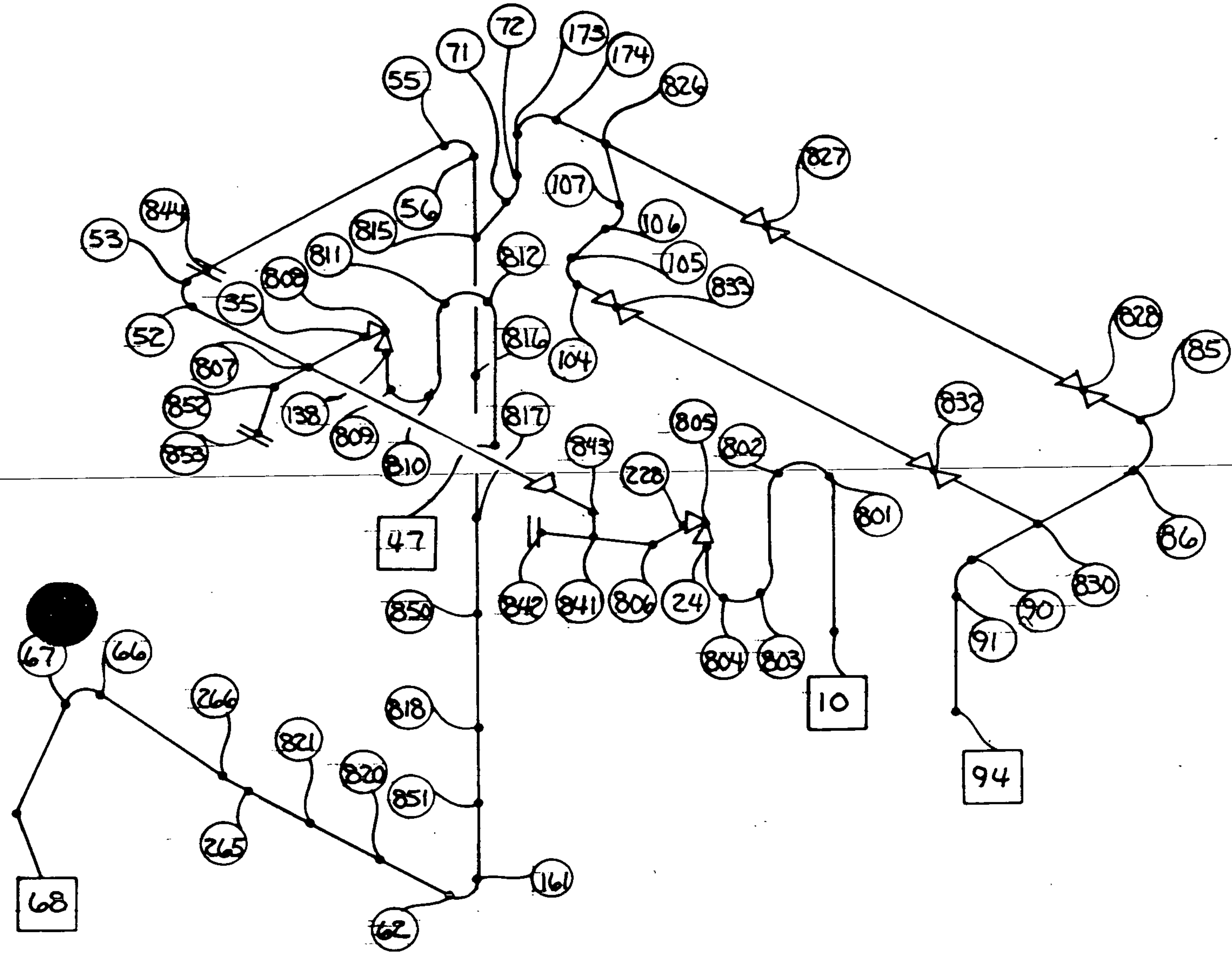
ADLPIPE* Lump Mass	Piping Leg	Description of Pipe Segment**
806	Leg 1	From outlet of safety valve PR-3A to center of first 45-degree elbow.
841	Leg 2	From center of first 45-degree elbow to outlet of rupture disk at PR-3A discharge.
843	Leg 3	From outlet of 6-inch by 6-inch by 6-inch tee to center of second 45-degree elbow.
807	Leg 4	From outlet of safety valve PR-3B to the 6-inch inlet of the 10-inch by 6-inch cross.
852	Leg 5	From outlet of the 10-inch by 6-inch cross to outlet of rupture disk at PR-3B discharge.
52	Leg 6	From center of second 45-degree elbow to the center of the first 90-degree, 10-inch elbow.
55	Leg 7	From center of first 90-degree, 10-inch elbow to center of second 90-degree, 10-inch elbow (first 10-inch vertical elbow).
161	Leg 8	From center of second 90-degree, 10-inch elbow to center of third 90-degree, 10-inch elbow (the 56-foot, 10-inch vertical piping run).
265	Leg 9	From the center of the third 90-degree, 10-inch elbow to the center of the 22-degree, 10-inch pipe elbow in the horizontal piping going to the pressurizer relief tank.
66	Leg 10	From the center of the 22-degree, 10-inch pipe elbow to the fourth 90-degree, 10-inch elbow.
67	Leg 11	From the center of the fourth 90-degree, 10-inch elbow to the inlet of the pressurizer relief tank.
91	Leg 12	From the outlet of the pressurizer to the center of the first 45-degree, 4-inch elbow of the PORV piping.
86	Leg 13	From the center of the first 45-degree, 4-inch elbow to the first 90-degree, 3-inch elbow of the PORV piping.

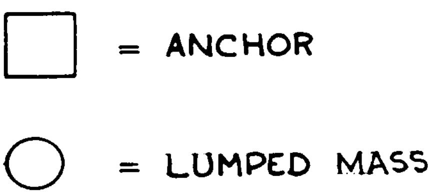
TABLE 7-8 (Continued). DESCRIPTION OF THE FORCE PIPE SEGMENTS USED IN ADLPIPE

ADLPIPE* Lump Mass	Piping Leg	Description of Pipe Segment**
104	Leg 14	From the outlet of 3-inch by 4-inch branch connection on the PR-2A pipeline to the center of first 90-degree, 3-inch elbow downstream of PORV PR-2A.
106	Leg 15	From the first 90-degree, 3-inch elbow downstream of PORV PR-2A to center of the first 45-degree, 3-inch elbow downstream of PORV PR-2A.
826	Leg 16	From the center of the first 45-degree, 3-inch elbow downstream of PORV PR-2A to the inlet of the 4-inch by 3-inch branch connection which connects the pipeline from PORV PR-2A to the pipeline from PORV PR-2B.
174	Leg 17	From the first 90-degree, 3-inch elbow of the PORV PR-2B pipeline to the first 90-degree, 4-inch elbow which is common to both PORVs PR-2B and PR-2A.
72	Leg 18	From the first 90-degree, 4-inch elbow which is common to both PORVs PR-2B and PR-2A to the center of the first 45-degree, 4-inch elbow in the PORV piping.
815	Leg 19	From the center of the first 45-degree, 4-inch elbow in PORV piping to the 10-inch by 4-inch branch which connects to the safety valves discharge piping.

*Forces summed into lump mass.

**Figure 7-8 illustrates a lump mass.





LUMP MASS SKETCH OF
KEWAUNEE S/RV PIPING LAYOUT
FIGURE 7-8

For the double safety valve actuation simulation, both safety valves 3A and PR-3B were simulated to "pop" open. When both safeties open together, the rupture disk bursts, allowing loop seal water out of the piping system and reducing the overall pressure build-up of the piping system.

Table 7-9 presents the thermal/hydraulic loads calculated for single and double safety valve actuations using two rupture disks. The plotted transient results for the single and double safety valve actuation are presented in Appendix I.

Based on the evaluations of the above four cases, the two worst case discharge piping loads were found to occur during the double safety valve actuation simulation with the cold loop seal case and the safety valve PR-3B actuation simulation with a cold loop seal case. These piping loads were used to determine the appropriate moments and stresses on the S/RV piping and supports of the Kewaunee power plant as described in Section 8.

TABLE 7-9. PEAK FORCES CAUSED BY SAFETY VALVE(S) ACTUATION WITH TWO RUPTURE DISKS, EXTENDED 10-INCH PIPE AND ONE ADDITIONAL RESTRAINT

	Forces** Due to Double PSV Actuation		Forces** Due to Single PSV PR-3A Actuation		Forces** Due to Single PSV PR-3B Actuation	
ADLPIPE* Lump Mass	Maximum Force kips	Maximum Negative Force kips	Maximum Force kips	Maximum Negative Force kips	Maximum Force kips	Maximum Negative Force kips
806	4.3	-4.0	2.8	-4.0	0.81	-0.71
841	24.5	-16.0	15.0	-13.3	1.51	-1.1
843	9.4	-6.4	9.6	-6.3	2.69	-1.5
807	14.2	-11.8	3.0	-2.3	7.0	-5.6
852	11.6	-9.4	1.8	-2.1	16.0	-14.0
52	15.6	-23.5	28.0	-20.0	12.0	-9.1
55	17.6	-12.4	3.8	-11.4	13.4	-13.3
161	8.4	-16.7	***	***	20.2	-18.3
265	5.8	-11.4	***	***	9.9	-18.3
66	4.0	-6.4	***	***	3.6	-5.1
67	2.9	-4.1	***	***	1.1	-1.6

*Table 7-8 presents description.

**Forces are positive in direction of flow.

***Did not calculate peak forces which are assumed less than forces from double PSV or single PSV PR-3B actuations.

8.0 KEWAUNEE PIPING STRESS ANALYSES

The Kewaunee safety and relief valve discharge stress analyses for the modified piping layout consisted of the following parts.

(1) The Kewaunee S/RV piping was analyzed in accordance with the requirements of the Kewaunee Final Safety Analysis Report (FSAR).

(2) The Kewaunee S/RV piping restraints were evaluated based on their rated loads and the calculated loading.

(3) The Kewaunee S/RV piping restraint/supports, which include base-plates, anchors, and structural attachments, were evaluated based on transmitted loads from the associated restraint.

(4) The integral welded lug attachments for restraints RC-H8 and RC-H9 were evaluated using the finite element computer code EASE2.

(5) The orifice plate and associated flanges were sized according to the requirements of the Kewaunee FSAR and B31.1 piping code.

KEWAUNEE S/RV PIPING ANALYSES

The initial studies performed on the Kewaunee S/RV piping[24] revealed that the as-built piping system would be overstressed (exceeded faulted condition stress allowables) by large thermal/hydraulic loading. This thermal/hydraulic loading would be caused by the actuation of one or both safety valves. Subsequent to the actuation of these valves, subcooled water, which passed through the valves from the upstream loop seals, moved into the downstream piping, causing the large thermal/hydraulic loading.

The evaluations, as described in Section 7.0, were performed so that proposed modifications to S/RV piping could prove to be adequate. The modifications recommended for implementation at the Kewaunee Nuclear Power Plant include adding rupture disk/baffle plate assemblies and piping modifications which are presented in Section 9.0 and discussed in more detail in Reference 21. The following stress analyses are based on rupture disk/baffle plate assembly modification with the associated piping and restraint changes.

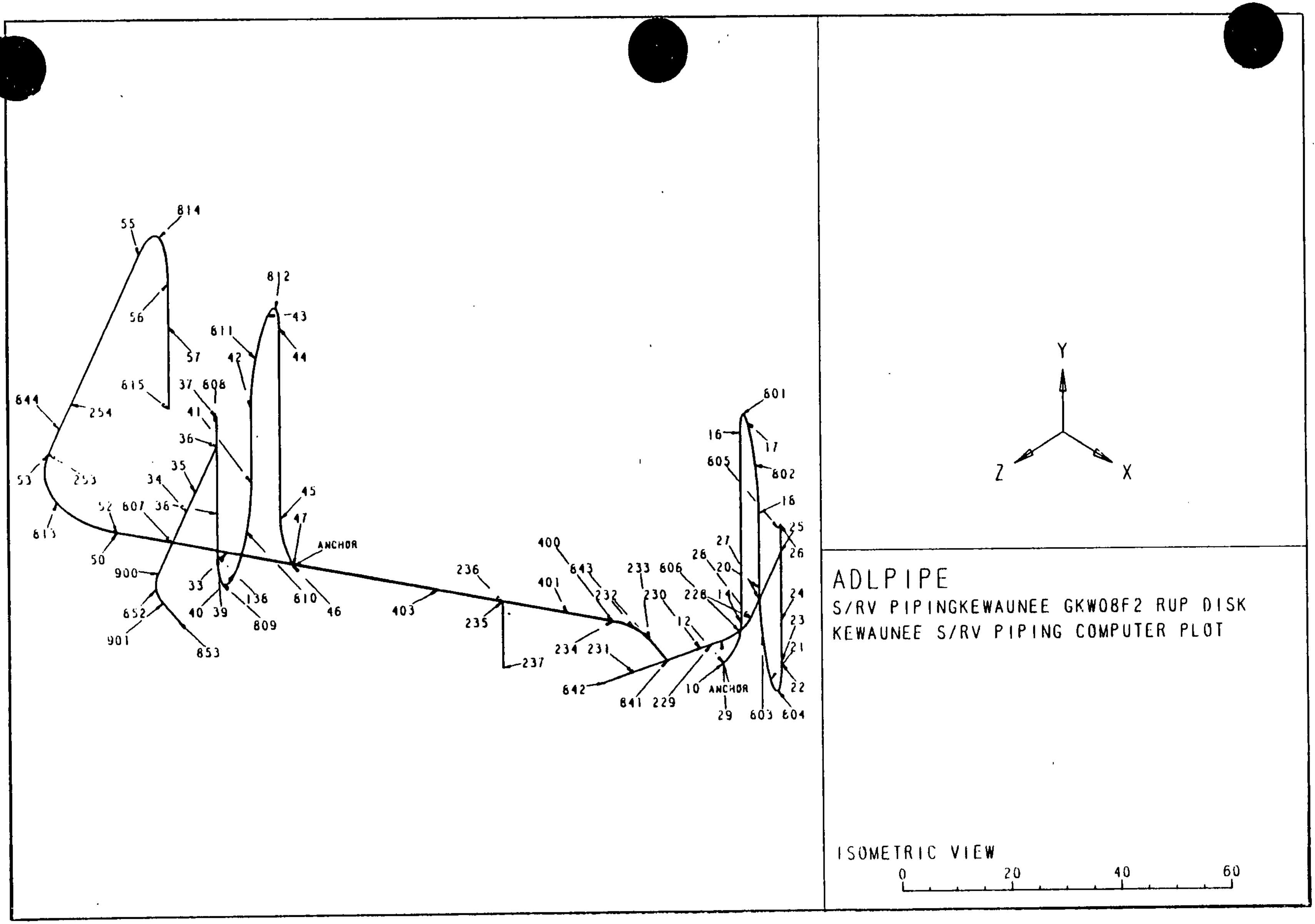
8.1.1 Kewaunee ADLPIPE Model

The computer program used to analyze the Safety and Power Ope Relief Valve (S/PORV) piping is known commercially as "ADLPIPE."[25] ADLPIP calculates piping stresses and provides restraint loading for static and time-dependent dynamic loading. ADLPIPE has been verified and is a recognized program in the public domain and has had sufficient use to justify its acceptability and validity. A description of ADLPIPE is given in Appendix D.

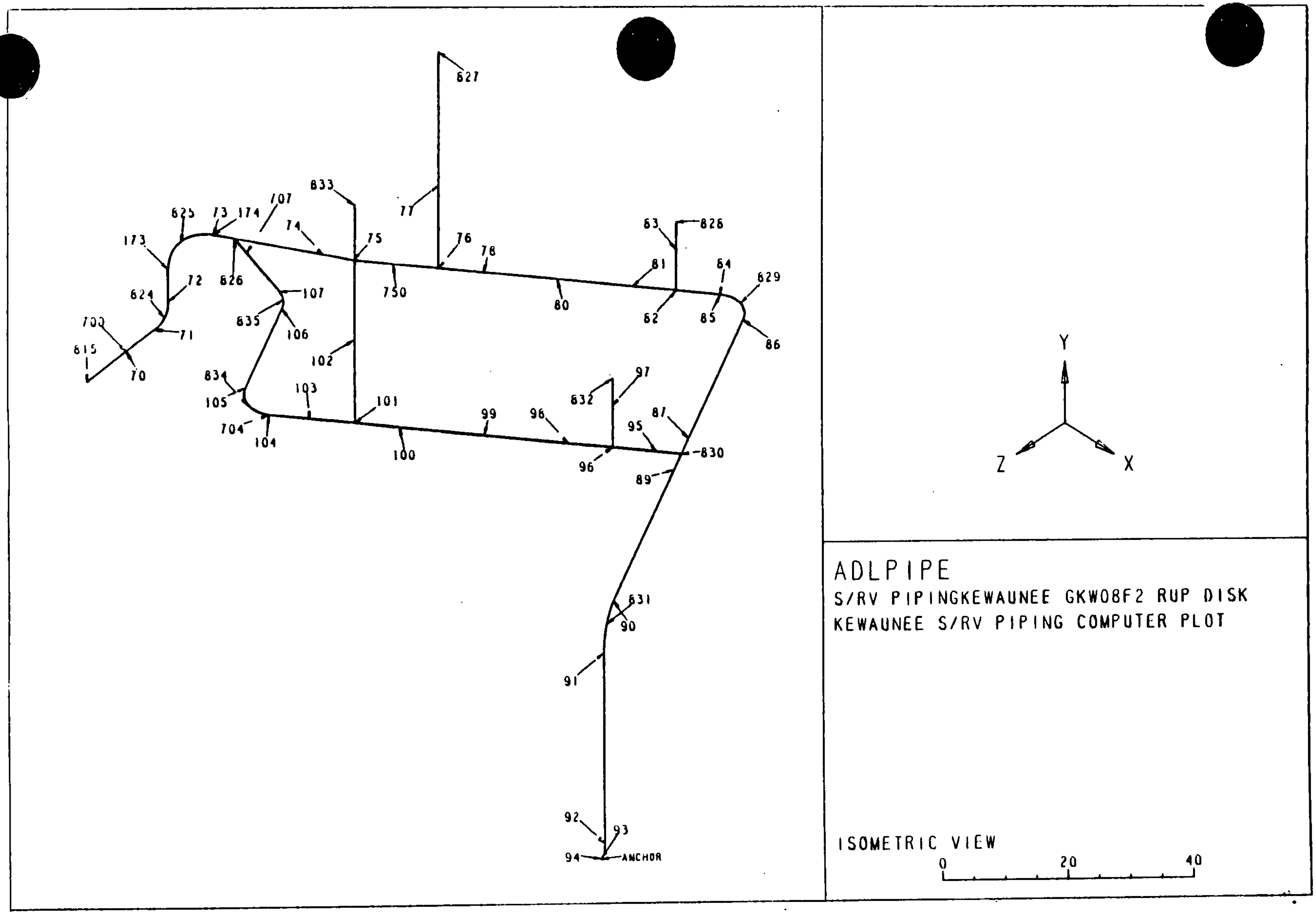
The Kewaunee S/RV piping was originally designed to USA Standard Code for Pressure Piping USAS B31.1.0 1967 Edition[26] and code cases to America Standards Association (ASA) B31.1-1955. Modified portions of the S/RV piping conformed to ANSI/ASME B31.1 1980 Edition[27] of Power Piping up to and including Winter 1980 Addenda. The piping analysis was performed usi ADLPIPE version D which meets or exceeds the requirements of the Kewaunee FSAR.

The piping system consists of the inlet piping from the pressurizer S/PORVs and the discharge piping which joins into a common header for discharging into the pressurizer relief tank. Figure 3-2 is a sc ic the piping layout, Tables 3-5 and 3-6 give the pipeline listing, and Figure 3-1 shows a dimensioned piping isometric. These as-built configurati were modified to reflect the addition of two rupture disk/baffle plate assemblies, the 6-inch piping between the two safety valves being replace with 10-inch piping, and the addition of a snubber at elevation 627 feet. Figures 8-1, 8-2, and 8-3, as generated by the computer from ADLPIPE inpu present the Kewaunee S/RV discharge piping system from the safety valves the pressurizer relief tank. Also shown are ADLPIPE related node numbers and anchor points. Table 8-1 describes piping restraints. The piping properties used for these calculations are given in Table 8-2. Table 8-3 presents the as-built reference number of the restraints. Table 8-4 presents the reference numbers of the modified restraints.

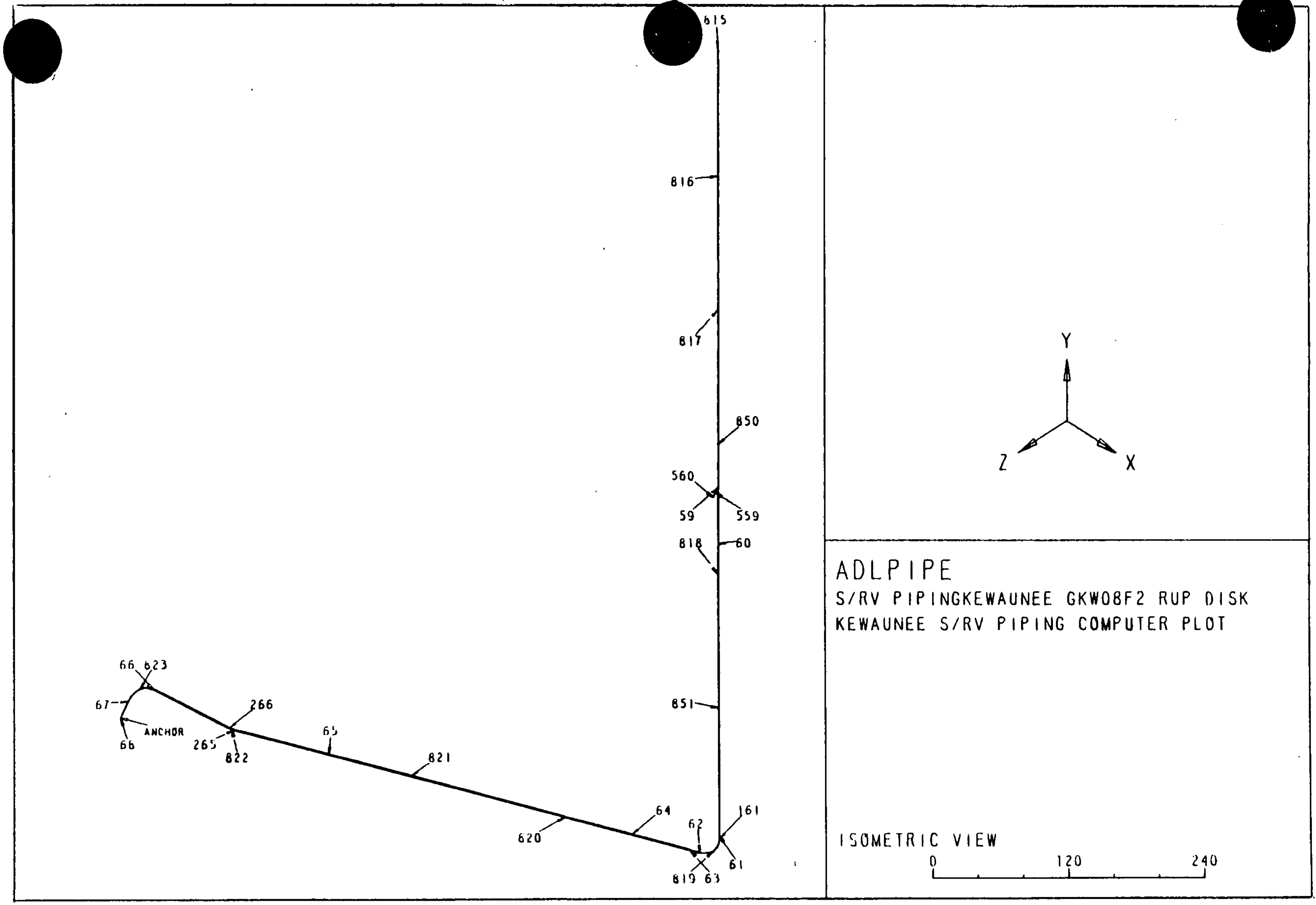
A listing of the ADLPIPE computer input for the double safety valve actuation is presented in Appendix H.



PIPING ISOMETRIC OF THE KEWAUNEE S/RV DISCHARGE PIPING
FROM SAFETY VALVES TO FIRST VERTICAL 10-INCH ELBOW
FIGURE 8-1



PIPING ISOMETRIC OF THE KEWAUNEE S/RV DISCHARGE PIPING
FROM PRESSURIZER THROUGH PORVS
FIGURE 8-2



PIPING ISOMETRIC OF THE KEWAUNEE S/RV DISCHARGE PIPING
FROM 10-INCH BY 4-INCH TEE TO PRESSURIZER RELIEF TANK
FIGURE 8-3

TABLE 8-1. KEWAUNEE PIPING RESTRAINTS DESIGN SPECIFICATIONS

Restraint	Pipe C ADLPIPE Location X ft	Y ft	Z ft	ADLPIPE Dir. Cosines i	j	k	Original Load lb	Rated Load lb	Comment
RC-H8	38.66	657.88	15.45	0.8227	0.0	0.5684	4,566	8,000	Strut
RC-H7	39.31	659.47	17.33	0.0	1.0	0.0	HL = 585 CL = 721	--	New location--spring can
RC-H40	36.89	659.47	18.50	-0.8526	-0.2425	0.4629	--	17,600	New location--snubber
RC-H6	33.14	659.47	20.52	0.0	1.0	0.0	HL = 745 CL = 876	--	Spring can
RC-H9	32.21	657.92	18.80	0.4772	--	0.8788	3,845	8,000	Strut
RC-H5	28.32	659.47	15.76	0.0	1.0	0.0	HL = 1,116 CL = 1,835	--	Spring can
RC-H37	28.32	657.60	15.76	0.4772	0.0	0.8788	--	17,600	Snubber
Snubber	28.32	627.25	15.76	0.0	1.0	0.0	--	27,300	Additional restraint
RC-H4	28.32	623.50	15.76	1.0	0.0	1.0	X = 1,458 Z = 1,385	--	Guide
RC-H3	28.32	623.50	15.76	0.0	1.0	0.0	HL = 619 CL = 731	--	Load per spring can
RC-H38	26.59	602.50	16.46	0.1740	-0.8886	0.4243	--	17,600	Snubber
RC-H39	28.32	604.00	15.76	0.9252	0.0	-0.3795	--	17,600	Snubber
RC-H1	4.88	602.50	25.36	0.0	1.0	0.0	HL = 482 CL = 524	--	Load per spring can
RC-H2	23.07	602.50	17.90	0.0	1.0	0.0	HL = 1,216 CL = 1,021	--	Spring can
[illegible]	33.00	658.71	13.21	0.0	1.0	0.0	HL = 1,237 CL = 1,440	--	Spring can
RC-H12	34.26	658.71	15.64	0.0	1.0	0.0	HL = 977 CL = 1,140	--	Spring can

NOTE: Original loads are from restraint drawing. Rated load is based on ITT Grinnell allowable loads from Catalog PH79. See calculation 9653.51.2006 for analysis of beams, plates, and expansion anchors.

TABLE 8-2. PIPING PROPERTIES USED FOR THE KEWAUN[illegible]/RV PIPING ANALYSIS

OD in.	t in.	w lb/in.	Design Temperature F	Design Pressure psia	Allowable Stress S_h psi	Allowable Stress S_a psi	Comments
3.5	0.216	0.63	400	700	14,950	27,175	A312 TP 304 Existing Outlet Piping
3.5	0.437	1.19	650	2,510	14,300	27,013	A376 TP 304 Existing Inlet Piping
4.5	0.237	0.90	400	700	14,950	27,175	A312 TP 304 Existing Outlet Piping
6.625	0.28	1.58	400	700	14,950	27,175	A312 TP 304 Existing Outlet Piping
6.625	0.28	1.58	400	800	16,200	27,550	A312 TP 304 Modified Outlet Piping
6.625	0.718	3.78	650	2,485	16,000	27,438	A376 TP 316 Existing Inlet Piping
10.75	0.365	3.37	400	875	16,300	27,513	A312 TP 316 Existing Outlet Piping
10.75	0.365	3.37	400	800	18,100	28,025	A312 TP 316 Modified Outlet Piping

NOTE: Properties for existing piping are from the USAS B31.1.0 Piping Code 1967 Edition.

Properties for modified piping are from the ANSI/ASME B31.1 Power Piping Code 1980 Edition including Winter 1980 Addenda.

TABLE 8-3. ITT GRINNELL AS-BUILT RESTRAINT DRAWINGS

Hanger No.	Reference Sketch No.	Date Drawn
RCH-1	4100	5/28/71
RCH-2	4101	5/28/71
RCH-3	4102	5/28/71
RCH-4	4104, 4105	5/29/71
RCH-5	4106	5/27/71
RCH-6	4108	5/29/71
RCH-7	4110	5/27/71
RCH-8	4111A	7/26/71
RCH-9	4112, 4112A	7/26/71
RCH-11	4114	5/28/71
RCH-12	4115	5/27/71
RCH-37	4145	1/7/74
RCH-38	4146	1/7/74
RCH-39	4147	1/8/74
40	4148	1/7/74

BLE 8-4. MODIFIED RESTRAINTS FOR THE KEWAUNEE S/RV PIPING SYSTEM

H Drawing Reference No.	Hanger No.	ITT Grinnell Reference Sketch No.
MS-36-31	RC-H6	4108
MS-36-32	RC-H7	4110
MS-36-33	RC-H40	4148
MS-36-34	RC-H73	(New Restraint)
MS-36-35	RC-H4	4104, 4105
MS-36-36	RC-H8	4111A
MS-36-37	RC-H9	4112, 4112A
MS-36-38	RC-H37	4145
MS-36-39	RC-H38	4146
MS-36-40	RC-H39	4147

8.1.2 <u>Pipe Support Modeling</u>

The dynamic piping supports were modeled as springs to ground, each having a calculated spring constant for the overall support assembly based on a series spring combination of all the components in the restraint assembly. The dynamic supports for the Kewaunee piping are of three restraint types which consist of structural components such as I-beam frame assemblies, ITT Grinnell Figure 211 rigid sway struts, and ITT Grinnell Figure 201 hydraulic shock and sway suppressors. The spring constant for the structural items were calculated with a structural computer code by modeling each structural assembly with the applicable beam properties included. The sway strut spring constant was based on a series spring combination of the calculated stiffness of the restraint components which included the clevis, pins, and center components. The snubber spring constants reflect test data values published by ITT Grinnell. The ITT Grinnell values are the average snubber spring rates based on test data.

The computer-predicted loads on all supports have been compared to the allowable values. The largest value based on the normal, upset, or faulted combination has been used as a design basis to ensure that allowable stress levels have not been exceeded. The stresses in structural components such as beams and plates are within AISC allowable stress levels. The loads on ITT Grinnell hanger components have been compared to the published allowable loads in Catalog PH79 which correspond to plant "normal" conditions.

The restraint loads based on Kewaunee normal, upset, and faulted load combinations are below the rated loads in Catalog PH79 with the exception of struts RC-H8, RC-H9, and snubber RC-H40. These loads, which exceed the ITT Grinnell "normal" allowables, were sent to ITT Grinnell for review. ITT Grinnell has qualified replacement restraints to the new loads.

The damping value used for the ADLPIPE time history analysis was 2 percent. This value is consistent with suggested values for SSE earthquake analysis found in US Nuclear Regulatory Guide 1.61.

8.1.3 Time Steps Used for ADLPIPE Model

The time steps used for the ADLPIPE modal superposition time [illegible]ry analysis was 0.001 second. This value is based on the following suggested formula from the Control Data Corporation REPIPE Application Manual.

$$\Delta t \leq \frac{0.1}{fi}$$

Where:

Δt = suggested time step.

fi = highest significant frequency.

An additional computer analysis was run for the two safety valve actuation with a time step of 0.0004 second to confirm the acceptability c the 0.001 time step value. The maximum predicted piping stress increased less than 1.0 percent with the time step value of 0.0004 seconds. The increase of less than 1 percent is considered insignificant. The time st used in the forcing functions applied to the model was based on the RELAP calculation. The REPIPE post-processor was used in the original evaluati and the FORCE post-processor was used in the final evaluations. The time steps varied depending on the transient conditions. For the lock[illegible]tor double safety valve, double rupture disk FORCE calculations, the F[illegible]E ti steps varied between 1.25 msec and 0.625 msec. The FORCE post-processor also checks for peak forces in the data from RELAP5. If a peak force is discovered, it also includes this force in the forcing function table to used in the ADLPIPE calculations.

8.1.4 ADLPIPE Dynamic Frequency Evaluation

The forcing functions being used in the ADLPIPE two safety valve tin history analysis were examined for frequency content by extracting the Fourier series coefficients and plotting the sine and cosine coefficients versus frequency. Examination of the cosine coefficients indicates that the majority of frequencies with large coefficients are at or below the to 120 hertz range. One forcing function in the upper portion of the piping system had significant cosine coefficients near the 200 hertz ran The cutoff frequency used for the analysis was 300 hertz. Review of the modal participation factors for the two safety valve time history ADLPIP analysis indicated that the majority of the significant modal participation factors occurs below 100 hertz with some vertical participation factors of about 0.4 near 130 and 230 hertz. The 300 hertz cutoff frequency and the relatively low modal participation factors of higher frequencies indicate that the major thermal/hydraulic loads due to the two safety valve transient have been included in the ADLPIPE analysis.

8.1.5 ADLPIPE Lump Mass Spacing

The lumped mass spacing used in the analysis was established for each pipe diameter and the corresponding pipe cross section based on the first mode (fundamental) frequency of a simply supported beam. The spacing span is based on the following equation.

$$L = \left[\frac{9.87}{2\pi}\right]^{1/2} \left[\frac{gEI}{f^2 W}\right]^{1/4}$$

Where

L = Lumped mass spacing, inches

E = Modulus of Elasticity, psi

I = Moment of Inertia, inch^4

W = Distributed weight of the pipe, lb/inch

f = Frequency, hertz

g = Acceleration of gravity, inch/sec^2

Table 8-5 is a summary of the lumped mass spacing for the Kewaunee S/RV piping. Based on previous engineering experience with these types of transients, the first mode frequency was chosen to be 100 hertz. Sensitivity studies were performed to determine the adequacy of using 100 hertz and the results are presented in Subsection 8.1.7.

8.1.6 ADLPIPE Valve Modeling

The safety valves and power operated relief valves were modeled to represent the approximate valve stiffness with the weight of the valve lumped at the modeled center of gravity. The valve body and upper housing for both valves have been modeled with pipe diameters equal to the adjacent piping. The wall of the valve has been modeled as two times that of the

TABLE 8-5. SUMMARY OF ADLPIPE LUMPED MASS SPACING

Pipe	Schedule	E psi x 10^{-6}	I $in.^4$	W lb/in.	f Hz	L ft
3	160	28.3	5.0	1.2	100	5
4	40	28.3	7.2	0.9	100	6
6	160	28.3	59.0	3.8	100	7
10	40	28.3	160.8	3.4	100	9
10	40	28.3	160.8	3.4	200	6

connecting piping for both the valve body and upper housing. The entire weight of the valve has been located as a lumped mass in the valve upper housing model at the location corresponding to the center of gravity of the actual valve assembly.

8.1.7 <u>Sensitivity Studies</u>

To determine the validity of the ADLPIPE model and modeling procedures several sensitivity studies were performed.

To verify the acceptability of modeling the pressurizer and the pressurizer relief tank as rigid anchors, a computer analysis for the two safety valve actuation was run with the anchors modeled simulating the approximate stiffness of the pressurizer and pressurizer relief tank. The results of the analysis with approximate anchor stiffness were compared to the results of the analysis with anchors modeled rigid. The maximum stresses in the piping system yield negligible differences in value (about 1 percent), thus justifying the use of rigid anchor modeling.

As indicated in Subsection 8.1.3, one forcing function, which is applied in the upper portion of the piping system, had a significant Fourier coefficient at about 200 hertz. To confirm the adequacy of lumped mass spacing based on 100 hertz, the 10-inch piping in the lower section was lumped at a 6-foot spacing and the two safety valve analysis was rerun. The analysis showed no significant changes in the piping stresses or loads on restraints. It is also noted that the lump mass spacing in the upper portion of the piping system is adequate for 200 hertz as mass points are used at elbows, tees, valves, etc., which resulted in a set of closely spaced lumped mass points because of piping geometry.

The ADLPIPE analysis for the two safety valve actuation event was performed by using forcing functions generated by the computer code FORCE. A single (net) forcing function was applied at the downstream end of each piping segment of discharge piping. The two safety valve actuation analysis was also analyzed with a set of forcing functions applied at both ends of each piping segment to investigate the effect of axial pipe extensions on the bending stresses induced into the piping. The analysis with forces applied at both ends of each piping segment includes bending stresses caused by net forces and bending stresses induced on adjacent pipi th axial extension of pipe segments. The points of highest stress in the piping system had a negligible difference in stress values when comparing stresses produced by the analysis with net forces to the stresses produced by the analysis with forces applied at each end of pipe segments. These minor fluctuations in piping stress values were about 1 to 3 percent.

8.2 DETERMINATION OF STRESS ALLOWABLES

The stress analysis for the S/RV piping and restraints utilized the loading combinations (FSAR Table B.7-1) and the stress allowables from the Kewaunee FSAR (FSAR Table B.7-3). In addition to the loading combinations specified in the Kewaunee FSAR, loading combinations recommended by the EPRI piping subcommittee[28] were also considered. Tables 8-6, 8-7, and 8- of this report contain piping-specific loading combinations and definitio

The Kewaunee piping system was analyzed for four separate valve actu tion possibilities. These events are the double PORV actuation, the sing actuation of safety valve PR-3A, the single actuation of safety v PR-3B, and the simultaneous actuation of both safety valves. The Kewaune FSAR load combinations for components do not contain a loading combinatio for the plant emergency condition as indicated by Tables B.7-1 and B.7-5 found in Appendix B of the Kewaunee FSAR. Therefore, since the emergency loading combination was not used in the original design basis for the plant, the emergency loading combination was not used for this evaluation It should be noted that the load combinations presented in Tables 8-4 and 8-5 of the original Kewaunee piping report[1] were based solely on EPRI recommendations. Subsequent to issuing this report, it was found that so of the information in the tables was not relevant to the Kewaunee design basis; therefore, the tables were changed for the final issue of this report.

The FSAR considers the locked rotor accident as a plant faulted con tion. This condition was considered the design basis for the Kewaunee evaluation.

TABLE 8-6. LOAD COMBINATIONS FOR FSAR CLASS I PIPING AND COMPONENTS

Condition	Load Combination*	B31.1 Equation	Stress Allowable	Remarks
Normal	DL + Pl	11	S_h	Primary and normal loads
Upset	$DL + PI \pm [SO^2 + SA^2 + ST1^2]^{1/2}$	12	$1.2S_h$	Primary and occasional loads
	TE + TA	13	S_a	Secondary loads
	TE + TA + DL + PI	14	$S_a + S_h$	Secondary and primary loads to be evaluated only if Equation 13 is exceeded
Faulted	$DL + PI \pm [SS^2 + SA^2 + ST_n]^{1/2}$	12	$2.4S_h$	Primary loads

*Table 8-8 lists definitions of symbols.

TABLE 8-7. LOAD COMBINATIONS FOR FSAR CLASS II P[illegible]G AND COMPONENTS

Condition	Load Combinations*	B31.1 Equation	Stress Allowable	Remarks
Normal	DL + PI	11	S_h	Primary and normal loads
Upset	DL + PI + $[SO^2 + SA^2]^{1/2}$	12	$1.2S_h$	Primary and occasional loads
	TE + TA	13	S_a	Secondary loads
	DL + PI + TE + TA	14	$S_a + S_h$	Secondary and primary loads to be evaluated only if Equation 13 is exceeded

*Table 8-8 lists definition of symbols.

TABLE 8-8. DEFINITIONS AND LOAD ABBREVIATIONS

DL	Dead Load
PI	Pressure
TE	Thermal Expansion
TA	Thermal Anchor Motions
SO	Operating Basis Earthquake (OBE)
SS	Design Basis Earthquake (DBE)
SA	Seismic Anchor Motions (OBE or DBE)
ST1	System Transient (2 relief valves)
ST2	System Transient (1 safety valve, PR-3B)
ST3	System Transient (2 safety valves)
ST4	System Transient (1 safety valve, PR-3A)
S_h	Hot allowable stress
S_a	Allowable stress range based on hot and cold stress allowables
S_n	Largest Loading Due to ST_2, ST_3, or ST_4

The piping downstream of the power operated relief valves and downstream of the safety valves is classified by the Kewaunee FSAR as Class II piping. All piping upstream of the valves is classified by the Kewaunee FSAR as Class I piping. The load combinations attached in Tables 8-6 and 8-7 are consistent with the Kewaunee FSAR load combinations in Table B.7-1 found in the FSAR. It was recognized that the downstream or Class II piping will affect the upstream or Class I piping during the plant normal, upset, and faulted condition loadings. To ensure the integrity of the upstream piping, all downstream or Class II piping has been subjected to Class I loading conditions for the plant normal, upset, and faulted condition. All piping, including upstream and downstream, has been evaluated to the load combinations for Class I piping and components. The resultant stresses are within the allowables for the FSAR Class I normal, upset, and faulted conditions. This will ensure that the integrity of the primary pressure boundary has not been influenced by downstream piping loading and deflections. Allowable stress values for as-built and modified piping are presented in Table 8-9.

The piping was analyzed for two seismic (earthquake) events. The seismic analysis included Operating Basic Earthquake (OBE) and the Design Basis Earthquake (DBE). The analysis was done utilizing the response spectra from the original analysis.[29] The original response spectra utilized in the analysis are consistent with the plant-specific response spectra.[30]

Table 8-1 presents restraint types, locations, and original design load.

On May 11, 1982, and on April 27, 1983, walk-downs of the safety and relief valve piping and restraints were performed. Existing restraints, pipe, and structural attachments were verified. All restraints conform to ITT Grinnell drawings, or field measurements were taken as needed.

8.3 RESULTS OF KEWAUNEE S/RV PIPING ANALYSIS

The as-built Kewaunee S/RV piping has several horizontal and vertical dynamic restraints which were designed and located to constrain the piping

TABLE 8-9. ALLOWABLE STRESS VALUES FOR KEWAUNEE AS-BUILT AND NEW S/RV PIPING

Material	Temp F	S_h psi	Comment
A376 TP 316	650	16,000	Existing Pipe (inlet, loop seal) 6-inch
A376 TP 304	650	14,300	Existing Pipe (inlet, PORV) 3-inch
A312 TP 316	400	16,300	Existing Pipe (outlet) 10-inch
A312 TP 304	400	14,950	Existing Pipe (outlet) 3-inch, 4-inch
A312 TP 316	400	18,100	Additional Pipe (outlet) 10-inch
A312 TP 304	400	16,200	Additional Pipe (outlet) 6-inch

Existing piping allowables from Reference 26, B31.1.0, 1967 edition.

Additional piping allowables from Reference 27, B31.1, 1980 edition.

during a seismic or dynamic event, for example, valve actuation. The modified piping configuration included the moving of snubber RC-H40 (due to the location of the added rupture disk/baffle plate assembly) and the addition of a new snubber RC-H73 at elevation 626 feet-0 inch. This modified piping configuration was simulated using ADLPIPE as discussed in Subsection 8.1.1.

The thermal/hydraulic force time histories from the RELAP5/FORCE computations (Section 7.0) were used as input to ADLPIPE. The piping stresses for normal, upset, and faulted conditions as described in Table 8-6 were determined. The results of these analyses are presented in Tables 8-10 and 8-11. As noted in the table, all piping stresses were under stress allowables for both upset and faulted conditions with the maximum stress of 34,600 psi occurring at the 10-inch by 6-inch cross.

The restraint loading was also found acceptable for all restraints except RC-H8, RC-H9, and RC-H40. These restraints have been requalified by ITT Grinnell for the higher loading. The results of the restraint evaluations are presented in Table 8-12.

8.3.1 Design Modifications for Anchors, Baseplates, and Associated Structural Members

Analyses were performed[31] for the Kewaunee S/RV piping restraint supports to determine if the as-built baseplates, anchors, and associated structural members were overstressed as a result of the dynamic loading from a double safety valve actuation. These loads were taken from ADLPIPE analyses[32] for the loads acting on as-built, modified (moved), and added (additional snubber) restraints (Table 8-13). The design criteria used to determine the stresses and stress allowables for the restraint supports were taken from Reference 33. A summary of the design changes is presented in Table 8-14.

8.4 UPSTREAM PRESSURE OSCILLATIONS

It was observed in CE Test Run 908 (Crosby 6M6 steam discharge test with high-pressure ramp [∿300 psi/sec] and a cold water [<200 F] filled loop seal) that large pressure oscillations occurred in the upstream of the

TABLE 8-10. MAXIMUM STRESS VALUES FOR THE KEWAUNEE S/RV PIPING BASED ON CLASS I* LOAD COMBINATION

Node	Stress psi	Allowable psi	Comment
104	17,703	35,880	3-inch existing outlet piping
76	24,164	34,320	3-inch existing inlet piping
75	20,105	35,880	4-inch existing outlet piping
234	29,468	38,880	6-inch modified outlet piping
10	26,859	38,400	6-inch existing inlet piping
265	15,169	39,120	10-inch existing outlet piping
807	34,663	43,440	10-inch modified outlet piping

*Faulted Condition with two safety valve actuation.

Node	Stress psi	Allowable psi	Comment
104	19,345	35,880	3-inch existing outlet piping
94	22,326	34,320	3-inch existing inlet piping
71	18,665	35,880	4-inch existing outlet piping
400	22,854	38,880	6-inch modified outlet piping
10	21,542	38,400	6-inch existing inlet piping
56	15,717	39,120	10-inch existing outlet piping
807	28,901	43,440	10-inch modified outlet piping

*Faulted Condition with safety valve PR-3A actuation.

Node	Stress psi	Allowable psi	Comment
750	20,355	35,880	3-inch existing outlet piping
76	24,116	34,320	3-inch existing inlet piping
75	19,659	35,880	4-inch existing outlet piping
233	20,411	38,880	6-inch modified outlet piping
138	17,070	38,400	6-inch existing inlet piping
265	17,716	39,120	10-inch existing outlet piping
807	22,574	43,440	10-inch modified outlet piping

*Faulted Condition with safety valve PR-3B actuation.

TABLE 8-11. MAXIMUM STRESS VALUES FOR THE KEWAUNEE S/RV PIPING BASED ON CLASS I* LOAD COMBINATION FOR NORMAL, UPSET, AND THERMAL RANGE CONDITIONS

Node	Stress psi	Allowable psi	Comment
750	5,247	14,950	3-inch existing outlet piping
80	8,004	14,300	3-inch existing inlet piping
70	5,183	14,950	4-inch existing outlet piping
400	6,530	16,200	6-inch modified outlet piping
22	6,250	16,000	6-inch existing inlet piping
65	6,909	16,300	10-inch existing outlet piping
53	6,900	18,100	10-inch modified outlet piping

*Normal Condition.

Node	Stress psi	Allowable psi	Comment
104	8,022	17,940	3-inch existing outlet piping
94	13,272	17,160	3-inch existing inlet piping
71	9,823	17,940	4-inch existing outlet piping
400	8,905	19,440	6-inch modified outlet piping
10	8,373	19,200	6-inch existing inlet piping
265	8,368	19,560	10-inch existing outlet piping
52	8,382	21,720	10-inch modified outlet piping

*Upset Condition with two PORV actuation.

Node	Stress psi	Allowable psi	Comment
707	10,009	27,175	3-inch existing outlet piping
94	7,637	27,013	3-inch existing inlet piping
71	4,311	27,175	4-inch existing outlet piping
843	10,500	27,550	6-inch modified outlet piping
17	15,734	27,438	6-inch existing inlet piping
819	13,065	27,513	10-inch existing outlet piping
807	11,075	28,025	10-inch modified outlet piping

*Thermal Range Condition.

TABLE 8-12. RESTRAINT LOADING

Hanger	Normal lb	Upset lb	Faulted lb	Rated Load* lb
RC-H8	7,816	8,714	20,421	8,000**
RC-H7	941	941	941	585
RC-H40	--	2,374	23,812	17,600**
RC-H6	1,709	1,709	1,709	745
RC-H9	4,308	5,329	22,716	8,000**
RC-H5	1,232	1,232	1,232	1,835
RC-H37	--	1,003	11,706	17,600
RC-H73	--	1,711	15,183	***
RC-H3	1,352	1,352	1,352	1,462
RC-H4 (X)	374	1,547	4,089	1,458
RC-H4 (Z)	108	1,030	3,465	1,385
RC-H39	--	928	9,073	17,600
RC-H38	--	999	9,222	17,600
RC-H2	731	731	731	1,216
RC-H1	745	745	745	924
RC-H11	1,110	1,110	1,110	1,237
RC-H12	899	899	899	977

*Rated load for normal plant condition, for original restraints.

**Requires requalification by ITT Grinnell.

***Restraint added; not part of original design.

TABLE 8-13. LOADS TO WHICH RESTRAINTS HAVE BEEN QUALIFIED INCLUDING AS-BUILT,* MODIFIED, OR ADDED RESTRAINTS

Hanger	Maximum Load lb	Minimum Load lb	Comment
RCH-4	4,089	-2,037	See 1 below
RCH-4	3,013	-3,465	See 2 below
RCH-6	1,709	-1,709	See 3 below
RCH-7	941	-941	See 3 below
RCH-8	12,152	-20,421	See 3 below
RCH-9	18,335	-22,716	See 3 below
RCH-37	11,706	-11,706	See 3 below
RCH-38	14,474	-9,222	See 3 below
RCH-39	9,073	-9,073	See 3 below
RCH-40	23,812	-23,812	See 3 below
RCH-73	15,183	-15,183	See 3 below

Comments:

1. + or - loads acting on restraint in the X (east-west) direction, + loads to east - loads to west.
2. + or - loads acting on restraint in the Z (north-south) direction, + loads to south - loads to north.
3. + loads put the restraint in tension - loads put the restraint in compression.

*Loads on as-built restraints are considered only where the load exceeds original design.

TABLE 8-14. SUMMARY OF DESIGN CHANGES FOR RESTRAINT SUPPORTS FOR KEWAUNEE S/RV PIPING

	RC-H4	RC-H6	RC-H7*	RC-H8	RC-H9	RC-H37	RC-H38	RC-H39	RC-H40*	RC-H73
Status of Restraint	Use Same Restraint	Use New Restraint (Spring Can)	Use New Restraint (Spring Can)	Use Size 2 Strut with ITT Re-qualification	Use Size 2 Strut with ITT Re-qualification	Use Same Snubber	Use Same Snubber	Use Same Snubber	Use Same Snubber if OK with ITT Grinnell	New Snubber
As-Built Baseplate	OK	OK	OK	Replace	Replace	Replace	Replace	Replace	Replace	N/A
New Base-plate	N/A	N/A	N/A	Use 11" by 11" by 1-1/8"	Use 16" by 16" by 3/4"	Use 16" hy 13" by 1"	Use 12" by 14" by 3/4"	Use 9" by 9" by 1/2"	Use 10" by 12" by 1/2"	Use two 8" by 10" by 1/2"
As-Built Anchor	OK	OK	Replace	Replace	Replace	Replace or Supplement	Replace	Replace or Supplement for both Beams	Replace	N/A
New Anchor	N/A	N/A	Three 3/4" HILTIs 5" embed-ment	Four 1" HILTIs 6" embed-ment	Four 3/4" HILTIs 9" embed-ment	Twelve 1" HILTIs 6" embed-ment	Four 3/4" HILTIs 7" embed-ment	Main Beam 1/2" by 4-1/2" Kicker 5/8" by 5-1/2"	Four 1/2" HILTIs 4-1/2" embedment plus four 3/4" HILTIs 7" embed-ment	Eight 1/2" HILTIs 4-1/2" embedment
Support Beams	Short Beams OK Long Beams Replaced or Reinforced	OK	OK	OK	OK	Rehuild Structural Assembly	OK	OK	Replace 4WF Beam with 8" by 6" by 1/2" Tube Section with 7" by 9" by 1/2" Plate	New W6 by 12 Beam

*These restraints must be relocated.

safety valve. Because of a limitation in the upstream pressure sensor for Test 908, the pressure measurements were "clipped" at about 3,400 psia. Subsequently, CE Test 1406 which used the same test parameters as Test 908 was run with the pressure sensor (PT105) range increased to 10,000 psia. In Test 1406 upstream pressure oscillations were measured up to 8,600 psia. These pressure oscillations occurred while the valve was passing the cold water from the loop seal before the valve popped to full open.

Because the 8,600 psia pressure exceeded pressure allowables for the upstream piping, Westinghouse[34] did a detailed evaluation using the ITCH-1D computer. It was concluded that the large upstream pressure oscillations could be attributed to the frequency of the pressure sensor instrumentation line and the actual pressure oscillations that would be seen in the upstream piping would be less than 5,000 psia. Based on tests and analytical work done by Westinghouse, all acoustic pressures observed or calculated before or during safety valve discharge are below the maximum permissible pressure as defined by Westinghouse.[32]

9.0 MODIFICATIONS

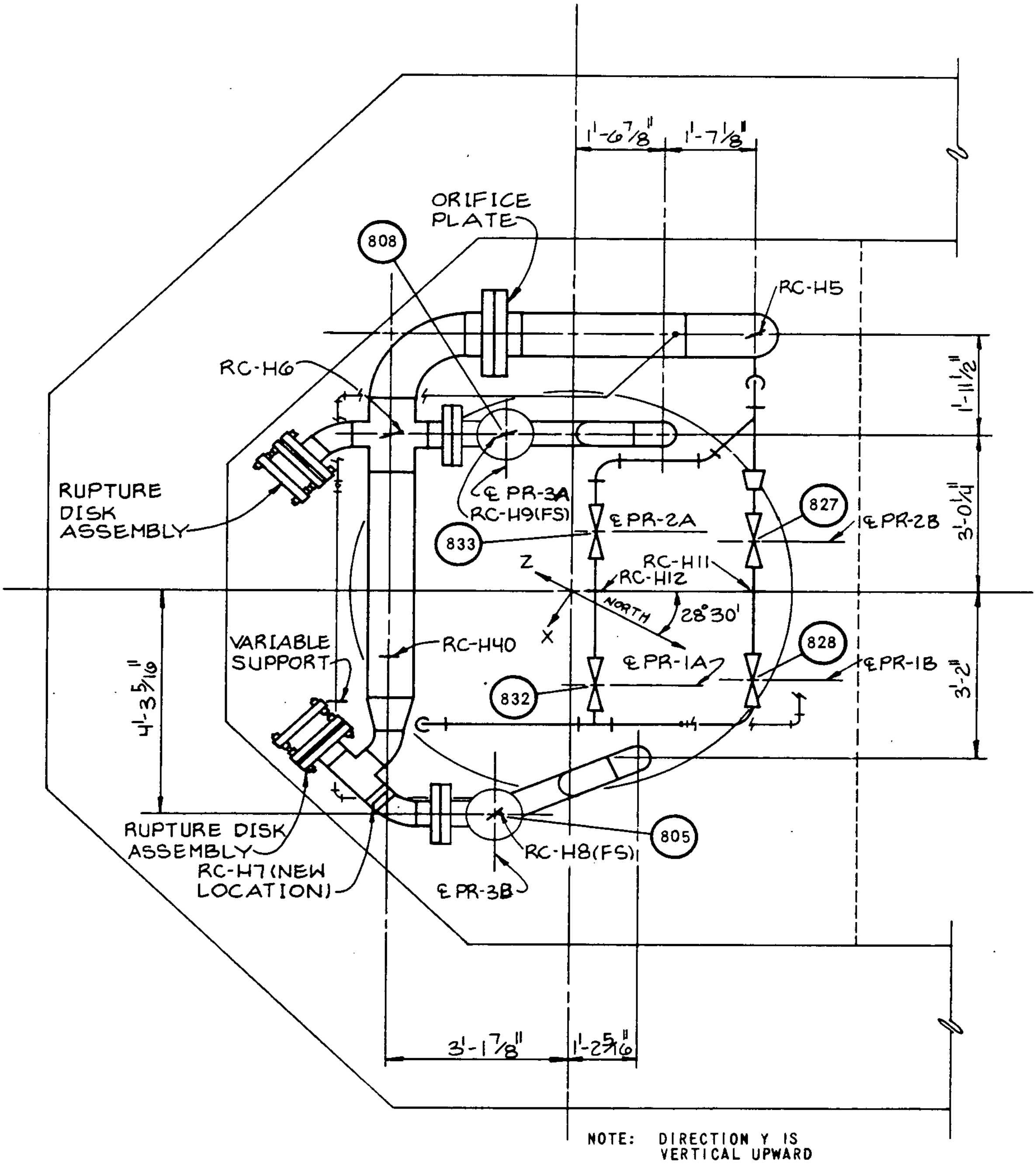
Two rupture disk/baffle plate assemblies will be installed at the Kewaunee Nuclear Power Plant discharge piping to reduce the thermal/hydraulic loads caused by the actuation of one or both safety valves. A double or single safety valve actuation will create a pressure buildup in the discharge piping which will cause the rupture disks to burst, allowing the subcooled water from the safety valve loop seals to escape from the discharge piping. The loss of the fluid through the rupture disk openings will also reduce the pressure rise in the discharge piping, thereby reducing the downstream driving force which contributes to large thermal/hydraulic loads in the discharge piping.

A plan view of the upper portion of the S/RV piping showing the added rupture disk/baffle plate assemblies is shown on Figure 9-1. Figures 9-2a and 9-2b present a plan view comparison between the as-built Kewaunee S/RV discharge piping and the Kewaunee piping design modification using the rupture disks, respectively.

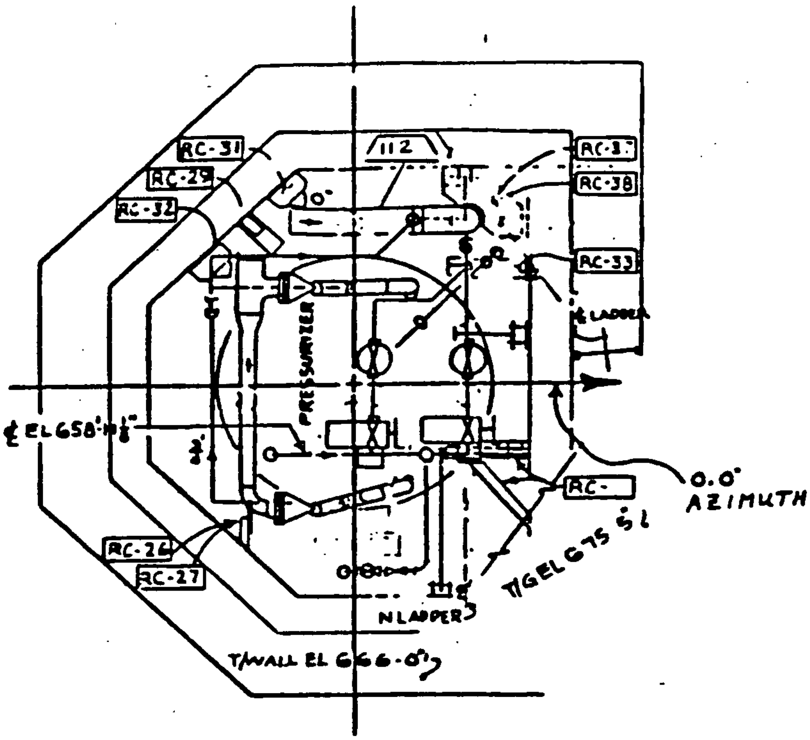
Major features of the rupture disk design are given below.

(1) An eccentric orifice plate with a maximum open area of 1.37 sq ft (approximately 25 percent of full open area) is to be located at the first 10-inch, 90-degree elbow downstream of both safety valves. The orifice plate is designed to allow drainage from leaking safety valves to pass into the downstream piping. This orifice plate serves two purposes. The first is to cause the upstream pressure to exceed the rated pressure set point of the rupture disk during a single safety valve actuation. The disk is required to rupture during a single safety actuation to ensure discharge piping loads are minimized. The second is to minimize the downstream flow of subcooled water from the loop seals and to minimize the downstream pressure wave. This will minimize the downstream forces.

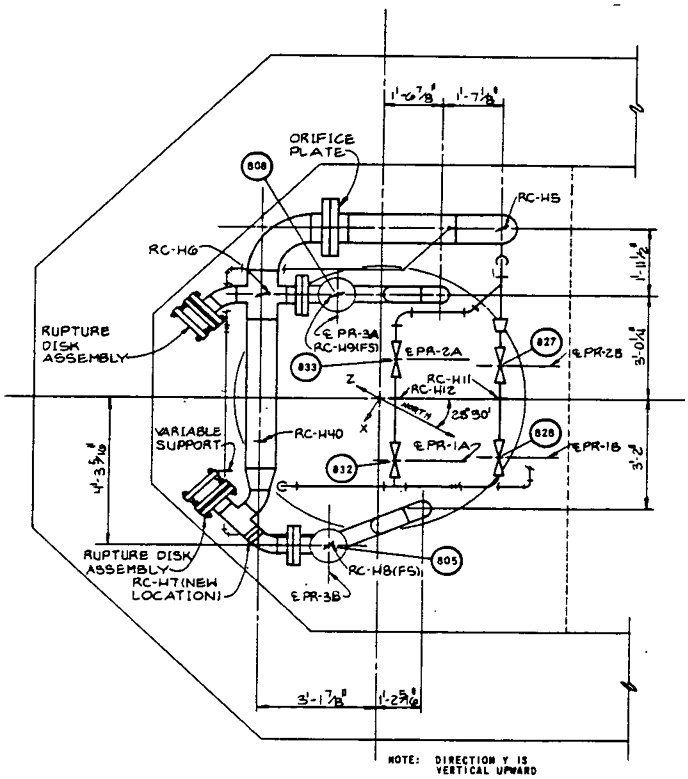
(2) The rupture disk has an upper limit (when allowing for functional tolerances) set point of 270 psid. This set point will provide a



PLAN VIEW OF KEWAUNEE
RUPTURE DISK CONFIGURATION
FIGURE 9-1



KEWAUNEE AS-BUILT--PLAN VIEW
FIGURE 9-2a



KEWAUNEE RUPTURE DISK MODIFICATION--PLAN VIEW
FIGURE 9-2b

sufficient margin to ensure that the disk does not rupture during a worst case power operated relief valve actuation. The worst case PORV actuation produced a pressure of 162 psig at the rupture disk/baffle plate assembly. The rupture disk is constructed out of Inconel material which is resistant to boric acid degradation.

(3) A 10-inch piping segment is required to replace the 6-inch piping run between the first 90-degree elbow at the safety valve PR-3A discharge and the 10-inch by 6-inch reducer. This additional 10-inch piping was found necessary to decrease the water hammer pressure spikes caused by the double safety valve actuation.

(4) An additional snubber rated at 27 kips will be installed at elevation 626 feet on the 10-inch vertical discharge piping run.

The stresses caused by the two safety actuation are the major contributor to the overall piping stresses for the plant faulted loading conditions. Table 9-1 indicates the largest stress values per the load combinations given in Section 8.0.

With the rupture disk configuration and associated modification implemented, it was concluded that the piping stresses and restraint loading for the Kewaunee S/RV piping would be within acceptable values during worst case safety valve(s) or PORV(s) actuation.

TABLE 9-1. MAXIMUM STRESS IN THE KEWAUNEE [illegible] PIPING

ADLPIPE Node	Stress psi	Allowable Stress psi	Plant Condition	B31.1 Equation	Location in Piping System
80	8,004	14,300	Normal	11	3-inch PORV inlet piping
94	13,272	17,160	Upset	12	3-inch PORV inlet piping
17	15,734*	27,013		13	6-inch safety inlet piping
807	34,663**	43,440	Faulted	12	10-inch discharge piping

*Stress range of all thermal modes.

**Includes loading due to two safety valve actuation.

10.0 REFERENCES

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APPENDIX A
RELAP5 CODE DESCRIPTION

APPENDIX A
RELAP5 CODE DESCRIPTION

A.1 INTRODUCTION

This Appendix describes the RELAP5/MOD1 computer code. The RELAP5/MOD1 code is a result of continued development beginning with the RELAP5/MODO code which was released May 1979 to the National Energy Software Center. The objective was to produce a more complete light water reactor transient analysis capability. The MODO version was a pressurized water reactor blowdown code. The MOD1 version extended the MODO capability to include models unique to small break situations and to include added capabilities for modeling accumulators, noncondensible gas, nucleonics, control systems, separators, and boron concentrations. The MOD1 code contains improvements in the flow regime maps, choked flow models, general code running time, and output edit.

The RELAP5/MOD1 code manual is self-contained and repeats some of the basic development material presented in the RELAP5/MODO code manual.[A-1] The repeated material has been appropriately revised to reflect the content of the MOD1 code version. One revision was made to RELAP5. This revision is presented in Table A-1.

A.2 GENERAL FEATURES OF RELAP5 AND COMPARISON TO RELAP4

The principal feature of RELAP5[A-3,A-4] is the use of a two-fluid, five-equation hydrodynamic model for two-phase flow. The five equations are a mass conservation equation for each phase, a momentum conservation equation for each phase, and an overall energy conservation equation. The one energy equation is supplemented by the assumption that one of the phases is at the saturated state. These equations allow a full two-velocity treatment and an adequate treatment of unequal temperature effects. Metastable states are allowed during vaporization and condensation. This advanced model replaces the one-fluid model with slip used in RELAP4. The new model also replaces RELAP4 submodels such as the bubble rise and enthalpy transport models.

TABLE A-1. UPDATES TO CORRECT AIR-WATER STATE LOGIC

```
*COMPILE DEFINE,SEGDIR
*IDENT ITIJAN82
*I  HXCR008.1094
C DONT CALL STH2X0  IF TG IS BEYIND CRITICAL
      IF(TG.GT.647.299) GO TO 267
*I HXCR008.1099
 267    CONTINUE
*/
*/ *****************ALL FOLLOWING UPDATES ARE TO ROUTINE STATE********
*/
*D HXCR008.1290
C IF PRESSURE EXCEED CRITICAL PRESSURE SET TMAX TO CRITICAL TEMP
C AND DONT CALL PSATPD ROUTINE.
 257  CONTINUE
      IF(P(I).GT.2.212E+07) GO TO 258
      CALL PSATPD(TMAX,P(I),DPDT,2,ERX)
*I HXCR008.1291
      GO TO 259
 258  CONTINUE
      TMAX=647.299
 259  CONTINUE
*D HXCR008.1339
 251  CONTINUE
      IF(IEF.NE.1) GO TO 252
      WRITE(OUTPUT,2000) TSAT,P(I),DTT
2000  FORMAT("0STATE FAILURE(LABEL 2000) FOR AIR-WATER EQUILIBRIUM STATE
     X CALCULATION."/1X," TRY RERUNNING USING NON-EQUILIBRIUM OPTION"
     X /1X,"TSAT  P(I) AND DTT ARE ",3E15.6)
       GO TO 1010
 252   CONTINUE
*I HXCR008.1478
C IF TEMP IS BEYOUND CRITICAL PT THEN CALL STH2X3 FOR LIQ PROPERTY
      IF(TF.GT.647.299) GO TO 514
*I HXCR008.1482
 514  CONTINUE
*D HXCR008.1515
2007  FORMAT("0 STATE ROUTINE(LABEL 2007) ERROR WITN AIR-WATER"
     X        /1X,"STATE OF AIR-WATER MIXTURE DOES NOT CONVERGE AFTER 20 IT
*D HXCR008.1544,1553
        SATT(I)=TMAX
*I HXCR008.1590
C DONT CALL STH2X0 IF TG IS GT CRITICAL TEMPERATURE
      IF(TG.GT.647.299) GO TO 271
*I HXCR008.1593
 271  CONTINUE
*D HXCR008.1626
      TG=AMAX1(TG-DTG,273.1601)
*D HXCR008.1630
     X   ) II=II+1
*D HXCR008.1636
2004  FORMAT("0  *******ERROR****STATE ROUTINE(LABEL 2004)  *ERROR*** "
     X        /1X,"STATE OF AIR-WATER MIXTURE DOES NOT CONVERGE AFTER 20 IT
*I HXCR008.1667
      IF(ERX) WRITE(OUTPUT,2010) PS
2010  FORMAT("0 ****ERROR***STATE FAILURE ON PSATPD CALL(LABEL 2010)
     X  PS=  ",E15.6)
*I HXCR008.1688
      IF(ERX) WRITE(OUTPUT,2011) PS
2011  FORMAT("0 ****ERROR***STATE FAILURE ON PSATPD CALL(LABEL 2011)
     X  PS=  ",E15.6)
*I HXCR008.1796
      IF(ERX) WRITE(OUTPUT,2012) TF
2012  FORMAT("0 ****ERROR***STATE FAILURE ON PSATPD CALL(LABEL 2012)
     X  PS=  ",E15.6)
*I HXCR008.1799
      IF(TG.GT.647.299) GO TO 310
*I HXCR008.1803
 310  CONTINUE
*D HXCR008.1846,1849
      TG=AMAX1(TG-DTG,273.1601)
      TF=AMAX1(TF-DTT,273.1601)
      IF(TF.EQ.273.1601 .OR.TG.EQ.273.1601) II=II+1
*D HXCR008.1855
2006  FORMAT("0   *****ERROR*****STATE ROUTINE(LABEL 2006)"
     X        /1X,"STATE OF AIR-WATER MIXTURE DOES NOT CONVERGE AFTER 20 IT
*D HXCR008.1902
C FORCE EQUAL TEMP APPROXIMATION ONLY IF STEAM IS SUBCOOLED MORE
C THAN 20C BELOW SATURATION TEMP( THE LIQUIDS TEMP)
      IF(TF.GT.TG+20.0) GO TO 400
*D HXCR008.2029
C FORCE EQUAL TEMP APPROXIMATION ONLY IF LIQUID IS SUPERHEATED MORE
C THAN 20C ABOVE SATURATION TEMP( THE VAPOR TEMP)
      IF(TF.LT.TG+20.0) GO TO 395
*D HXCR008.1945
2005  FORMAT("0 ******ERROR*****STATE ROUTINE(LABEL 2005) "
     X        /1X,"STATE OF AIR-WATER MIXTURE DOES NOT CONVERGE AFTER 20 IT
*I HXCR008.2048
C DONT CALL STH2X0 IF TG IS GT CRITICAL TEMPERATURE
      IF(TG.GT.647.299) GO TO 401
*I HXCR008.2053
 401  CONTINUE
*I HXCR008.2073
C IF TEMP IS BEYOND CRITICAL PT THEN PSAT DOESNT EXIST
      IF(TG.GT.647.299) GO TO 409
*I HXCR008.2076
 409  CONTINUE
*D HXCR008.2103
      TG=AMAX1(TG-DTG,273.1601)
*D HXCR008.2105
     X   ) II=II+1
*D HXCR008.2116
2009  FORMAT("0              ******ERROR*****STATE ROUTINE(LABEL 2009)  "
     X        /1X,"STATE OF AIR-WATER MIXTURE DOES NOT CONVERGE AFTER 20 IT
```

RELAP5 relies exclusively on the two-fluid model, with the possibility of using specialized constitutive relations in different parts of the system. RELAP5 is designed to be primarily a one-dimensional program and this version has only one-dimensional volumes. The finite difference approximations to the conservation equations assume that fluid enters or leaves a one-dimensional volume only at its end. Thus, when it is important to follow a mixture level or when a large spatial enthalpy gradient occurs such as in the reactor core, a larger number of volumes should be used with RELAP5 than with RELAP4. Given a large, vertically oriented vessel with several pipes leaving at various elevations, RELAP4 might model that with one volume with junctions attached at the different elevation levels. When the vessel contains two-phase fluid with gravity causing the liquid to settle towards the bottom, the bubble rise model would determine the varying mixtures of liquid and vapor entering the junctions. With RELAP5, separate volumes would be defined so that the different elevations of the pipes would be correctly modeled.

There are several reasons for the RELAP5 approach. First, the larger memories of current computers allow this approach to be implemented. Second, the superimposed models, especially the bubble rise model, are not compatible with the two-fluid equations which permit dynamic slip. Third, the superimposed models are themselves differential equations, and when combined with the basic hydrodynamic equations and the logic to merge them, the RELAP4 hydrodynamic model is more complex than the RELAP5 model. Careful consideration of storage requirements and coding practices has made it possible for RELAP5 with its larger number of volumes and junctions but simpler logic to be more cost effective than RELAP4.

Test problems have demonstrated the superiority of the RELAP5 approach. Tests with vertical pipes have shown the capability of the program to compute a sharp water-liquid interface to within one volume. Agreements have been achieved with several experiments. In the limited cases where there are comparable RELAP4 and RELAP5 simulations, RELAP5 provides superior results. A feature in RELAP5, not available in RELAP4, allows a time advancement with excessive error to be discarded, and the advancement to be redone with smaller time steps.

It was stated above that the volumes currently allowed in RE re one-dimensional, and flow was assumed to enter or leave a volume o t the ends. A branching capability provides for the merging and splitting o flow paths. Several components of hydrodynamic systems such as tees have multidimensional phenomena. An application technique of the branching capability that allows modeling of these components is presented.

RELAP5, with its improved hydrodynamics, does not require the modelin care required with RELAP4/MOD5. The user can quite easily apply the principles of RELAP5 to model his pipe network. Although the user must ensure convergence of his problem calculation, the absence of specific program models such as bubble rise, slip, etc., reduces this task considerably.

A.2.1 Numerical Scheme

The RELAP5 numerical scheme is based on a linear, semi-implicit, finite-difference integration scheme. The implicitness and use of donor-differencing for convective fluxes are sufficient to ensure stability for all time steps smaller than the material transport limit, and the lineari makes direct time step solution possible. Both of these factors ibu to fast execution. The stability has been tested numerically, applying t code to problems with exact analytical steady-state solutions and verifyi that the transient calculation converges to the steady-state result. The stability was also tested in numerous cases with sudden changes imposed a boundaries. The transient results were calculated without evidence of numerical instability.

The basic numerical hydrodynamic model was developed in a pilot code where the stability, accuracy, and fast execution capability could be readily evaluated. Once these characteristics were established, the mode was integrated into an efficient, user-oriented system code structure.

A.2.2 Development of the Hydrodynamic Model

The hydrodynamic model was selected after careful review of other advanced two-phase model development efforts. It was concluded that the model most consistent with existing knowledge is a five-field equation, two-fluid model. The model consists of the two phasic continuity equations, the two phasic momentum equations, and an overall energy equation. In this model, only two interphase constitutive relations are required: those for interphase drag and interphase mass exchange. An additional specification (that one-phase exists at the local saturation state) eliminates the need to specify energy transfer partitioning, either interphase or from the wall.

Special process models have been developed for abrupt area changes, branching, choking, pumps, accumulators, core neutronics, control systems, and valves. The fluid process models are based on the RELAP5 hydrodynamic model for quasi-steady conditions. This approach eliminates the need for localized fine nodalization and the attendant computational speed limitations resulting from a greater number of nodes and decreased Courant limit.

Some process and component models were obtained with little or no development work by transforming existing RELAP4 models to International System of Units and dynamic storage compatible with RELAP5. Examples of models obtained in this manner are those for pumps, valves, trips, neutronics, and certain input features.

A.3 RELAP5/MOD1 CAPABILITY

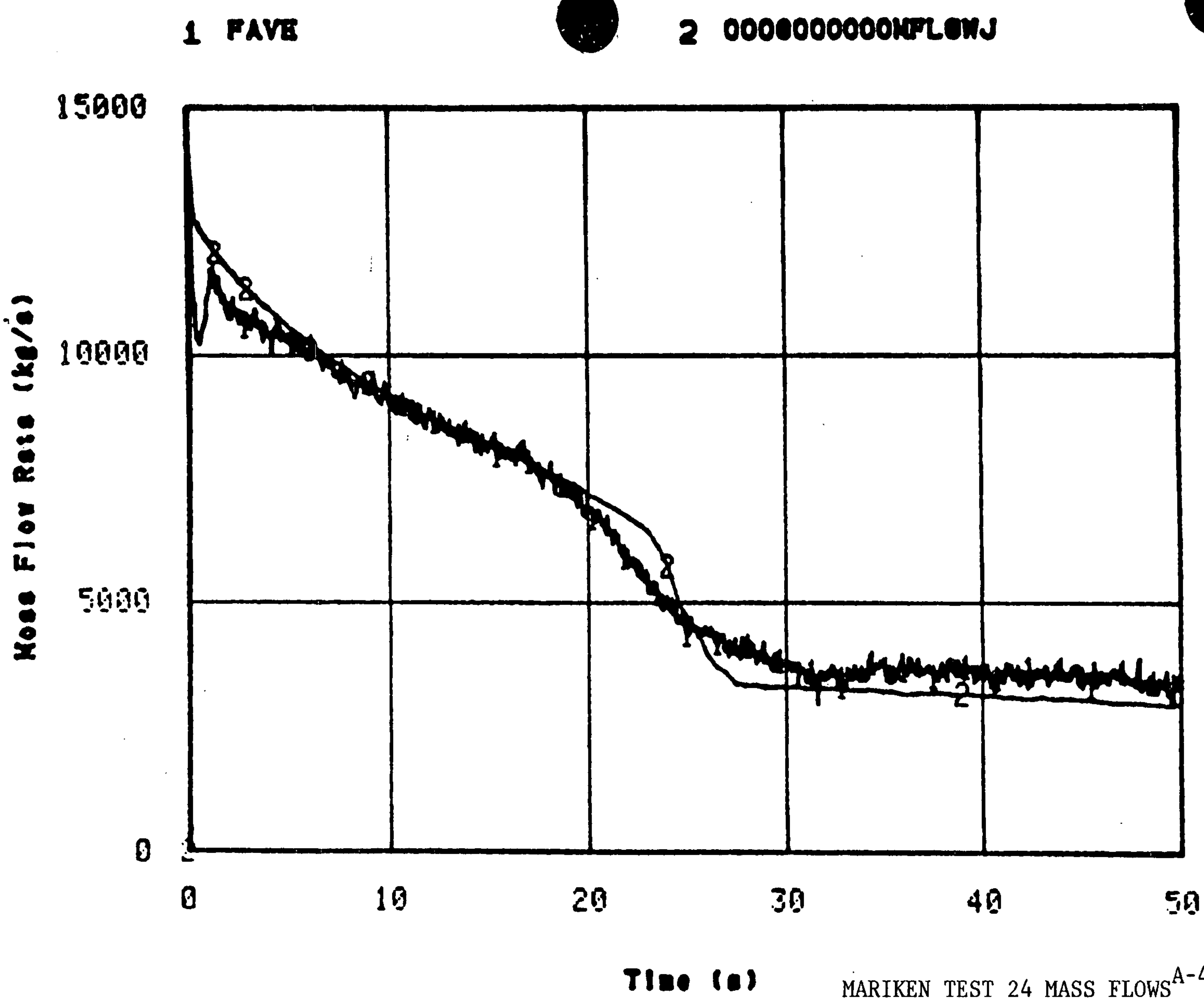
An assessment of RELAP5/MOD1 capabilities is presented in Reference A-2. Most applications discussed are checkout applications of the code and are described in more detail in Volume 3 of Reference A-1.

The RELAP5/MODO code is a one-dimensional, transient system analysis code designed for analyses of light water reactor (LWR), loss of coolant accident (LOCA), and non-LOCA transients. Development of this version was terminated at a somewhat arbitrary point as a result of an NRC decision. Subsequent development of RELAP5 continued in support of experimental programs at the Idaho National Engineering Laboratory (INEL). The RELAP5/MOD1 code is the product of this continued development.

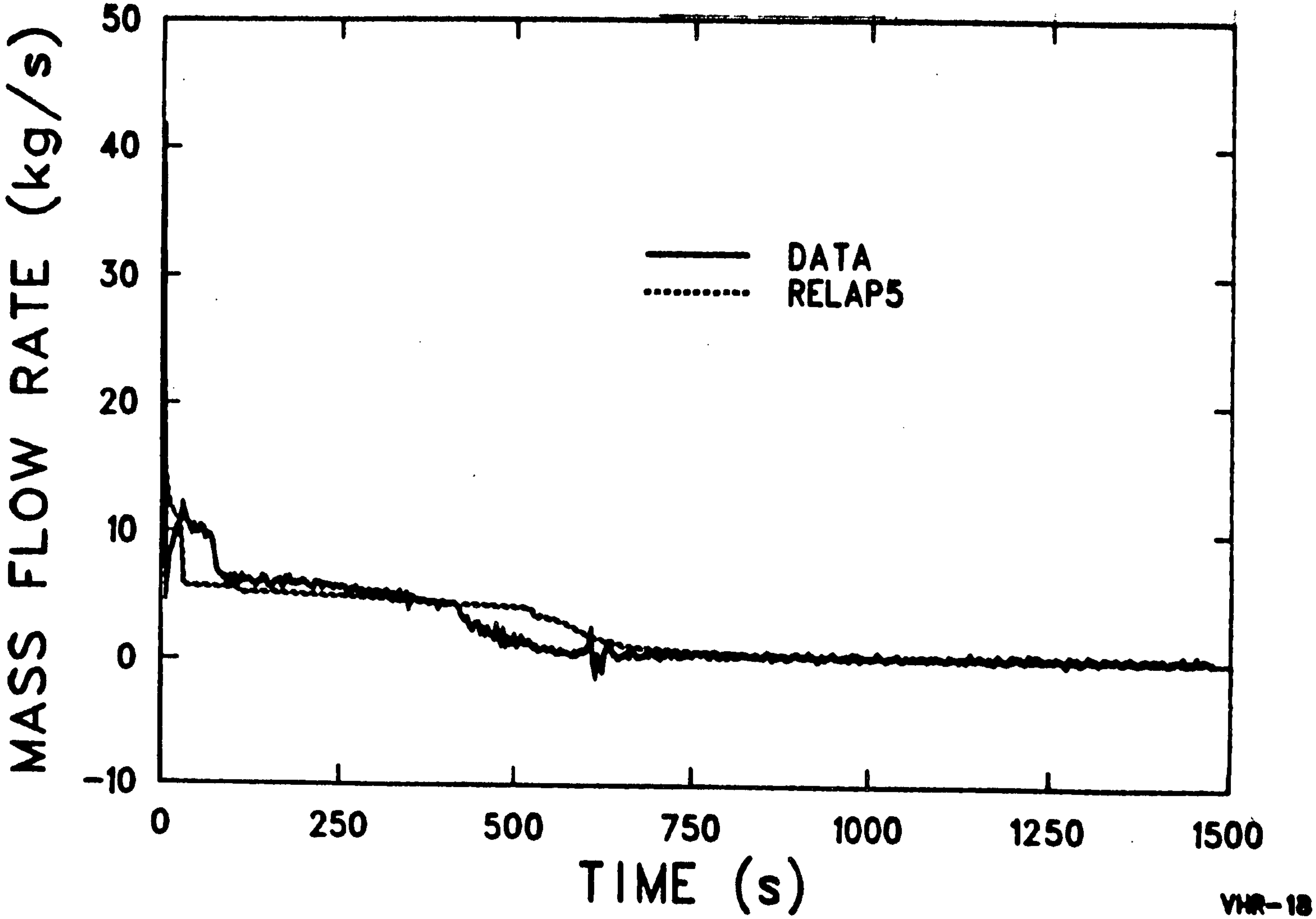
During development of RELAP5/MOD1, the code was used extensively for pretest and post-test predictions in the LOFT and Semiscale experimental programs at the INEL. Most of these experiments were small break LOCA's that motivated extension of RELAP5/MODO modeling to include mechanistic processes peculiar to small break phenomena. The transient calculations for small break experiments span periods composed of thousands of seconds. Thus, calculational speed has become increasingly important. The calculational speed and modeling accuracy with RELAP5/MOD1 represent significan improvement over those available in past codes. While RELAP5/MOD1 is a significant step toward the goal of a complete LWR system code, there remain several areas that must continue to be developed. These include thermal/hydraulic and fuel behavior under reflood conditions, even faster running capability, and increased user conveniences.

RELAP5/MOD1 overall capability has been successfully applied to a wi range of problems. These applications include many separate-effects tests such as Edwards Pipe Blowdown Experiment, the Moby Dick Tests, the Mariken Experiment, the LOFT Wyle Orifice Calibration Tests, and the General Electric Corporation (GE) Level Swell Tests. The first two of these experiments (documented in the MODO manual) are representative of the RELAP5/MO capability. Examples of application to the Mariken Test, LOFT Wyle Test, and GE Level Swell Test are given in Reference A-1. The code produced results in agreement with the data in all the cases listed. Figure A-1 i a comparison of predicted and calculated mass discharge rates for Mariken Test 24. This application is a good test of the subcooled choked flow model and the code's ability to model liquid level in a tank. The LOFT Wyle Orifice Calibration Test requires modeling of stratified flow in a horizontal pipe as well as flow in a vertical vessel component. The predicted mass discharge rate is compared with data shown on Figure A-2. Th experiment includes periods of subcooled and stratified two-phase choked flow discharge.

RELAP5/MOD1 was applied in the Semiscale and LOFT experimental prog at the INEL for experiment planning, pretest prediction, and post-test analyses. Several of these applications were selected as checkout probl presented in Volume 3 of Reference A-1. The best example to illustrate overall system capability of the code is the application to LOFT Test L3 This is a small break test, and pretest and post-test calculations were



MARIKEN TEST 24 MASS FLOWS
FIGURE A-1



RELAP5 WYLE SMALL BREAK TEST MASS FLOW
FIGURE A-2

made with RELAP5. The pretest prediction of the system pressure is compared with the data shown on Figure A-3. The post-test calculation of the system pressure with only the steam generator main steam control valve leakage rate changed to correspond to the actual leak rate is compared with the data on Figure A-4.

RELAP5 utilizes mechanistic process models where possible, avoiding the use of optional models to describe the same phenomena. This leads to less ambiguity in system modeling and provides viable results with fewer trained personnel.

A.4 RELAP5 EVALUATION OF S/RV

RELAP5 was used to evaluate the results of EPRI/Combustion Engineering Test 908.[A-5] RELAP5 evaluations were also made as part of the EPRI S/RV test program.[A-6] RELAP5 calculations provided agreement with several of the CE test cases.[A-5]

A.5 RELAP5 VERIFICATION

The execution of RELAP5 at four computer facilities was verified by comparing calculated results provided by INEL for the Edward's Pipe Problem with RELAP5 results calculated at the three computer facilities. Agreement was obtained in each case.

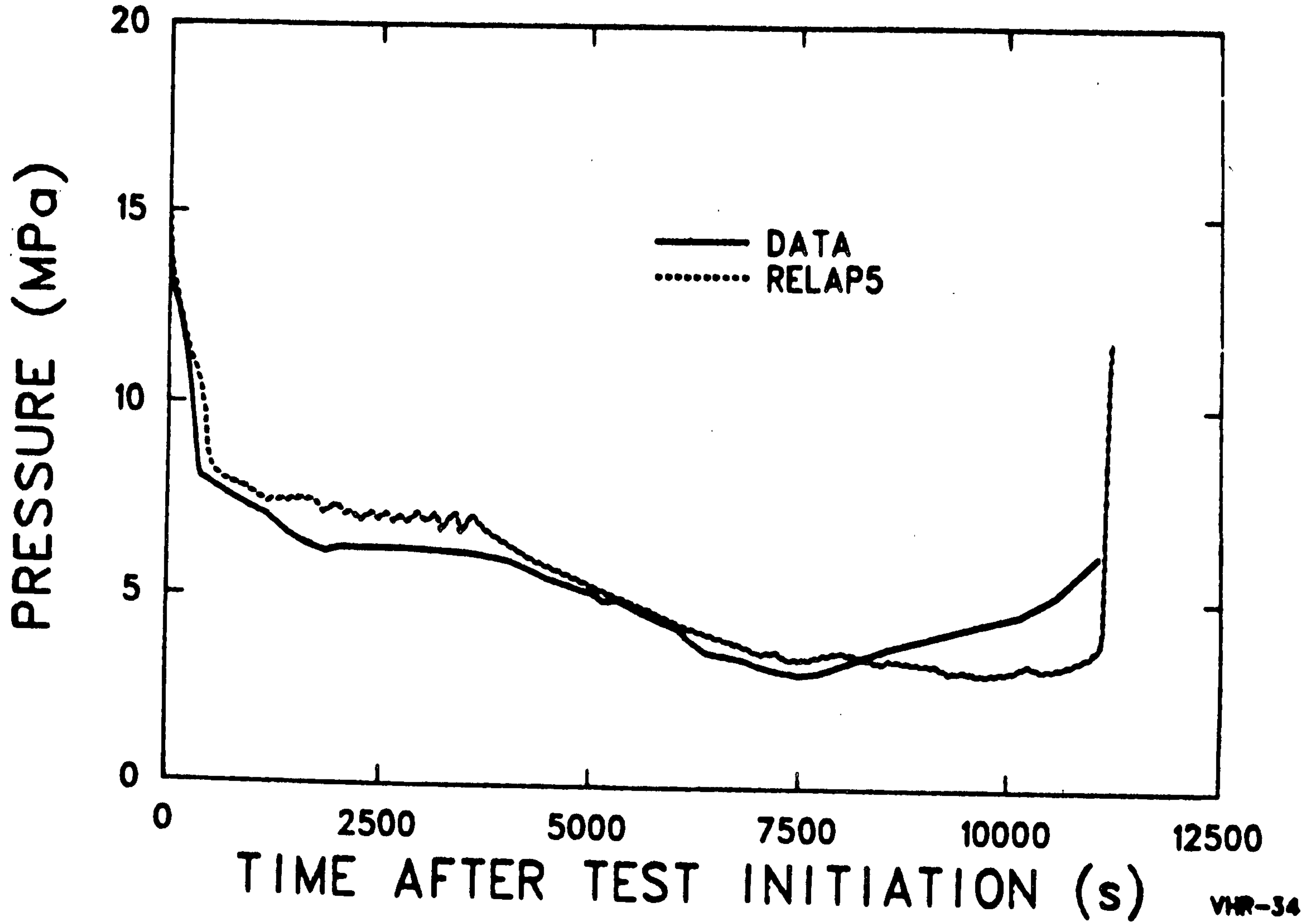
The four facilities are the Control Data Corporation's CDC-176 in Houston, Texas; the United Computer Corporation's CDC-176 in Dallas, Texas; the Babcock & Wilcox CDC-7600 in Lynchburg, Virginia; and Boeing Computer Services Company's CRAY in Seattle, Washington.

A.6 REFERENCES

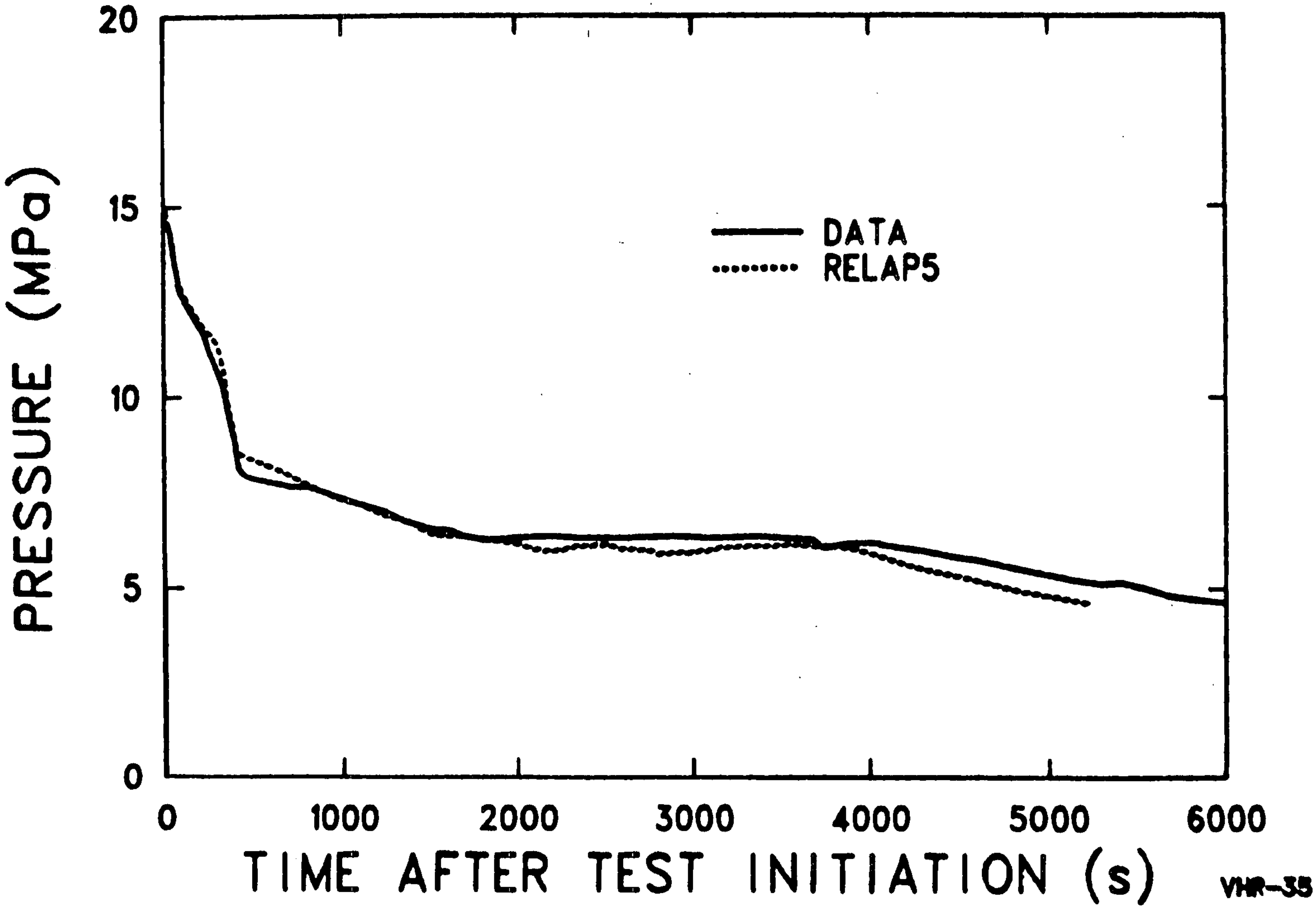
A-1. R. J. Wagner et al., RELAP5/MODO User's Manual, Volumes 1-3, CDAP-TR-057, May 1979.

A-2. J. A. Trapp, "Descriptive Evaluation of RELAP5," NP-2361 EPRI Research Project 1938-2, Practical Analysis and Computing, Inc., April 1982.

A-3. Richard J. Wagner et al., RELAP5/MOD1 Code Manual Volume 2: Users Guide and Input Requirements, EG&G, Idaho, Inc., NUREG/CR-1826 Revision 2, September 1981.



AP5 LOFT L3-7 PREDICTION SYSTEM PRESSURE
FIGURE A-3



RELAP LOFT L3-7 POST-TEST SYSTEM PRESSURE[A-4]
FIGURE A-4

A-4. Victor H. Ransom et al., RELAP5/MOD1 Code Manual Volume [illegible] System Models and Numerical Methods, EG&G, Idaho, Inc., [illegible]EG/CR-1826 Revision 2, September 1981.

A-5. Kewaunee Nuclear Power Plant Safety and Relief Valves Piping Qualification Report, Revision 0, issued by Black & Veatch, Engineers-Architects to Wisconsin Public Service Corporation, June 28, 1982.

A-6. M. A. Langerman et al., "Application of RELAP5/MOD1 for Calculation of Safety and Relief Valve Discharge Piping Hydrodynamic Loads," Intermountain Technologies, Inc., Interim Report, March 1982.

APPENDIX B
REPIPE AND FORCE PROGRAM DESCRIPTIONS

APPENDIX B
REPIPE AND FORCE PROGRAM DESCRIPTIONS

B.1 BASIC APPROACH AND CODE STRUCTURE FOR REPIPE*

B.1.1 Basic Equations

REPIPE is based on the formulation devised by Moody[B-1] for the calculation of the time-dependent loading on a piping system. However, the approach used may be best explained by the treatment of Lahey and Moody.[B-2]

To obtain the time-dependent force acting on a piping segment, the portion of pipe between the two elbows on Figure B-1 can be used as an example. The volume of fluid contained within the elbows is assumed to be small compared to the total volume of the segment. The forces acting on the segment may be broken into two groups. The first group contains the forces F_{11}, p_1A_1, F_{22}, and p_2A_2 which have lines of action parallel to the pipe segments joined to each end of the control volume. The second group, forces F_1 and F_2, are parallel to the axis of the pipe segment under consideration. The ambient pressure, p_a, acts on the outer surface of the pipe and cancels everywhere except at areas A_1 and A_2. The force F_s is the wall shear.

The forces acting on the segment may be obtained by writing the momentum conservation equations. For the direction parallel to the segment axis, the following equations can be written.

$$F_1 - F_s - F_2 = [F_{11} - (p_1 - p_a)A_1 - (G_1^2 A_1)/(g_c\rho_1)]\cos\gamma_1$$

$$=[F_{22} - (p_2 - p_a)A_2 \cdot (G_2^2A_2)/(g_c\rho_2)]\cos\gamma_2 + (1/g_c)\frac{\partial}{\partial t}\int_0^L GAdz \qquad (1)$$

Somewhat simpler momentum equations can be written by considering the control volume to be divided into two parts by the double-dashed line shown on Figure B-1. This boundary is normal to the pipe axis. A momentum

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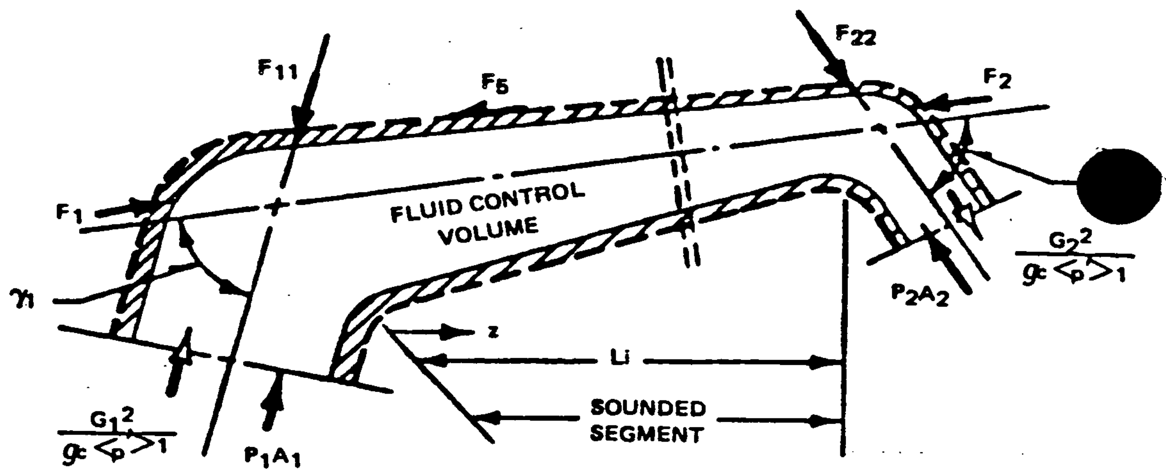
*Parts of this code description were taken from "Evaluation of the RELAP4/REPIPE System for Calculation of Transient Piping Forces on Systems Containing Water and Steam," Control Data Corporation, July 1978.



a. PIPE REACTION FORCES

BOUNDED PIPI
CONTROL VOLUME
FIGURE B

balance in this direction can be written for the left- and right-hand portions of the volume and is given as follows.

$$[F_{11} - (p_1 - p_a)A_1 - (G_1^2A_1)/(g_c\rho_1)]\sin\gamma_1 = 0 \qquad (2)$$

$$[F_{22} - (p_2 - p_a)A_2 - (G_2^2A_2)/(g_c\rho_2)]\sin\gamma_2 = 0 \qquad (3)$$

Equations (1), (2), and (3) may be combined to obtain what Moody calls the "wave force," F_w, and is given by

$$F_w = F_1 - F_2 - F_s = (1/g_c)\frac{\partial}{\partial t}\int_0^L GAdz \qquad (4)$$

This wave force is due to the fluid acceleration and leads a thrust parallel to the direction of the fluid flow. The major reaction force, exerted by the pipe restraints, is then also parallel to the fluid flow.

A segment of the type just considered is designated as a "bounded" segment. One must also consider an open segment in which the fluid is discharging to the atmosphere. The force on such a segment can be obtained by considering the pipe segment of Figure B-1 but with $\gamma_2 = 0$, under conditions $F_{22} = 0$. By combining Equations (1) and (3), the force, F_N, on the discharging segment is given by

$$F_N = (1/g_c)\frac{\partial}{\partial t}\int_0^L GAdz + (p_2 - p_a)A_2 + (G_2^2A_2)/(g_c\rho_2) \qquad (5)$$

The force F_N may be considered the sum of the so-called wave force, F_w, and a "blowdown force," F_B, where

$$F_B = (p_2 - p_a)A_2 + (G_2^2A_2)/g_c\rho) \qquad (6)$$

Although the wave force will disappear at steady-state, the blowdown force will remain. It should be noted that, when the last piping segment is a right angle bend, the blowdown force perpendicular to the flow direction will be of the same magnitude as that given by Equation (6).

B.1.2 Code Structure

REPIPE is a post-processor to RELAP4[B-3] and RELAP5.[B-4] The time-dependent fluid properties, velocity, and acceleration calculated by RELAP4 or RELAP5 are used by REPIPE to calculate pipe loadings.

REPIPE considers the piping to be divided into bounded legs a[illegible]pen legs. The wave forces on the bounded legs are computed by Equatio[illegible]), whereas the sum of wave and blowdown forces on the open leg is computed by Equation (5). The user must specify which flow junctions constitute the boundaries of the various legs and thus assign each RELAP control volume i the piping to one of the legs.

For example, the blowdown of the simple system shown on Figure B-2 ca be modeled as shown on Figure B-3. The open leg is leg 4 and the reaction force, R_N, on leg 4 is given below.

$$R_N = - P_g A_g - \rho_g V_g^2 A_g - \sum_{i=7}^{9} (L_i/g)\ (dW_i/dt) \qquad (7)$$

where

$$W_i = G_i A_i$$

Because the fluid acceleration dW_i/dt is calculated in the junction, the junction over which the sum is taken must be specified. The volume which is discharging must also be specified. The pressure at the discharge end will be atmospheric until critical flow occurs, and, at that tim[illegible] may be substantially above atmospheric.

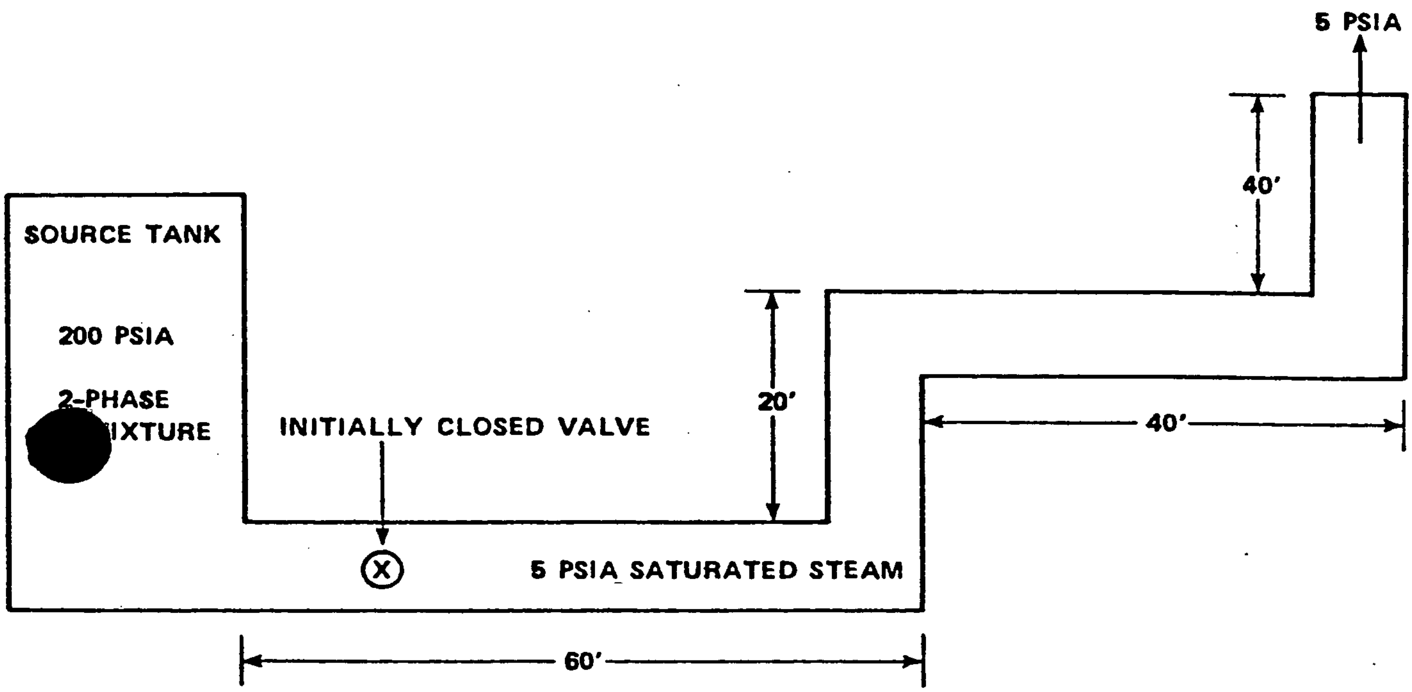
In the bounded junctions the "wave force" is computed by Equation (4 Thus for leg 2

$$R_N = - \sum_{i=4}^{5} (L_i/g) dW_i/dt) \qquad (8)$$

B.2 CODE ASSUMPTIONS AND LIMITATIONS

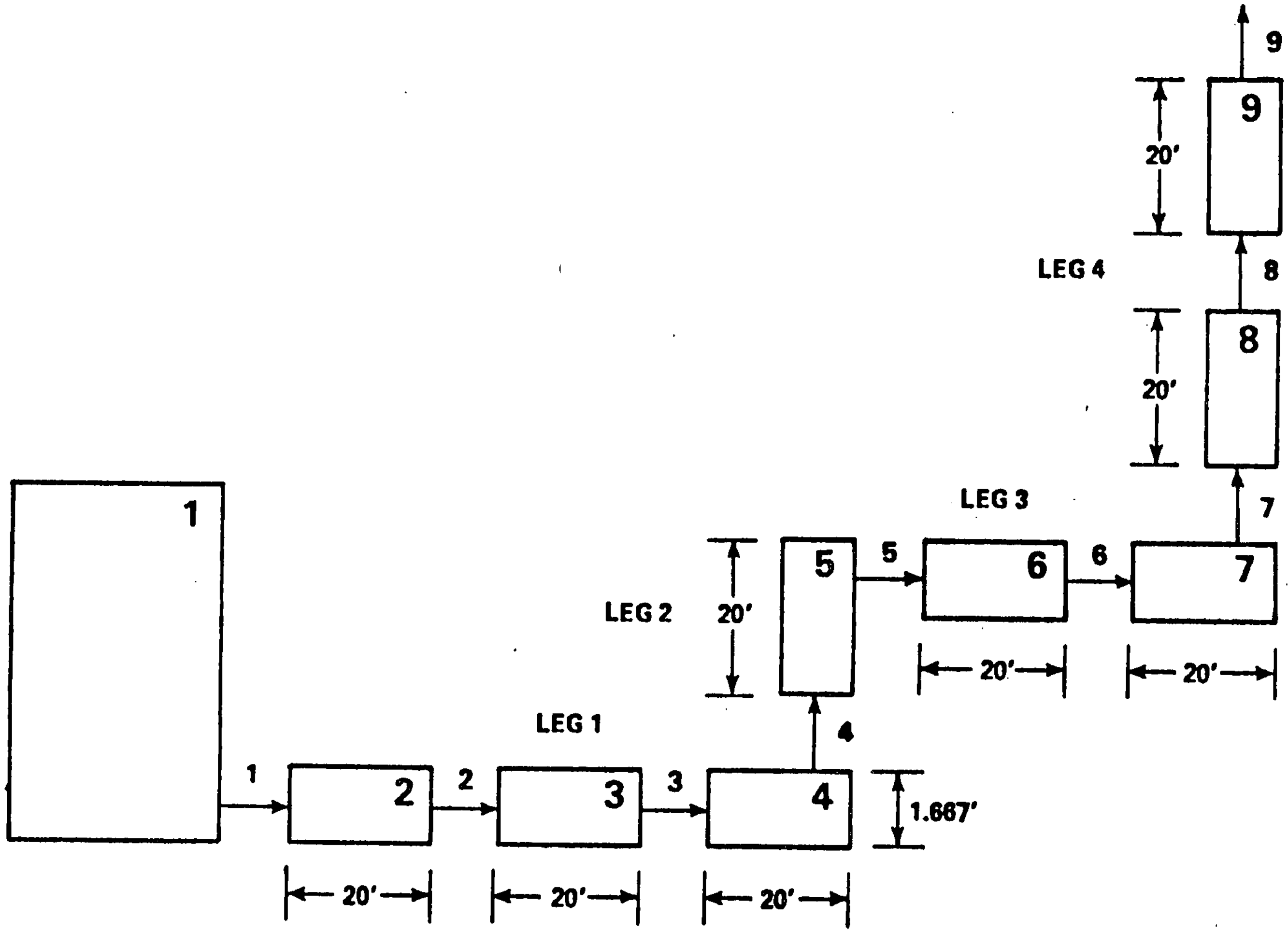
REPIPE uses a simple and straightforward approach which is based on well accepted theory. However, it is necessary to recognize that REPIPE computes a one-dimensional approximation to three-dimensional behavior.

Whenever there is a change in piping direction (bend or elbow), for are exerted in two directions to change the flow directions. Hence, the reaction force has components in two Cartesian directions. To avoid the necessity of a multidimensional approach, REPIPE considers all the pipin except for the length adjacent to the discharge, to be bounded by a bend



ALL PIPES DIA = 1-2/3 FT
VALVE FULLY OPEN AT 0.05 SEC

ARRANGEMENT FOR
BLOWDOWN PROBLEM
FIGURE B-2



RELAP/REPIPE MODELING OF BLOWDOWN PROBLEM B-5
FIGURE B-3

either end. Effectively, REPIPE considers the bends to be so placed that the net force on the piping caused by direction changes is zero. The forces on the inlet bend exactly cancel the forces on the outlet bend when both bends subtend the same angle and are in the same plane. Obviously, if one bend is in the x-y plane and the other is in the y-z plane, this will not be true. REPIPE calculates the forces in the direction parallel to the axis of each piping segment but does not compute the forces in the two directions orthogonal to the segment axis.

In the unbounded segment at the discharge end of the piping, REPIPE assumes a bend at one end only. The bend is taken to be oriented so that the force parallel to the piping segment axis which is required to change the fluid direction is acting in the same direction as the force caused by fluid acceleration.

It should be noted that both the wave force, defined by Equation (4), and the force on the discharge segment, defined by Equation (6), exclude the frictional, or shear, force on the piping. Thus, to obtain the total external force on the piping along the flow axis, it is necessary to add he frictional force as well as the multidimensional effects not considered y REPIPE.

REPIPE has modified the definitions of F_W and F_N when internal choking occurs within any volume. When such choking occurs, there can be an internal drag force on the pipe far in excess of that which would be calculated by a steady-state analysis. The additional drag force ($\Delta P_{choke} \times A_{choke}$) has therefore been added to the reaction force computed by REPIPE.

B.3 ABILITY OF RELAP4/REPIPE TO PREDICT KNOWN BEHAVIOR

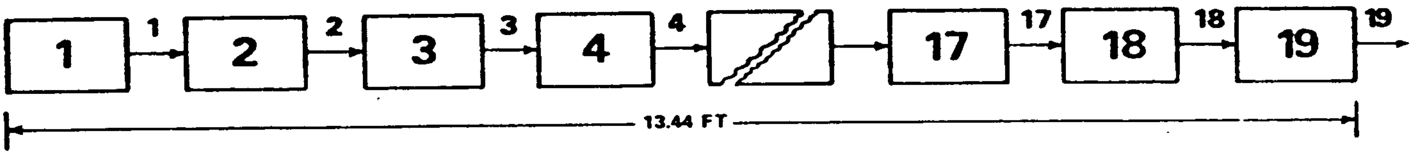
To ascertain the ability of the RELAP4/REPIPE combination to predict piping reaction forces during transients, the program was used to model several problems for which measured forces or analytical solutions were available. The first of the problem chosen was the Edwards and O'Brien[B-6] blowdown of a 13.44-foot long pipe having an inside diameter of 2.88 inches. Based on results given by the Energy, Inc.,[B-7] the RELAP4 models best fitting the observed pressures were selected and RELAP4 was rerun in conjunction with REPIPE. The geometry of the modeling used for this model is shown on Figure B-4.

The thrust force calculated from the Edwards and O'Brien data is shown on Figure B-5, and the results from REPIPE are shown on Figure B-6. It is apparent that the predictions agree fairly well with the data in both magnitude and shape. These results confirm REPIPE's ability to calculate thrust properly when appropriate flows, pressures, and fluid properties are supplied by RELAP4. Obviously, greater disagreement would be seen if less appropriate RELAP4 modeling was used.

The second experiment examined was the blowdown experiment of Hanson. In this test, water at 60 F and 2,175 psia was released from a two-segment pipe. (The upper right of Figure B-8 shows the geometry of pipe.) The blowdown was initiated by rupturing a disc at one end of the pipe. In the RELAP4 model, the large pipe was broken into eight control volumes and the small pipe into two volumes (Figure B-7). The RELAP4/ REPIPE results are compared to the experimental results on Figure B-8. Also shown are the results of a simplified analytical model derived by Moody.[B-1] It can be seen that the REPIPE results match the experimental results quite well and are a considerable improvement over the simplified analytical model. In obtaining these results, a 0.2 msec break opening time was assumed. This is believed reasonable, but the sensitivity of the results to this assumption was not examined.

The final comparison of REPIPE to known results was made with a problem solved analytically by Lahey and Moody.[B-2] The configuration (shown on Figure B-9) consisted of a large volume connected to a long pipeline. The pipeline is 160 feet long with segments of 64, 32, and 64 feet in length and with a flow area of 100 sq in. Initially, the system is full of saturated steam at 1,000 psia. The force time behavior was estimated on the three segments for an instantaneous rupture at the end of the pipeline.

A RELAP4 model of 21 volumes was used (Figure B-10). However, it was assumed that the pipe was straight and at the same elevation because exact bend angles were not specified by Moody. This assumption is justified since Moody's analytical approach was also one-dimensional.



19 EOUAL VOLUMES

GEOMETRY OF EACH VOLUME

LENGTH = 0.70796 FT

AREA = 0.0452 FT^2

DIAMETER = 0.24 FT

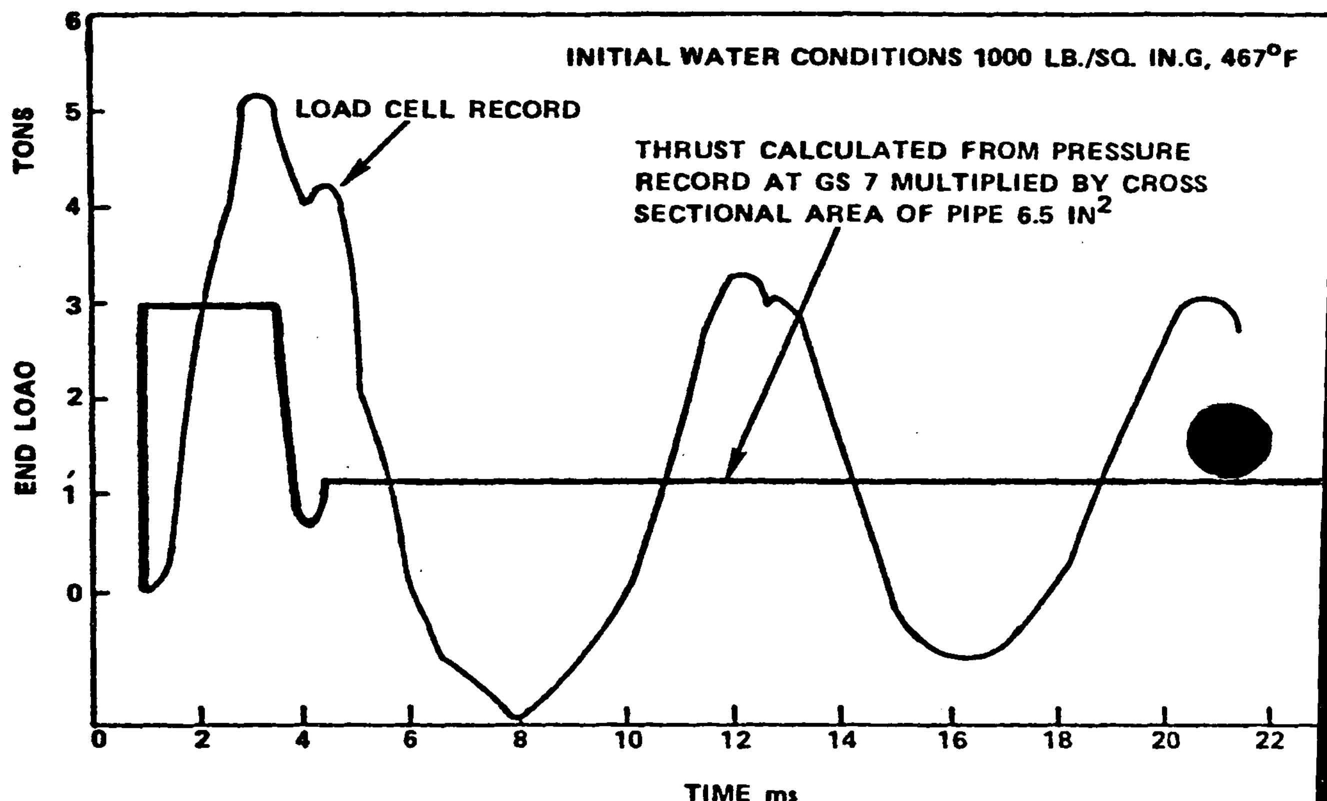
VOLUME = 0.032 FT^3

INITIAL CONOITION

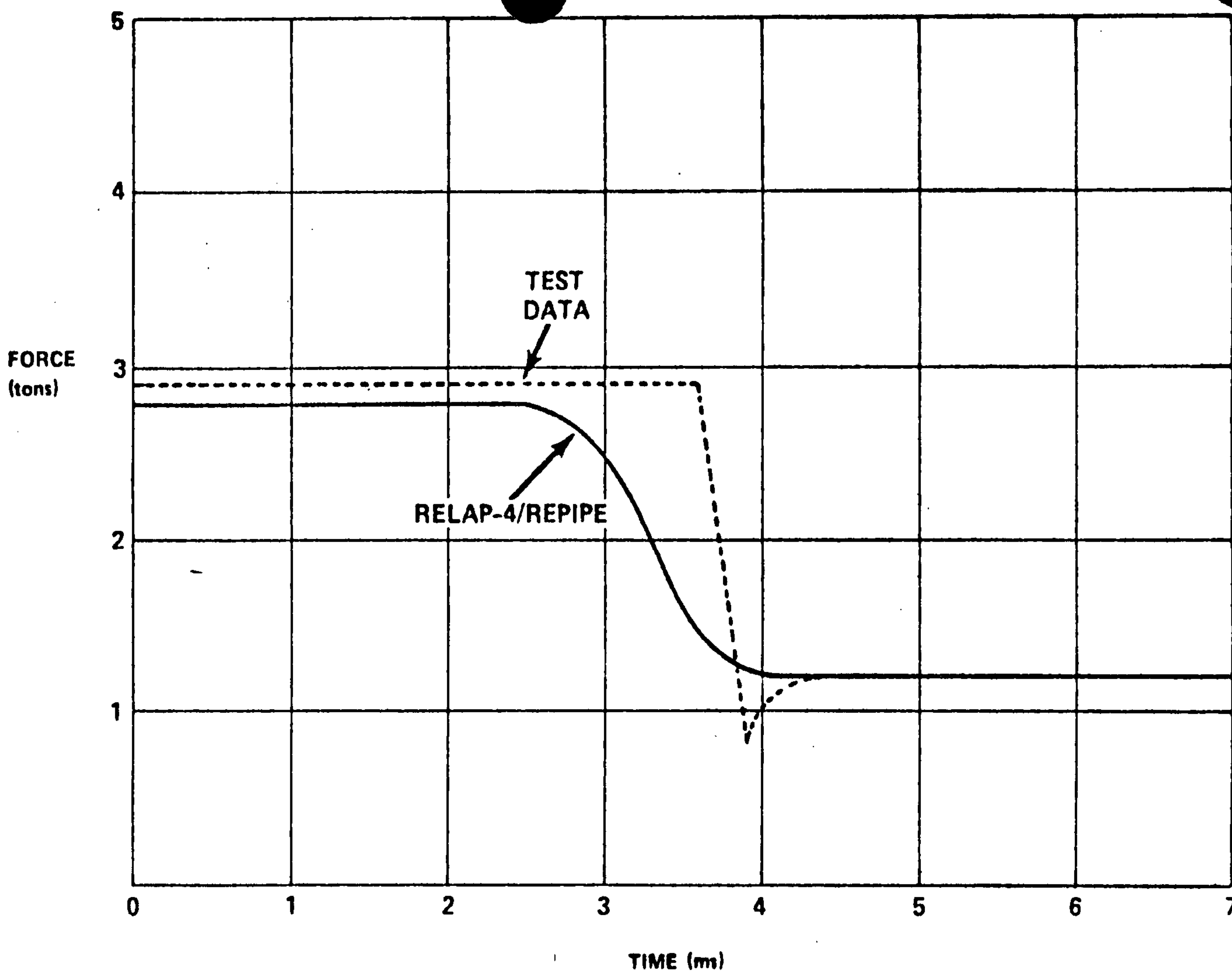
ALL VOLUMES 1000 PSIG, 467°F (SUBCOOLED)

RELAP/REPIPE MODEL OF
EDWARDS AND O'BRIEN
EXPERIMENT
FIGURE B-4

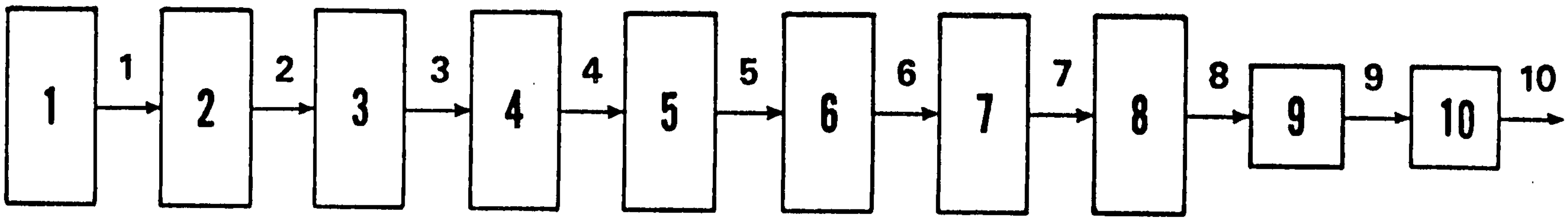
B-5



EDWARDS AND O'BRIEN DATA[B-5]
FIGURE B-5



REPIPE PREDICTIONS OF EDWARDS AND O'BRIEN EXPERIMENT[B-5]
FIGURE B-6



GEOMETRY DATA

8 EQUAL VOLUME

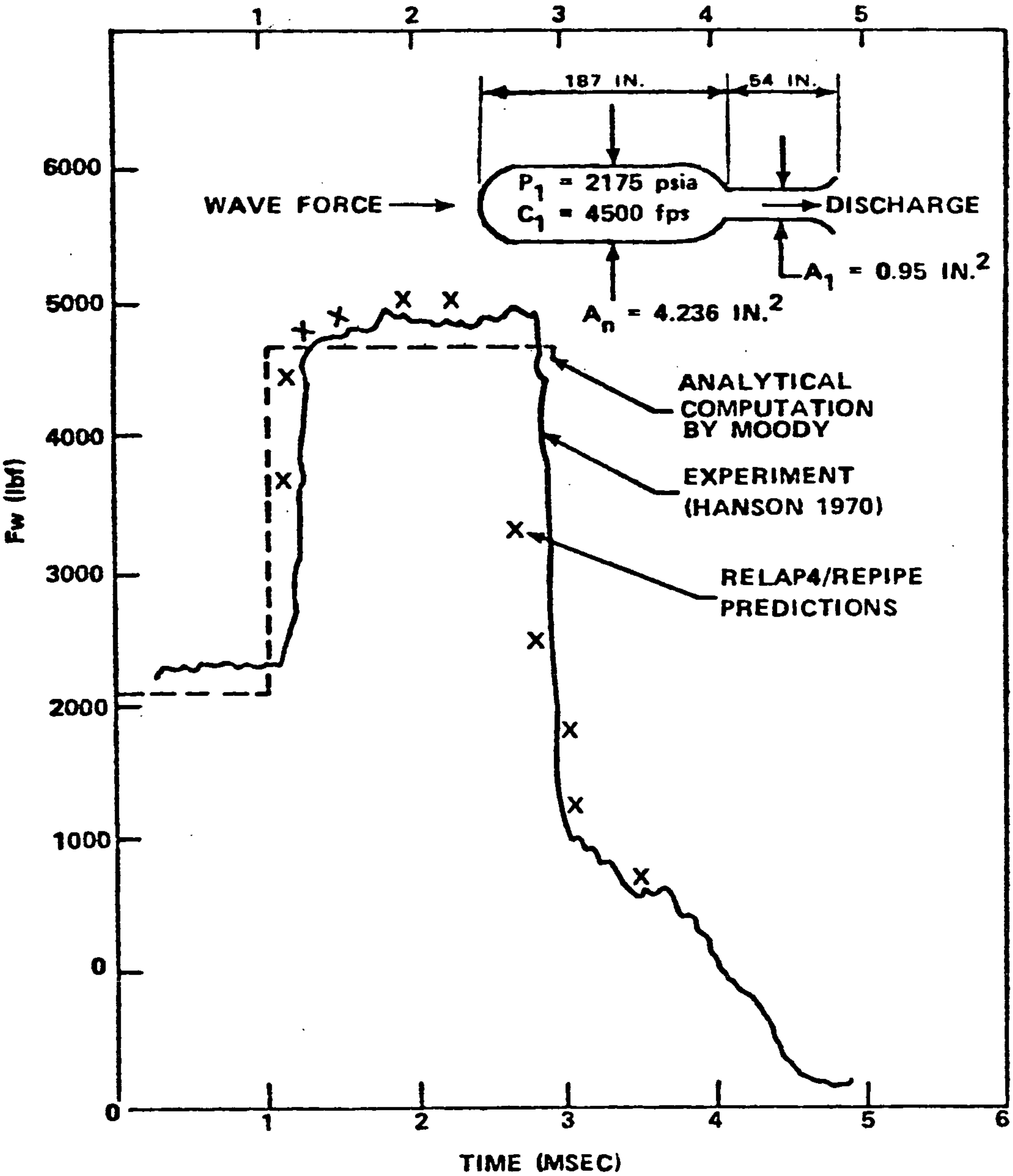
AREA	=	0.0294 FT^2
DIAMETER	=	0.193477 FT
LENGTH	=	1.04166 FT
VOLUME	=	0.030625 FT^3

2 EQUAL VOLUME

AREA	=	0.0066 FT^2
OIAMETER	=	0.09107 FT
LENGTH	=	2.25 FT
VOLUME	=	0.01485 FT^3

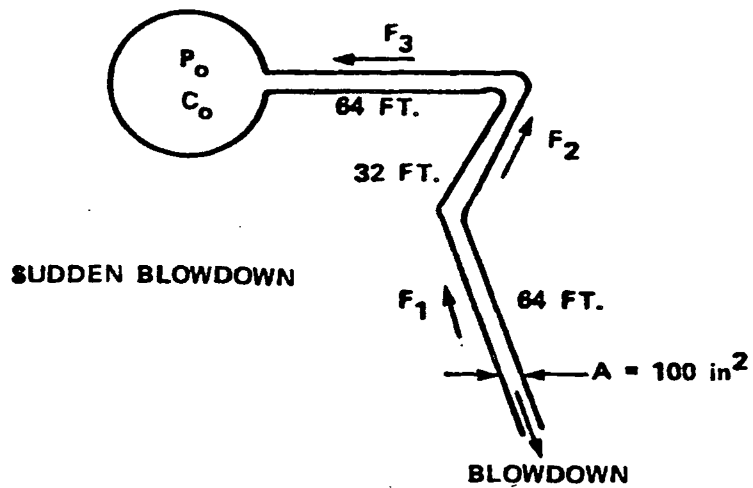
INITIAL CONDITION: P = 2175.0 PSIA
T = $60^{o}0$ F (SUBCOOLED)

RELAP/REPIPE MODELING OF HANSON EXPERIMENT[B]
FIGURE B

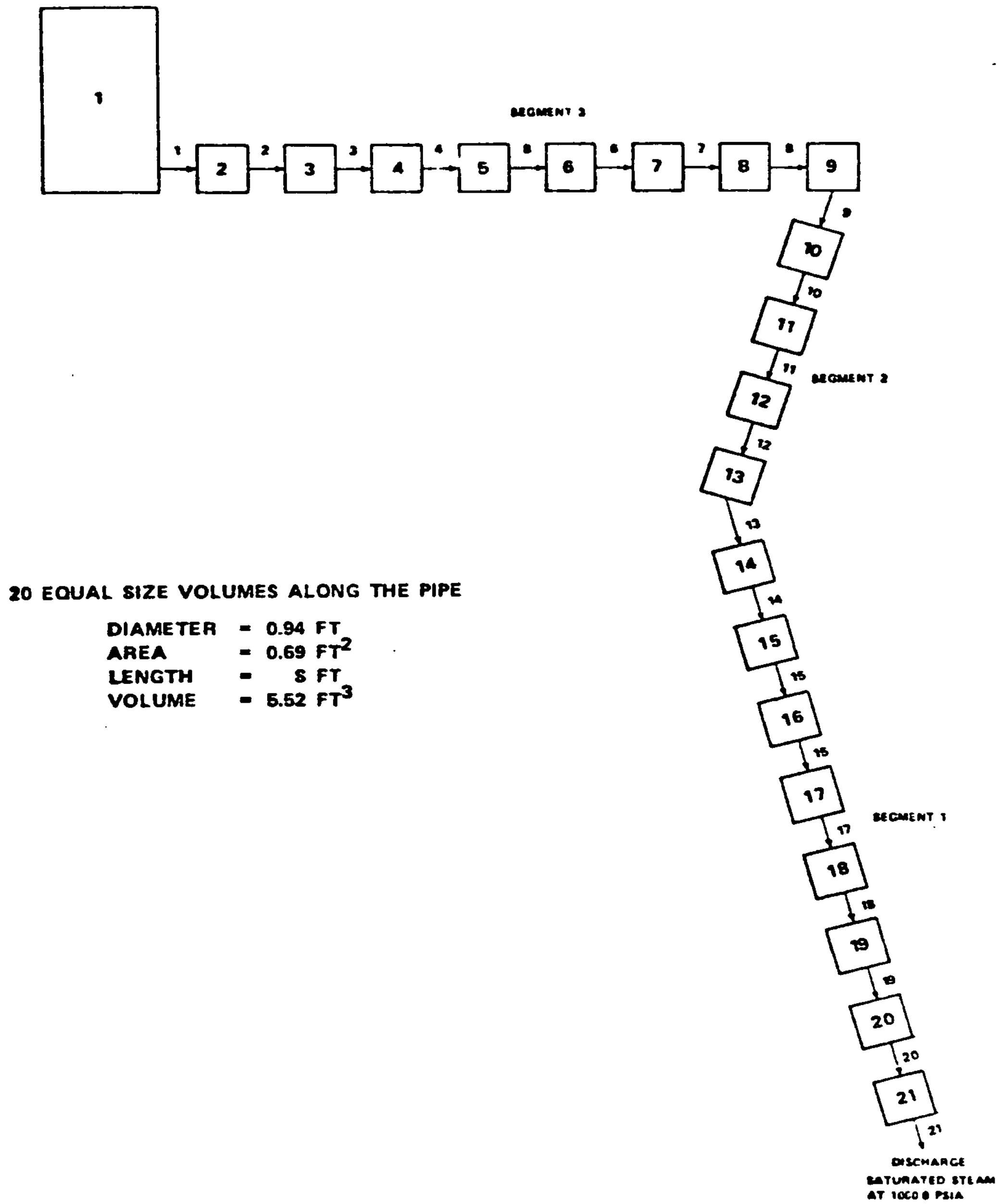


COMPARISON OF PREDICTIONS
AND HANSON'S OBSERVATIONS
FIGURE B-8

B-2



CONFIGURATION USED FOR MOOD
AND LAHEY SAMPLE PROBLEM
FIGURE B-



RELAP MODEL FROM MOODY AND LAHEY PROBLEM[B-5]

FIGURE B-10

REPIPE was run to calculate the wave force on segments two an[illegible]ree and the sum of wave force plus blowdown force on segment one. The[illegible]ults of the initial computations showed lower forces on leg 2 than were expect[illegible] Examination of the RELAP4 output indicated that the high friction in the line led to a situation where both steam and water were present. Since Moody's analysis assumed all steam and frictionless flow, a large D_e was assigned to the line to keep friction low. When this was done, the two-phase situation was avoided, and the results shown on Figure B-11 were obtained.

From comparison of the REPIPE calculations with Moody and Lahey's results, shown on Figure B-11, it may be seen that the wave forces on leg[illegible] and leg 3 agree very well with the analytical solution in shape and magni-tude. The wave force in segment 1 is slightly low in the latter part of the transient, but otherwise the agreement is very good. Based on the results obtained previously with the Edwards and O'Brien problem,[B-6] it seems likely that this slight underestimation is due to the inability of the compression pulse to penetrate the control volume discharging to the atmosphere. In an attempt to avoid this situation, the last cont[illegible]olu[illegible] was replaced by a T-branch and the problem rerun. The results, al[illegible] show[illegible] on Figure B-11, indicate no significant improvement.

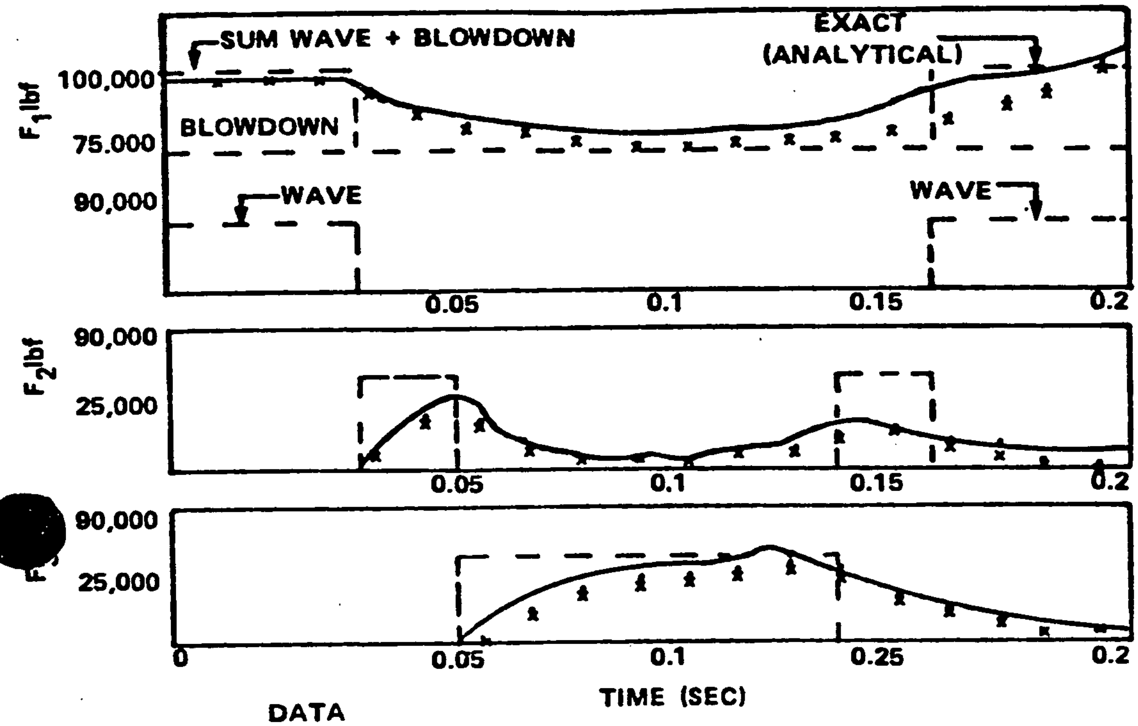
Although there is a slight underestimation of the force on segment [illegible] in the latter part of the transient, the overall agreement is quite good. The agreement obtained in the sample problems indicates REPIPE to be correctly formulated and programmed.

B.4 ABILITY OF RELAP4/REPIPE TO MODEL TRANSIENTS OF INDUSTRIAL INTEREST

To examine the behavior of RELAP4/REPIPE under conditions similar t[illegible] those under which it must be used commercially, more complex transients were examined, that is, two-phase blowdown across a relief valve and val[illegible] closure in a piping system containing a two-phase fluid.

B.4.1 Two-Phase Blowdown

Figure B-12 shows the schematics of the system used for this exampl[illegible] The system consists of a reservoir connected to a long pipe which discha[illegible]



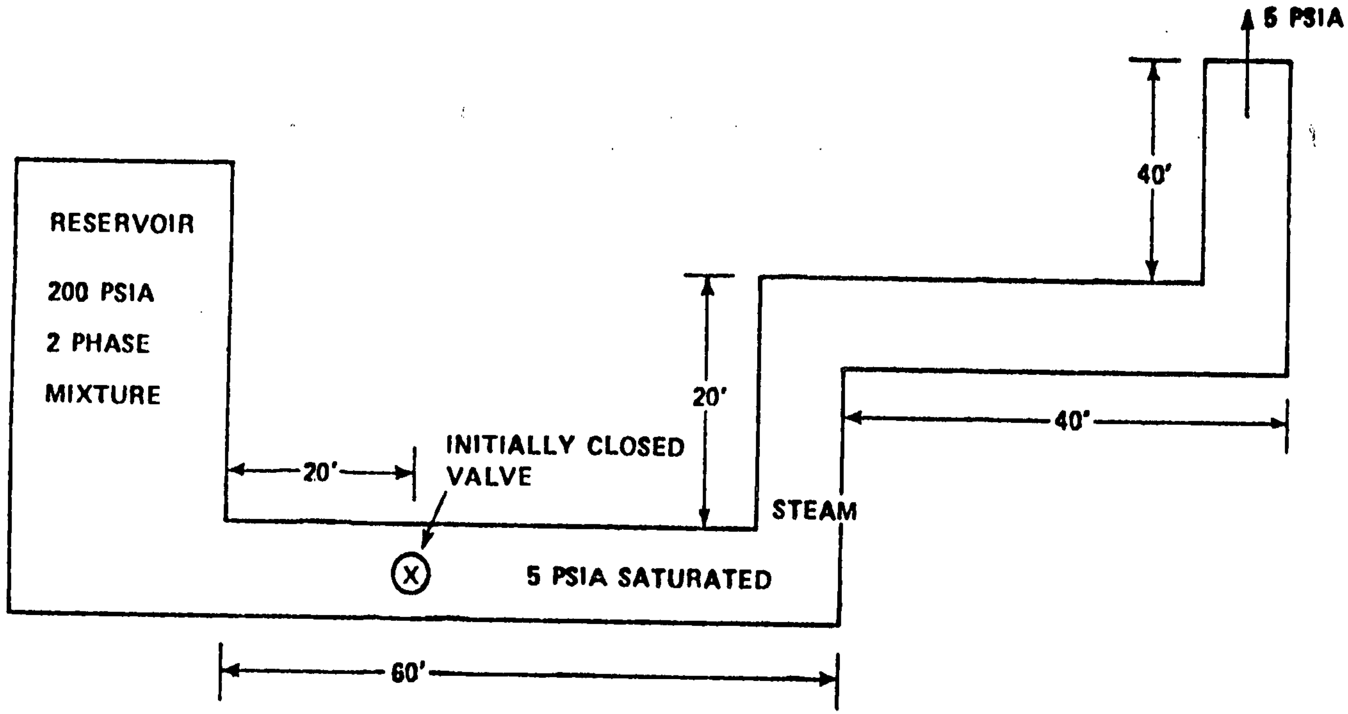
DATA

. . . : RELAP4 RESULTS WITH EQUIVALENT DIAMETER 1.0 E10

x x x: RELAP4 RESULTS WITH EQUIVALENT DIAMETER 1.0E10, WITH T-BRANCH

——: ANALYTICAL DATA

COMPARISON OF ANALYTICAL
SOLUTION AND RELAP4/REPIPE
RESULTS FOR LAHEY-MOODY
PROBLEM B-2
FIGURE B-11



ALL PIPES WITH DIAMETER = 1.667 FT (1-2/3 FT)
VALVE AND RUPTURE END OF PIPE FULLY OPEN AT 0.05 SEC.

SYSTEM USED FOR BLOWDOWN PROBLEM

FIGURE B-1

to the atmosphere. The reservoir is initially separated from most of the piping by a closed valve located 20 feet from the reservoir. The reservoir initially contains a two-phase mixture of steam and water at a pressure of 200 psia and a quality of 0.92. The piping downstream of the valve is assumed to contain saturated steam at 5 psia. The atmosphere is also assumed to be at 5 psia.

The piping is taken to be closed off initially by a rupture disk. Both valve and disk are taken to begin opening at the start of the transient (0.0 second), and they are fully open at 0.05 second. The high-pressure differential causes a rapid blowdown and significant forces on the piping segments.

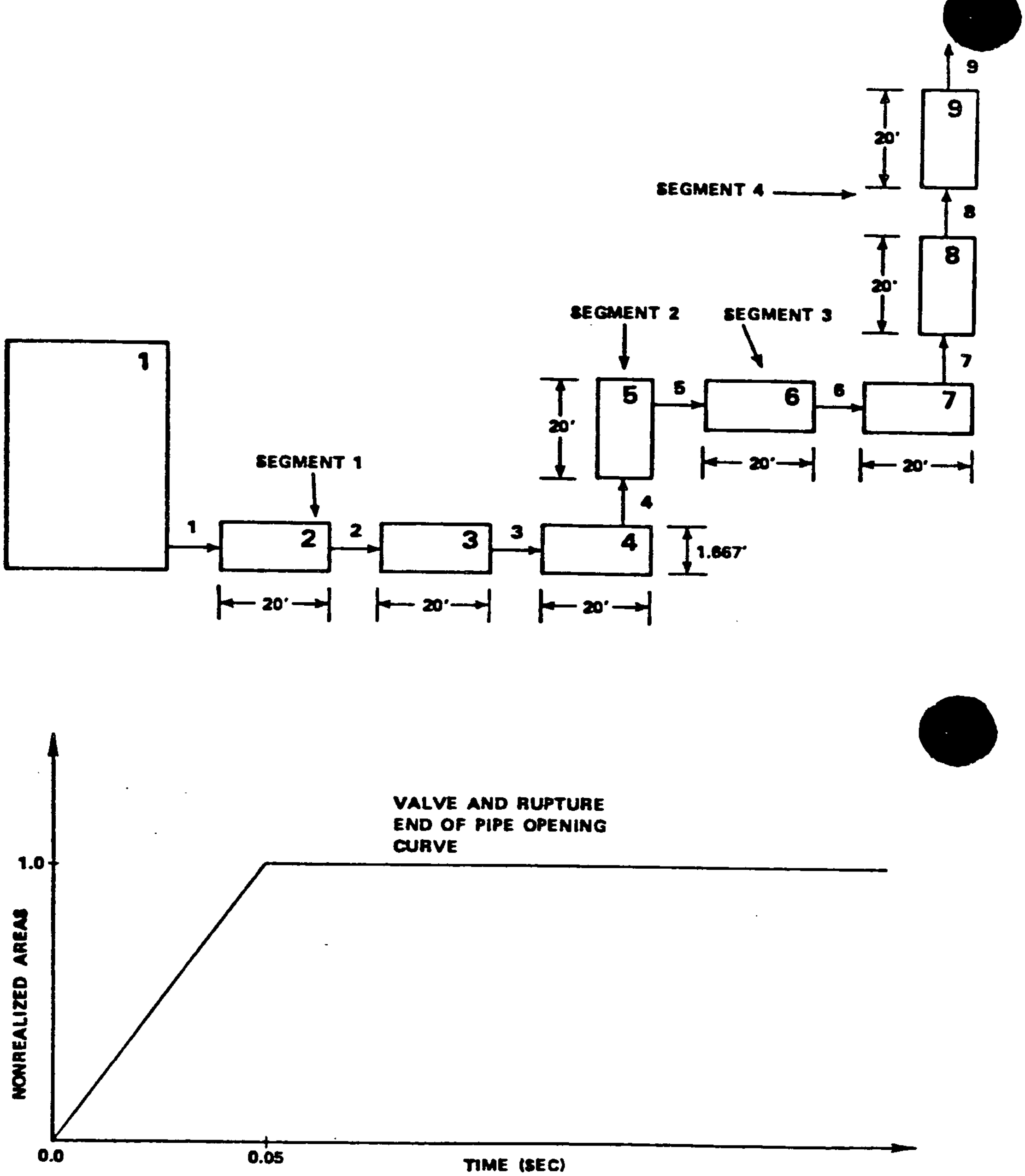
Figure B-13 shows the modeling used for the RELAP4 simulation of the system. Eight volumes were used for the piping and a single volume for the reservoir. The relative velocity between vapor and liquid in the reservoir was taken as 3 ft/sec (obtained by setting bubble rise velocity input at 3 ft/sec). Homogeneous flow is assumed in the piping.

As expected, high wave forces are seen as the fluid accelerates rapidly in the early portion of the transient. This is illustrated by the plots of the time variation in wave force on segments 1 and 2, shown on Figures B-14 and B-15. The forces shortly go to zero on these segments once the fluid has been accelerated. On the last segment, segment 4 (Figure B-16), the loading force remains high because of the blowdown component. It should be noted that on Figures B-14 through B-16 the reaction forces are plotted and hence the negative signs.

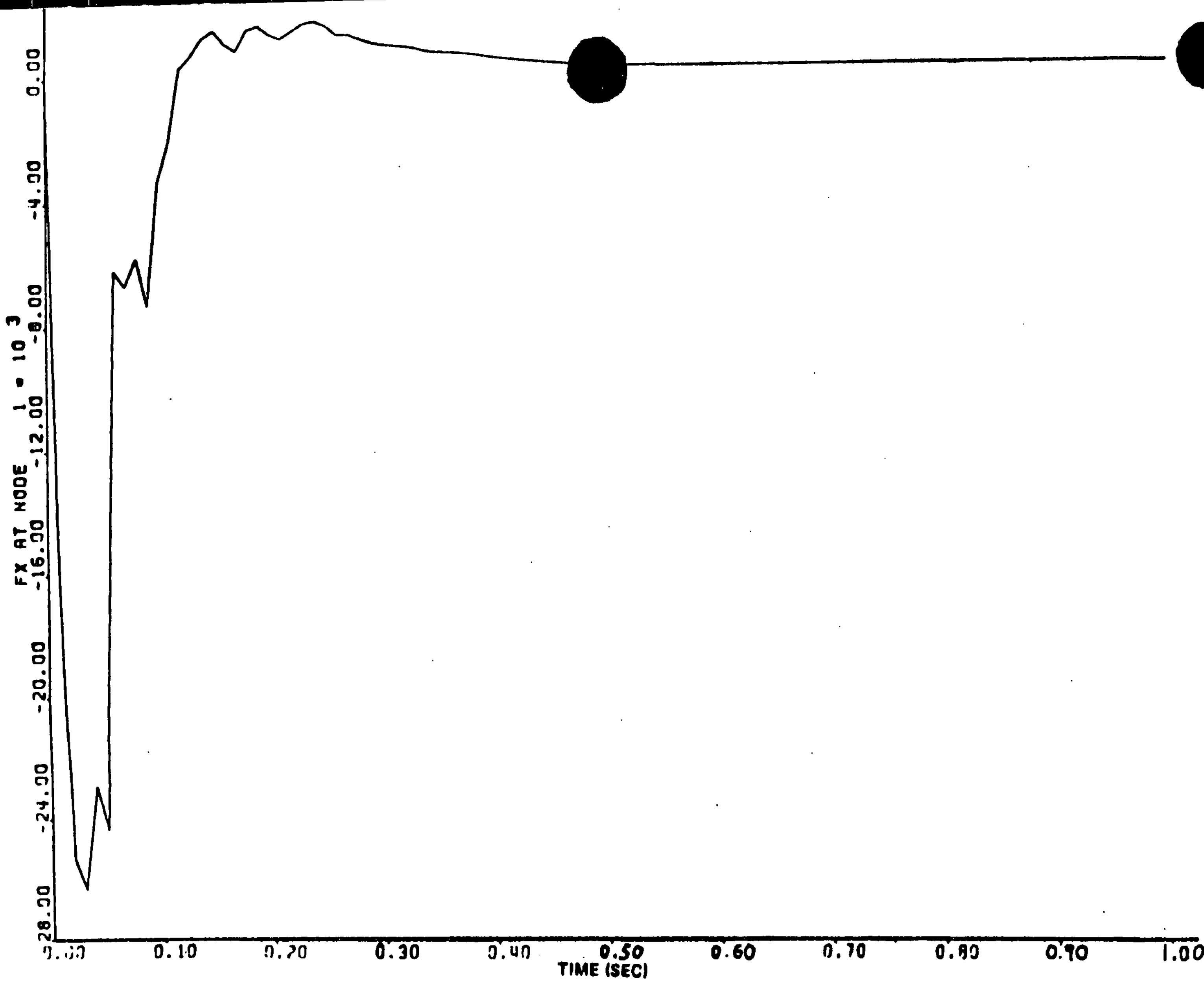
B.4.2 Valve Closing Example

Rapid valve closure in two-phase systems can produce substantial forces on a piping system. To examine RELAP/REPIPE's ability to treat such a situation, the configuration shown on Figure B-17 was used.

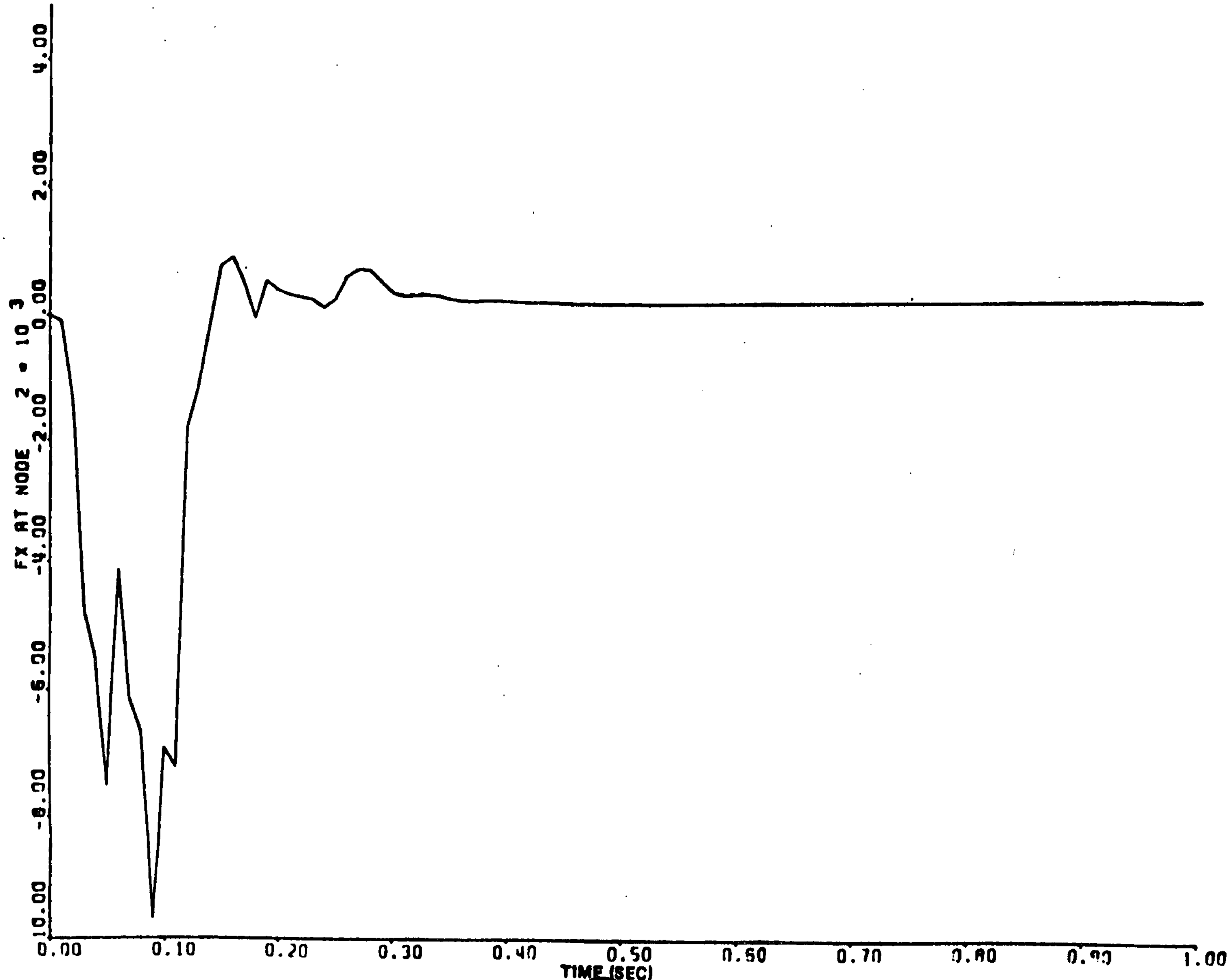
The system used differs from that used for the previous problem only in the addition of a second reservoir at the end of the piping and the changing of the valve location. Again the system is initially assumed to contain a steam-water mixture at a quality of 0.92 with a pressure gradient



RELAP MODELING FO
BLOWDOWN PROBLE
FIGURE B-1

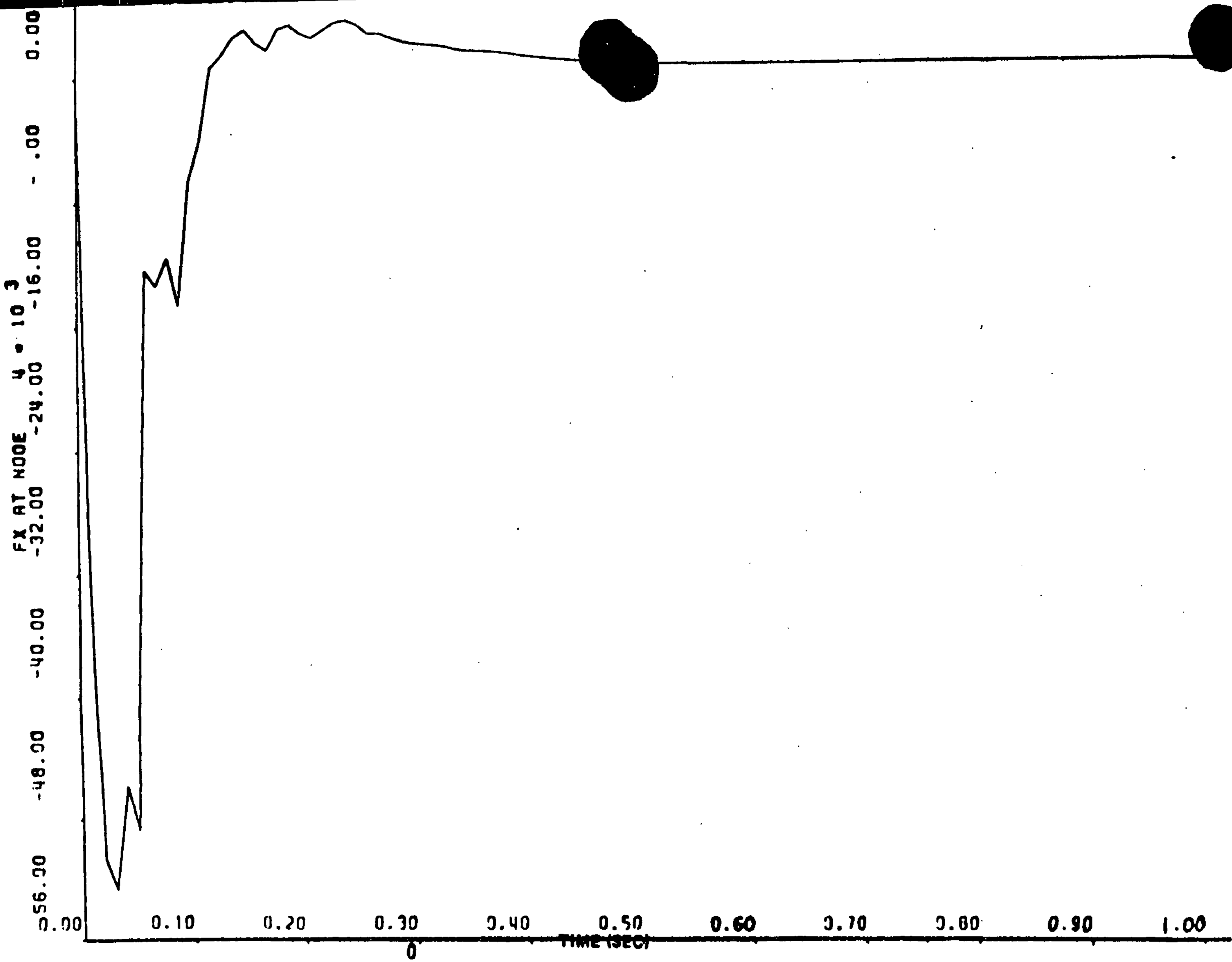


WAVE FORCES ON SEGMENT 1 DURING BLOWDOWN[B-5]
FIGURE B-14



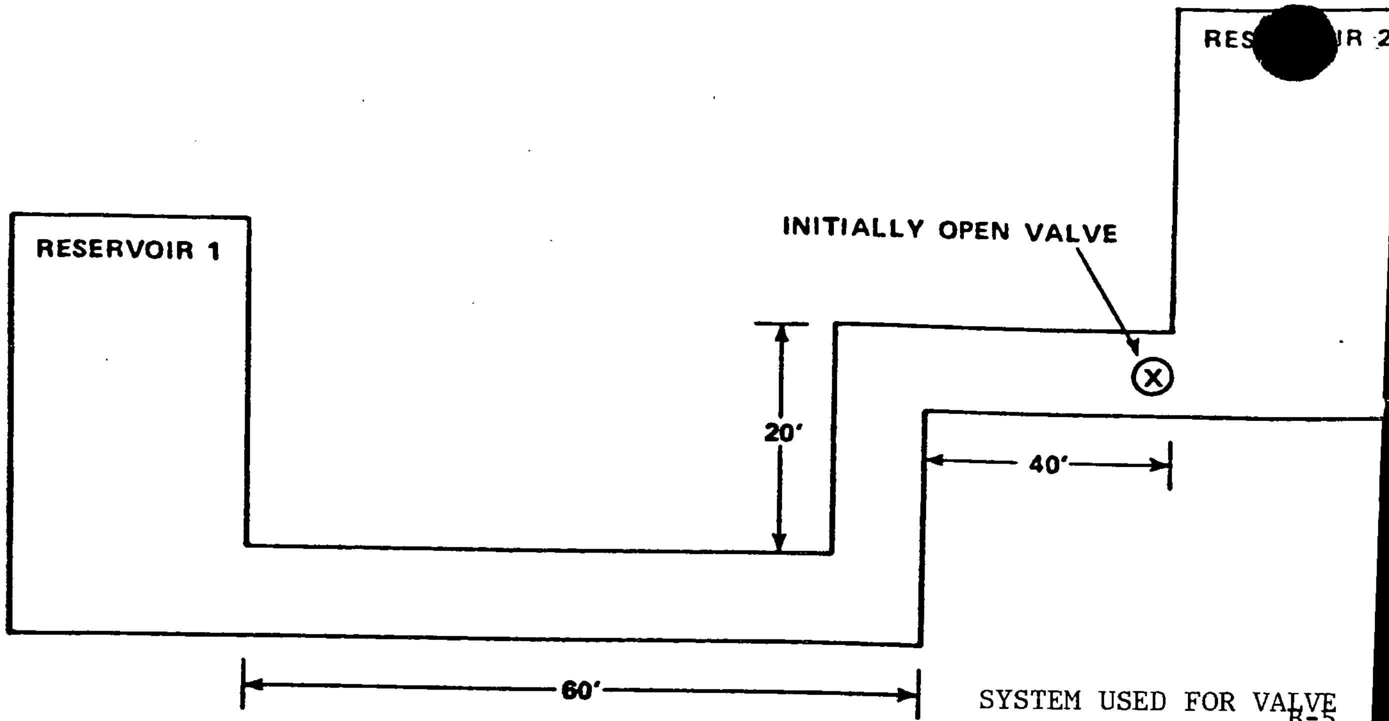
WAVE FORCES ON SEGMENT 2 DURING BLOWDOWN B-5

FIGURE B-15

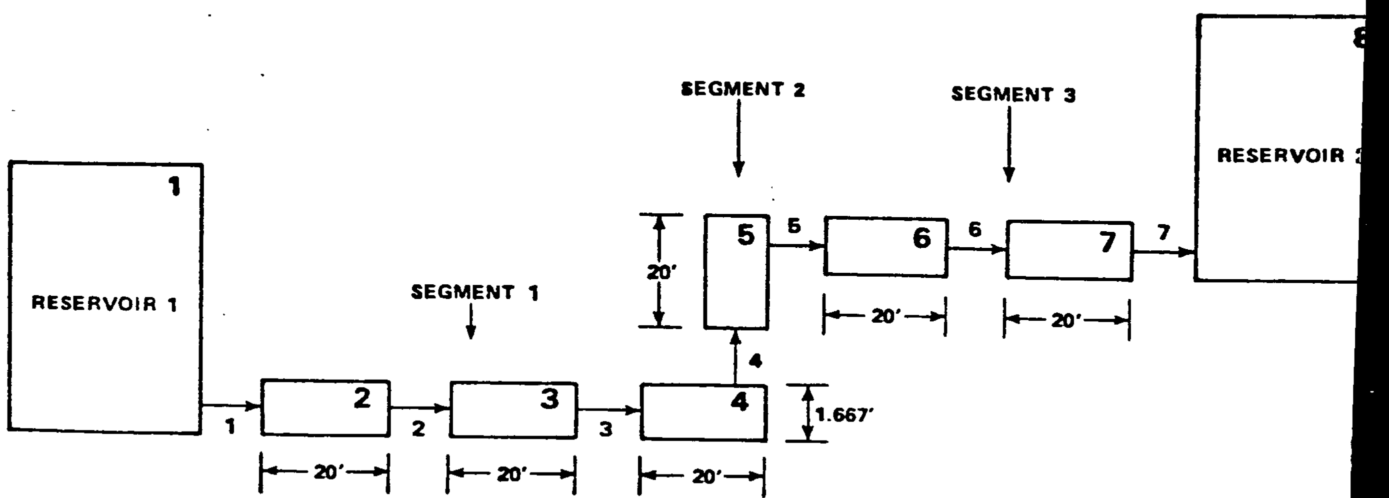


WAVE AND BLOWDOWN FORCES ON SEGMENT 4[B-5]

FIGURE B-16



SYSTEM USED FOR VALVE[B-5]
CLOSURE PROBLEM
FIGURE B-17



RELAP MODELING OF VALV
CLOSURE PROBLEM
FIGURE B-1

so that, prior to the transient, fluid is flowing at the rate of 595.0 lb_m/sec from Reservoir 1 to Reservoir 2. The valve at the entrance to Reservoir 2 is assumed to close instantaneously at 10^{-5} seconds after the transient begins.

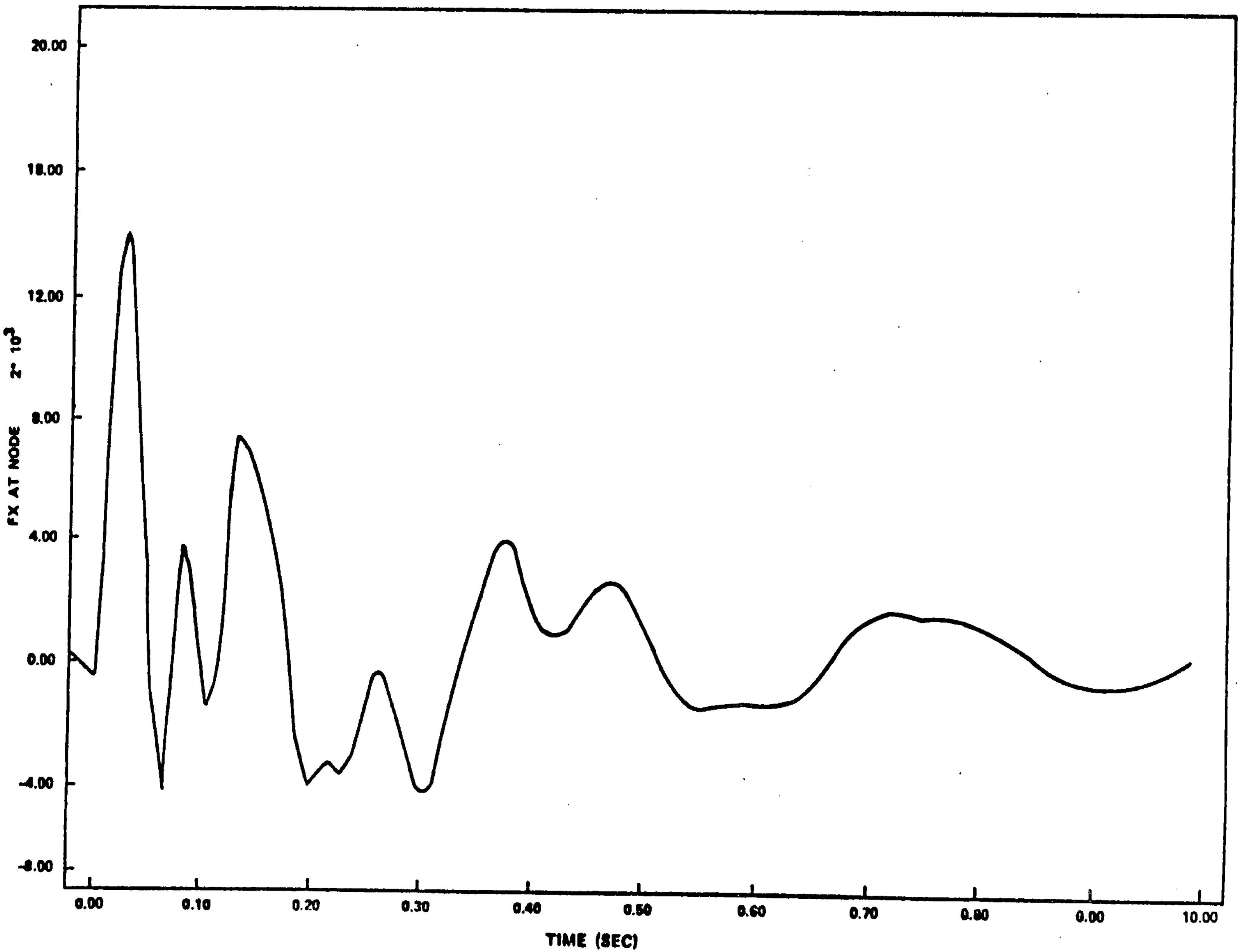
The RELAP4 noding (Figure B-18) used for this problem used two volumes for each of the reservoirs and six volumes for the piping (total of eight volumes). The reservoirs were modeled as time-dependent volumes which allowed constant conditions to be maintained in the reservoirs throughout the problem. The initial pressure distribution in the reservoirs and piping is shown in the table below.

PRESSURE DISTRIBUTION OF TEST CASE 2

Volume	Pressure psia
1	200.0
2	169.0
3	165.0
4	162.0
5	163.0
6	142.0
7	137.0
8	133.0

The time variation in loading in the second piping segment is shown on Figure B-19 and is of the form expected. The oscillatory forces seen are the result of the pressure pulses being reflected through the system. The forces are gradually damped by the usual dissipative mechanisms as the transient continues.

As shown in Section B.4, the RELAP/REPIPE package operated well when used for prediction of system behavior during blowdown across a relief valve and after rapid valve closure in simple piping configurations containing water-steam mixtures. Reference B-9 also presents evaluations using RELAP4/REPIPE in predicting piping forces.[B-9]



LOADING OF SEGMENT 2 DURING TRANSIENT
FOLLOWING VALVE CLOSURE
FIGURE B-19

B.5 BASIC APPROACH AND CODE STRUCTURE FOR FORCE

B.5.1 Introduction

The FORCE post-processor was used in place of REPIPE for the final Kewaunee S/RV piping design calculations. The change was made because of the availability of a larger computer (CRAY) to execute RELAP5 (i.e., REPIPE is executed on the CDC-176 computer and FORCE is executed on the CRAY).

FORCE takes thermal/hydraulics parameters from RELAP4, RELAP5, and TRAC and generates forces in the various node positions in the piping network for input into the ADLPIPE stress analysis computer code.[B10] The data transfer between RELAP, FORCE, and ADLPIPE has been automated, and so is the plotting of the transferred data that are relevant to the physics of the problem.

FORCE first computes the force at every junction. This force is the sum of the pressure force, momentum force and wave force, all of which will be derived in the next section based on the second and third laws of motion. Then the cumulative force at each node is obtained by adding up forces at those junctions that are associated with this node. Since the forces are represented in their global X-, Y-, and Z-components, this addition and any future reference to a particular force component is straightforward.

FORCE allows specification of an "open" ended or a "closed" ended node, in addition to the normal end.

FORCE also allows a reduction of the number of time points to be treated by either cutting it off at a time point less than the total or by specifying a "SKIP" number by which time points are skipped per every force output to ADLPIPE. In the skipping mode, local peaks and valleys in the force-time history are preserved.

So to prepare input for FORCE, one simply goes through each node consecutively, providing the following information.

(1) Type of node--A "bend" or a straight "pipe."

(2) Direction--Along X-, Y-, or Z-axis, or horizontal or vertical angles if 2- or 3-D.

(3) End Type--Normal end (leaving blank), "open" end or "closed" end

(4) Junctions--Numbers of those junctions associated with the node.

For a "bend" the above information is given twice, once for the inlet piping and once for the outlet piping.

The component forces at each node can be plotted by FORPLO--simply type "-FORPLO" and give the node number. FORPLO knows how many component forces each node has and plots them all.

B.5.2 Derivation of Equations for FORCE

B.5.2.1 Second Law of Motion. Consider a body of fluid in a section of pipe as follows.

Total force on fluid = time rate of momentum change of fluid

where,

Total force = force from wall on fluid + pressure force at two ends

and,

Rate of momentum = sum of

(1) Rate of change of momentum inside the section of pipe due to changes in density and velocity, and

(2) Rate of change of momentum due to fluid crossing the end surface

Briefly, we have,

Rate of momentum change = volumetric rate + surface rate.

B.5.2.2 Third Law of Motion. We are interested in the interaction force between the wall and the fluid, which is as follows.

Force from wall on fluid = -pressure force + rate of momentum change

Since action equal to negative reaction,

Force from fluid on wall = -force from wall on fluid

Substituting from above,

Force from fluid on wall = normal pressure force
-volumetric rate of momentum change
-surface rate of momentum change

B.5.3 RELAP Terminology for FORCE

To translate the above physics into computation terms expressible by thermal hydraulics parameters from RELAP4 and RELAP5, such as pressure, flow, specific volume, and time rate change of flow, we have the followi

Pressure force = pressure * area

Since,

Momentum = velocity * mass

Mass = density * area * length

and,

Flow = velocity * density * area

we have,

Momentum = flow * length.

Then it follows that,

Volume rate of momentum change = rate change of flow * length

and,

Surface rate at one end = velocity * mass crossing end per second

or simply,

Surface rate = velocity * flow.

In RELAP terminology,

Surface rate = flow * flow * specific volume/area

.6 COMPUTATIONAL IMPLEMENTATION

The body of fluid is conveniently taken to be that within two adjacent half control volumes surrounding a junction. Because of the directional nature of the forces and the possibility of direction change across the junction, such as in a pipe bend, the force is partitioned at the junction associated with the two adjacent half volumes into two separate forces, one on the inlet side of the junction and another on the outlet side.

Letting positive direction to be that of the flow, then

Inlet force: (all quantities referring to those of inlet)

Force = -pressure x area
-0.5 x length x average rate of flow change
+(sign of flow) x flow x specific vol/area

Outlet force: (all inlet quantities)

Force = -pressure x area
-0.5 x length x average rate of flow change
-(sign of flow) x flow x specific vol/area

with, by linear interpolation,

Average rate of flow change = 0.75 x rate of flow change at t

junction + 0.25 x rate of flow change at the adjacent junction

where

Force is considered to be associated with the junction where pressure flow, and specific volume are given at the volume center. Rate of flow, however, is given at the junction.

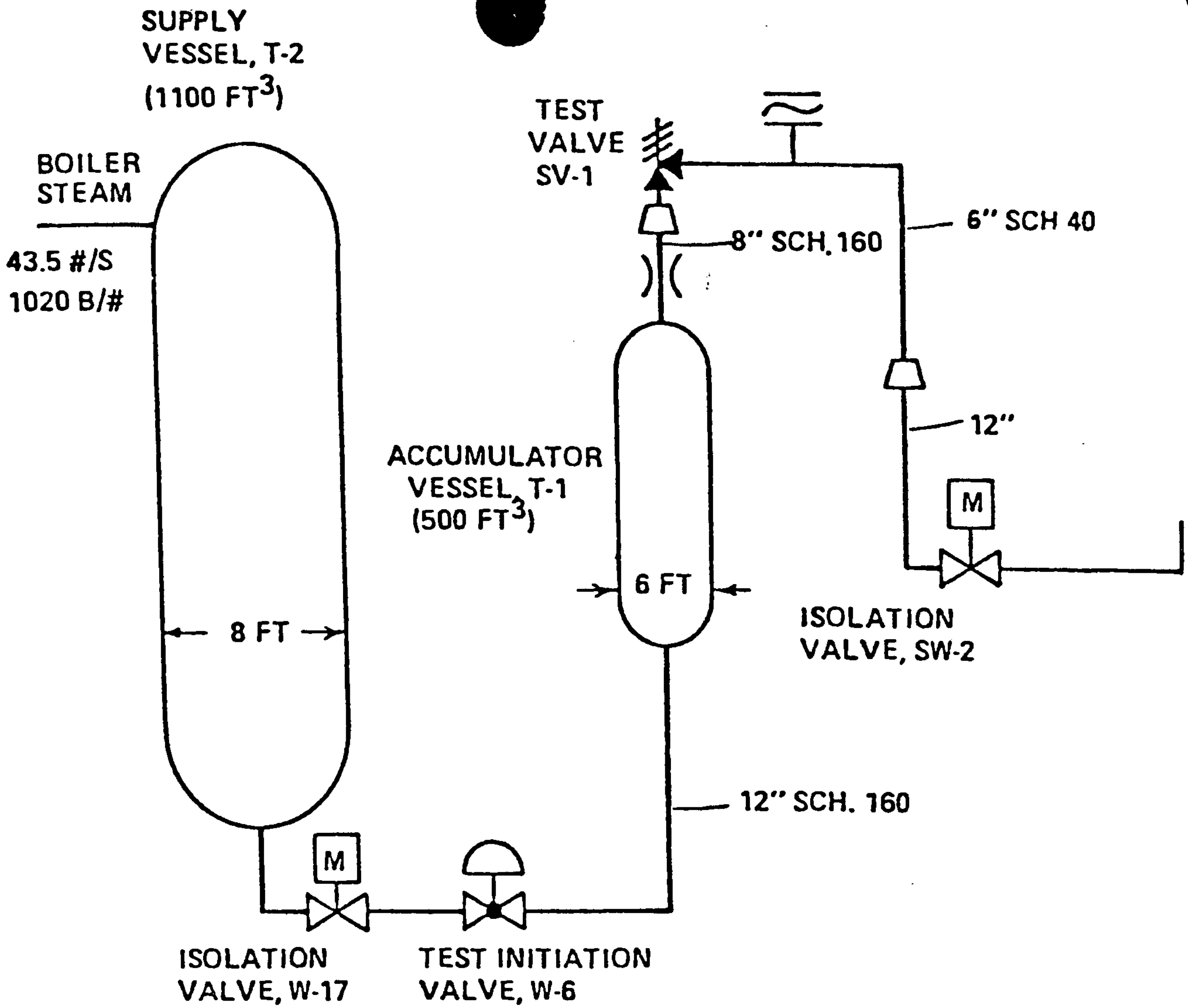
B.7 VERIFICATION OF RELAP5/MOD1 AND FORCE FOR CALCULATION OF SAFETY AND RELIEF VALVE DISCHARGE PIPING HYDRODYNAMIC FORCES

The Boeing Computer Service's (BCS) CRAY Version (3) of RELAP5/MOD1 benchmarked against the CE Test 1411 (steam discharge). Figures B-20 and B-21 show the schematics and nodalization of the CE Test Facility. The calculated pressures are compared with the measured pressures and the computed pressures reported by Intermountain Technologies, Inc. (ITI), an the Electric Power Research Institute (EPRI)[B-11] on Figures B-22, B-23, a B-24. Since the same RELAP5 input decks are used as in Reference B-11, t calculated pressure values are the same.

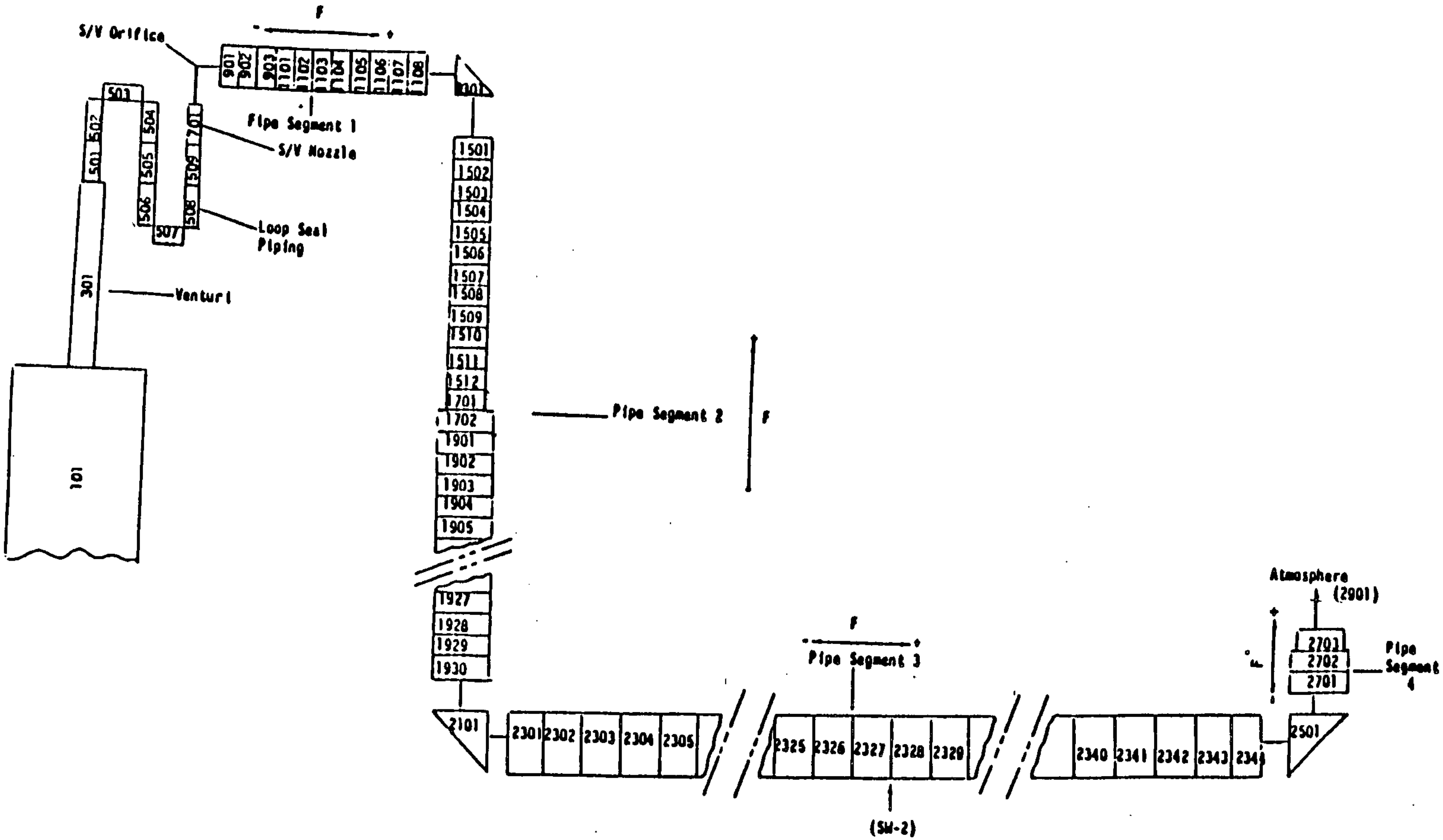
The hydrodynamic forces are calculated by the BCS Program, F . T results of the FORCE calculations are compared with the measured EPRI forces and the ITI calculated forces on Figures B-25, B-26, B-27, and B-2 As can be seen from the comparisons, RELAP5/FORCE code combination did we in predicting thermal/hydraulic loading.

B.8 ABILITY OF RELAP5/REPIPE TO MODEL SAFETY VALVE TRANSIENT

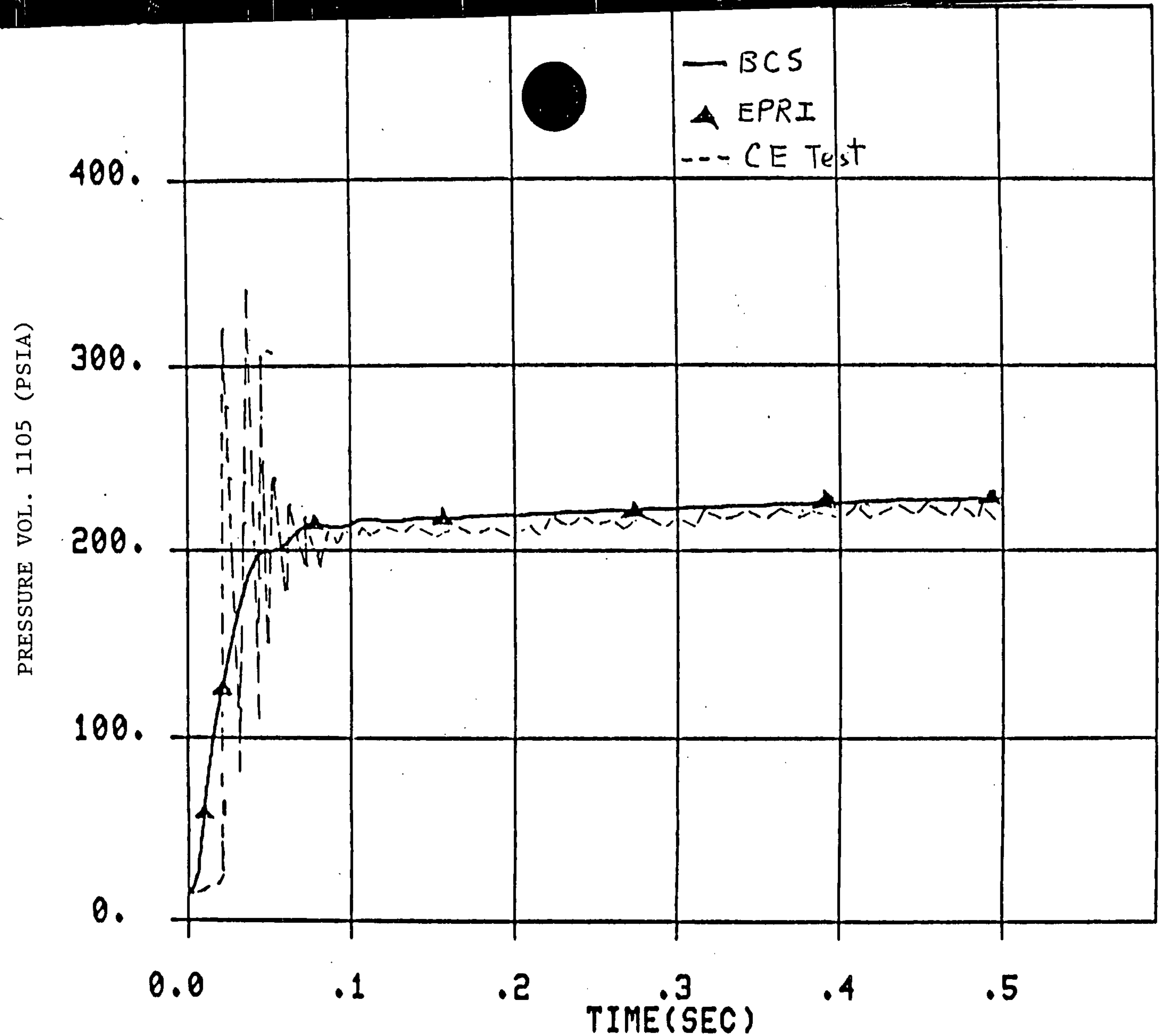
The ability of REPIPE in conjunction with RELAP4 has been demonstra in the previous subsections. The ability of REPIPE in conjunction with RELAP5 to predict results from the Combustion Engineering test facility shown in Section 6.0 of Reference B-12. With these comparisons it can b concluded that REPIPE is a viable post-processor of thermal/hydraulic calculations from either RELAP4 or RELAP5. Since the RELAP5/REPIPE calc lations were compared to RELAP5/FORCE calculations, producing almost ide tical results, the RELAP5/FORCE calculations of the CE 908 test simulati would be the same as presented in Section 6.0 of Reference B-12.



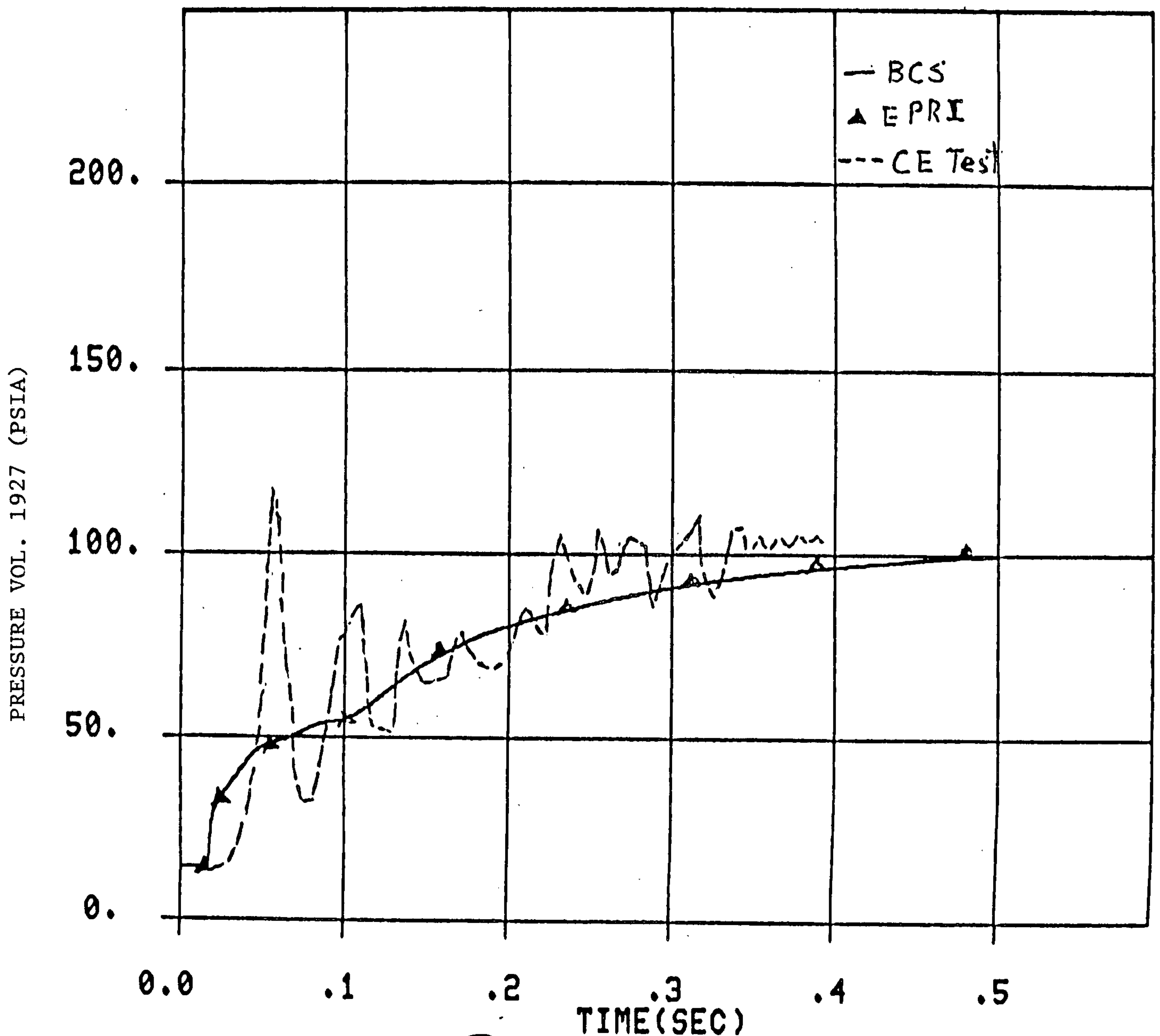
SCHEMATIC OF THE CE TEST FACILITY
FIGURE B-20



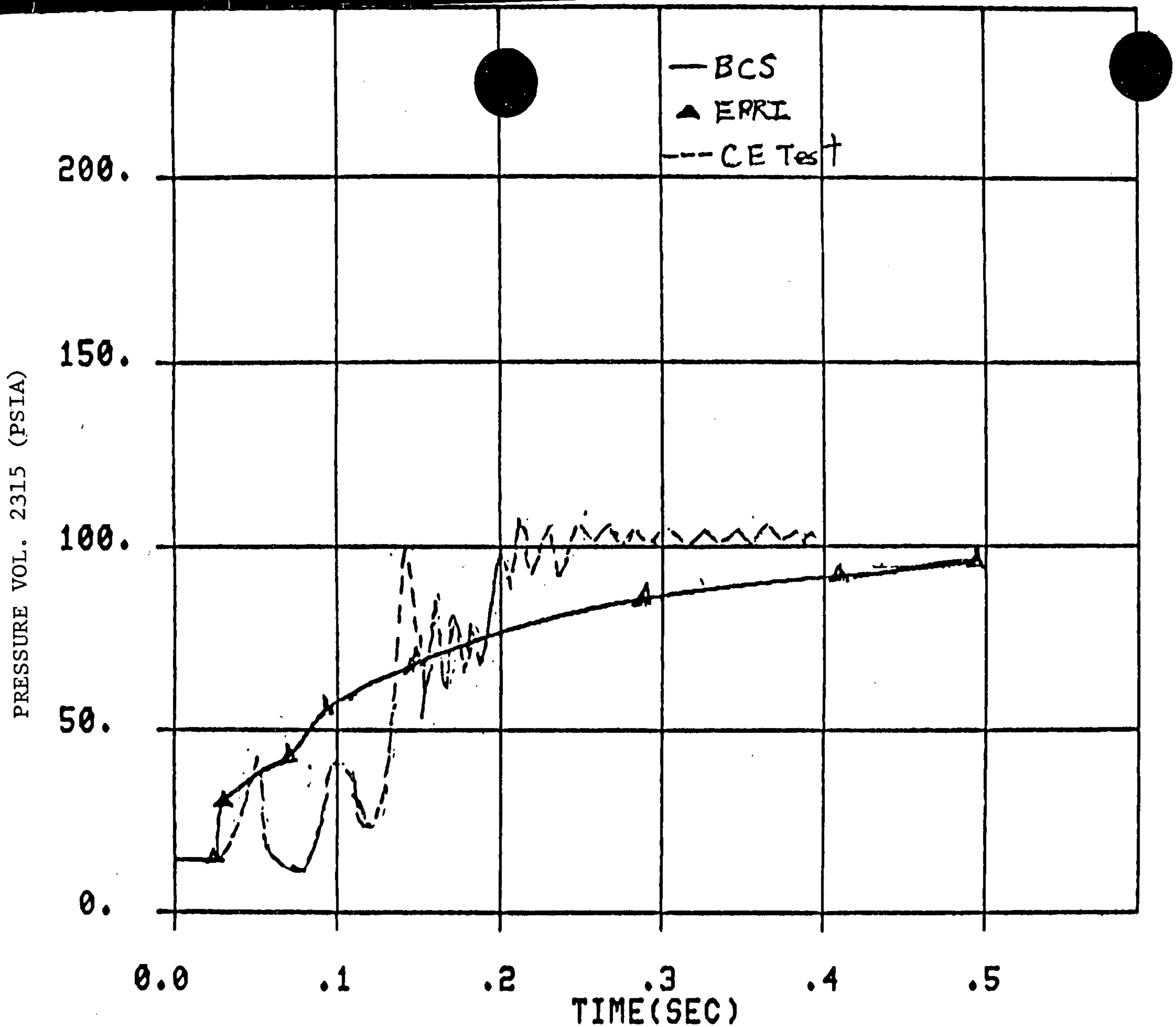
NODALIZATION DIAGRAM OF THE
RELAP5/MOD1 INPUT MODEL
FIGURE B-21



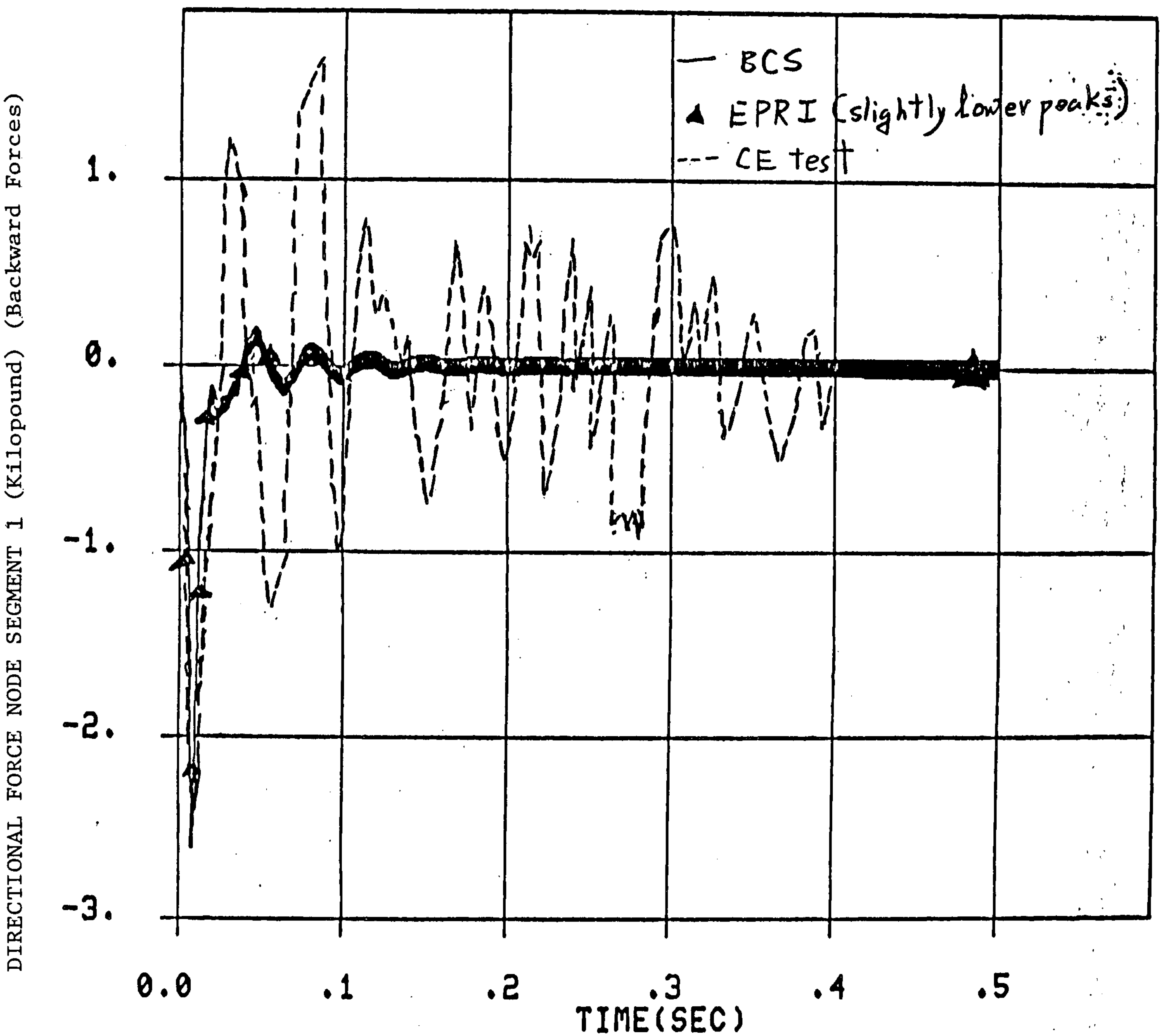
CE STEAM TEST 1411 VERSUS
RELAP5/MOD1 CYCLE 14 CALCULATION
FIGURE B-22



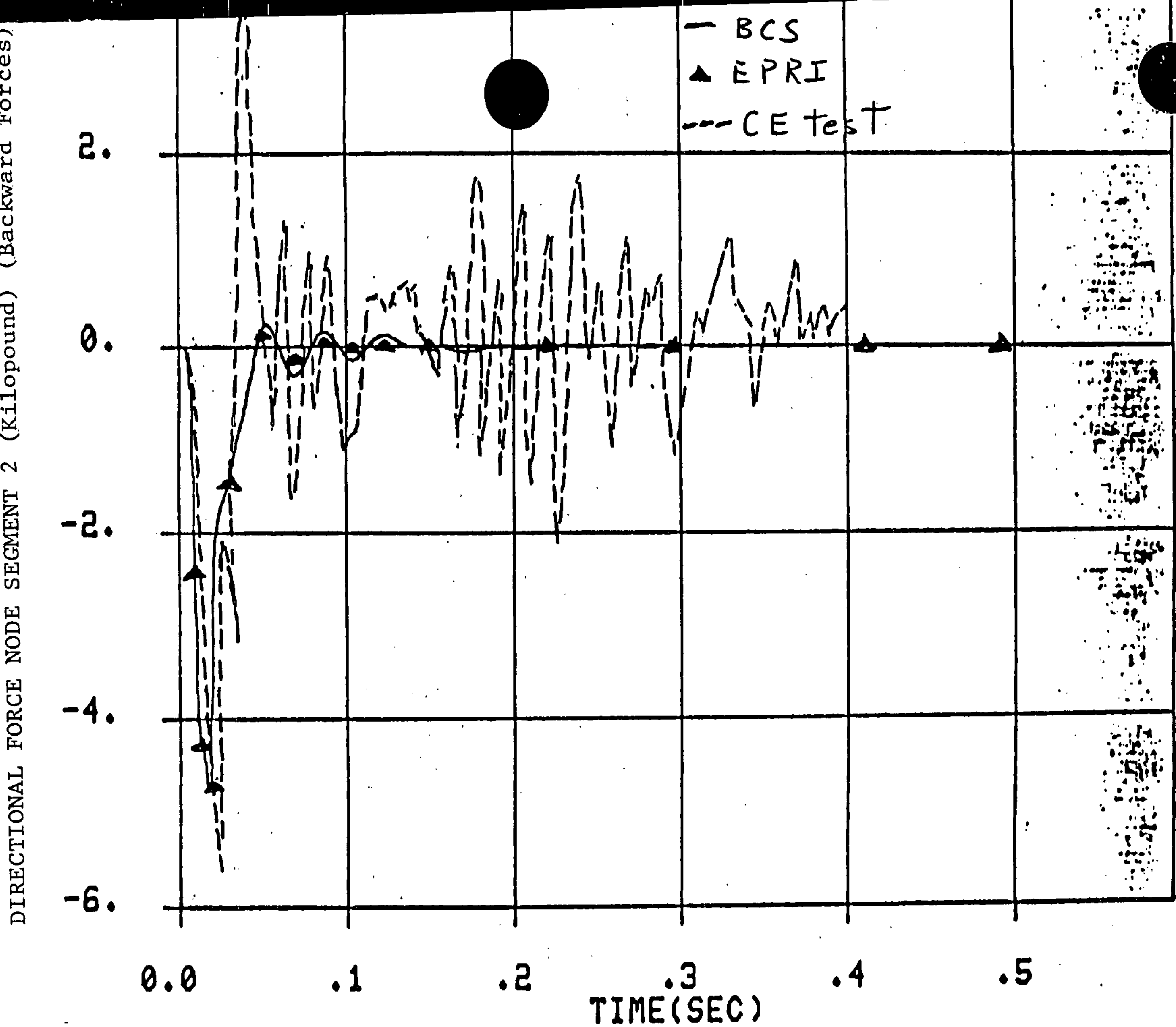
CE STEAM TEST 1411 VERSUS
RELAP5/MOD1 CYCLE 14 CALCULATION



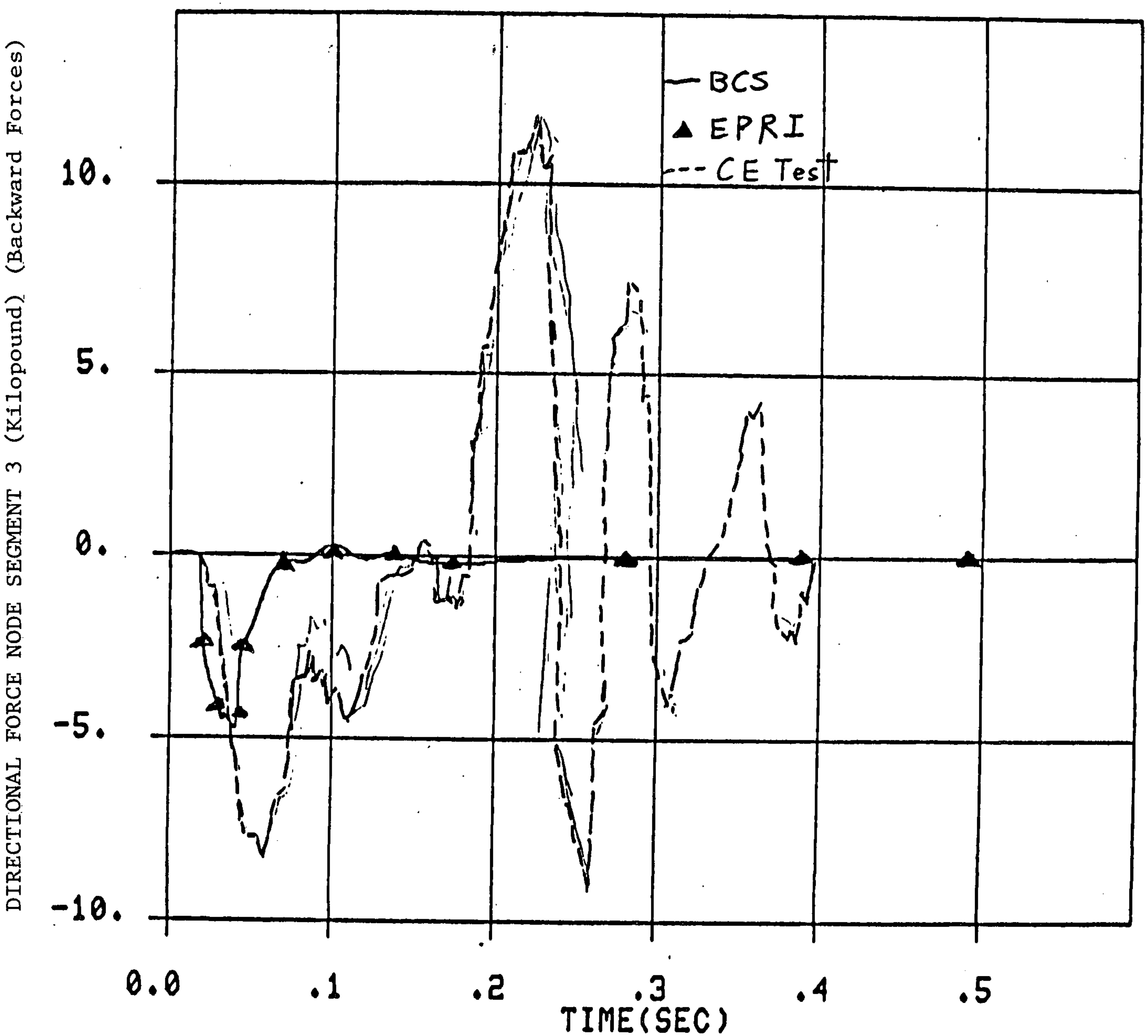
CE STEAM TEST 1411 VERSUS
RELAP5/MOD1 CYCLE 14 CALCULATION
FIGURE B-24



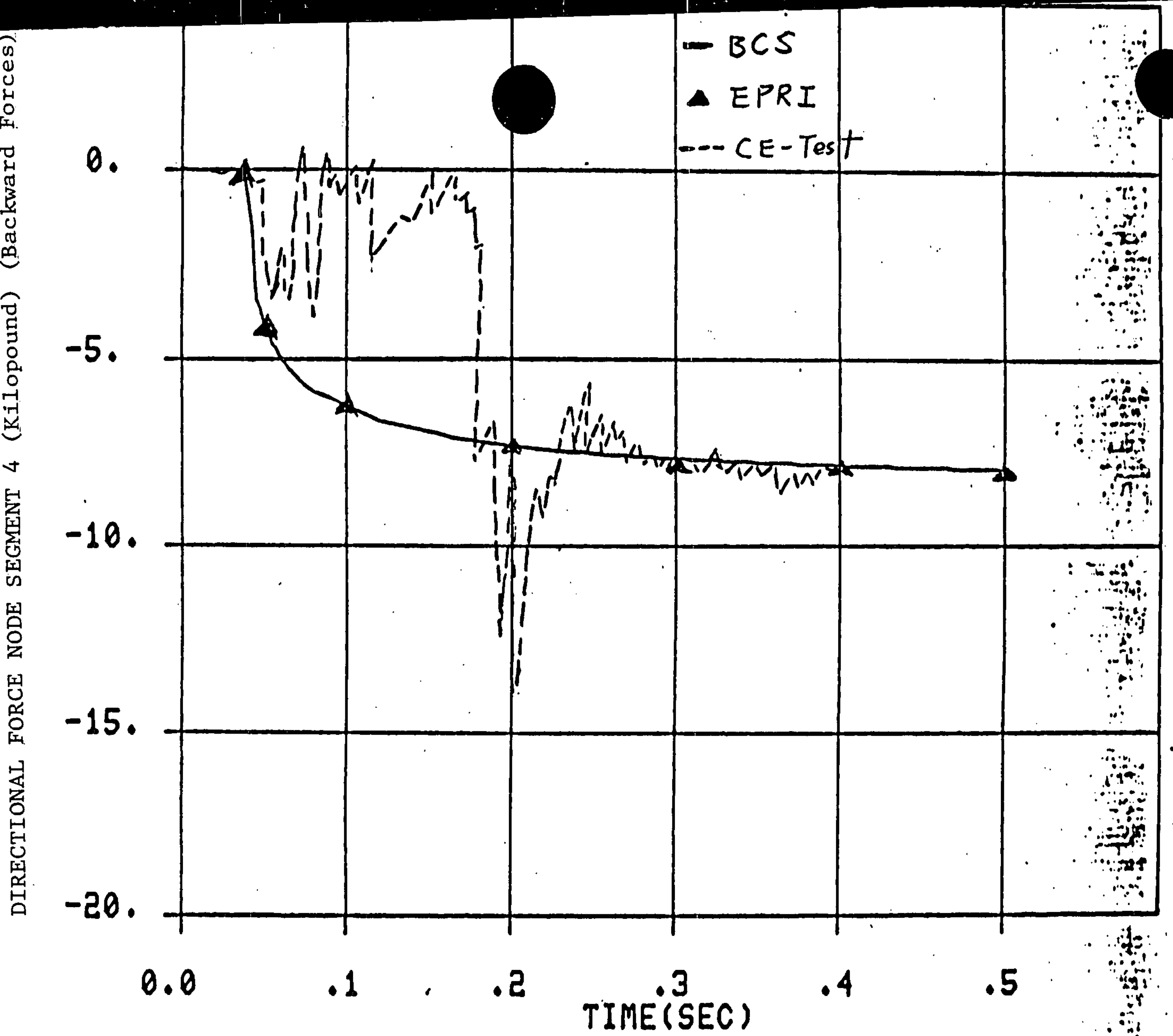
CE STEAM TEST 1411 VERSUS
RELAP5/MOD1 CYCLE 14 CALCULATIONS
(FORCE SEGMENT 1)
FIGURE B-25



CE STEAM TEST 1411 VERSUS
RELAP5/MOD1 CYCLE 14 CALCULATIONS
(FORCE SEGMENT 2)
FIGURE B-26



CE STEAM TEST 1411 VERSUS
RELAP5/MOD1 CYCLE 14 CALCULATIONS
(FORCE SEGMENT 3)
FIGURE B-27



CE STEAM TEST 1411 VERSUS
RELAP5/MOD1 CYCLE 14 CALCULATIONS
(FORCE SEGMENT 4)
FIGURE B-28

B.9 REFERENCES

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B-11. R. K. House (ITI) and A. J. Wheeler (EPRI), "Evaluation of RELAP5/MOD1 for Calculation of Safety and Relief Valve Disch Piping Hydrodynamic Loads," Intermountain Technology, Inc. a Electric Power Research Institute, February 1982.

B-12. Kewaunee Nuclear Power Plant Safety and Relief Valves Piping Qualification Report, Revision 0, June 28, 1982.

APPENDIX C

TAC2D PROGRAM DESCRIPTION

APPENDIX C
TAC2D PROGRAM DESCRIPTION

C.1 GENERAL DESCRIPTION

TAC2D is a code for calculating steady-state and transient temperatures in two-dimensional problems by the finite difference method. It is written entirely in Fortran V. The configuration of the body to be analyzed is described in the rectangular, cylindrical, or circular (polar) coordinate system by orthogonal lines of constant coordinate called grid lines. The grid lines specify an array of nodal elements. Nodal points are defined as lying midway between the bounding grid lines of these elements. A finite difference equation is formulated for each nodal point in terms of its capacitance, heat generation, and heat flow paths to neighboring nodal points. A system of these equations is solved by an implicit method. More concerning the numerical technique is presented in Reference C-1.

Some advantages of the code are as follows.

(1) The geometrical input is simple.

(2) The input of thermal parameters is by Fortran V arithmetic statement functions. Many of the calculation variables (time, local temperature, local position, etc.) are available for use in these functions.

(3) Internal and external flowing coolants may be used.

(4) There may be internal and external thermal radiation.

(5) There is a wide selection of optional output.

The principal limitations of the code are as follows.

(1) The grid line system must be orthogonal in the rectangular, cylindrical, or circular coordinate system. Therefore, the sides of the nodal elements must also be orthogonal. The entire problem must be bounded by four grid lines in one of the coordinate systems. Difficulties in treating irregular boundaries can be overcome to some extent through the use of materials having specially chosen properties.

(2) All radiation is treated one-dimensionally.

(3) There are no provisions for thermal expansion or change of phase. Such special heat transfer situations could be included by extensions of the existing programming.

TAC2D has been assigned operational status. The machine requirement is a 65K Univac 1108, or equivalent. In addition to input-output, a maximum of four and a minimum of no tapes are required depending upon the code options being used.

C.2 BASIC CODE STRUCTURE

The digital computer code TAC2D* was developed at Gulf General Atomi for obtaining temperature solutions in the wide variety of two-dimensiona thermal systems which are encountered in the field of nuclear engineering Code calculations are governed by the heat conduction equation:

$$\nabla \cdot k\nabla T + q''' = \frac{\partial}{\partial t} \rho c T$$

where

k = thermal conductivity, Btu/h-ft-F

T = local temperature, F

q''' = volumetric heat generation rate, Btu/h-ft^3

ρ = density, lb/ft^3

c = specific heat, Btu/lb-F, and

t = time, h.

This equation is replaced by an equivalent set of linear finite differenc equations, which is solved for the local temperatures at given points in time by the implicit numerical method.[C-1] Steady-state results are founc by extending a transient calculation to the limit where thermal equilibri is attained. An option is available for performing this pseudo-transient calculation as efficiently as possible. If it is used, specific heats a time increments are determined as a part of the calculation rather than being given as input. In the finite difference equations, the local val of k may be an effective overall thermal conductivity which includes the effects of convection and/or radiation.

*The acronym TAC2D stands for "Thermal Analysis Code - Two-Dimensio

The problem must be modeled within the geometry envelopes of one of the three coordinate systems shown in Figure C-1. The choice depends upon whether it is best described as a rectangle, a polar rectangle, or a cylinder. The code includes provision for both internal and external coolants. Use of internal coolants is optional but coolants flowing on the four outer surfaces must always be included to describe boundary conditions by assigning appropriate values to the coolant thermal parameters. There is provision for internal thermal radiation but its treatment is one-dimensional.

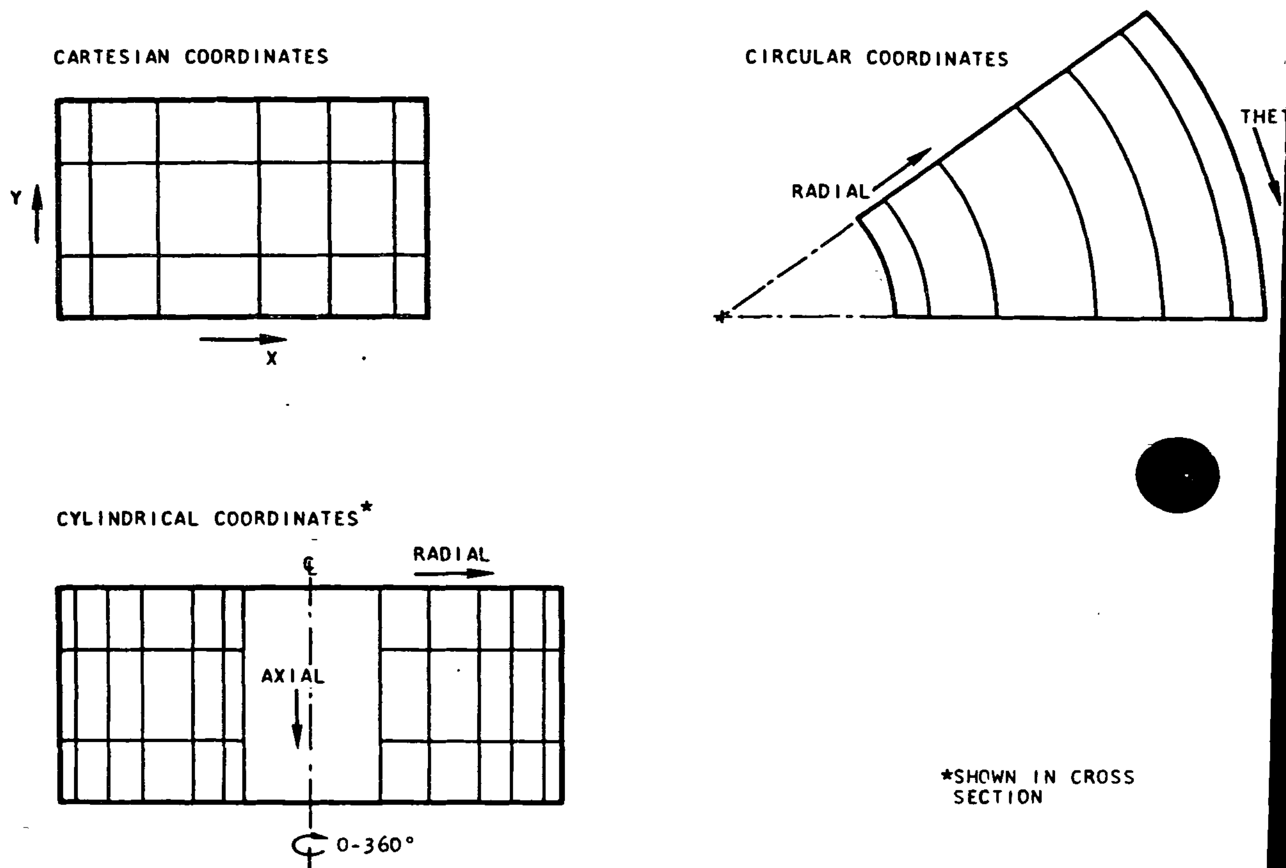
The purpose of this Appendix is to describe TAC2D. The mathematical formulations used and a programmer's description of the code are given in Reference C-2.

TAC2D is actually one of two generalized heat transfer codes which have been developed at Gulf General Atomic.

A code was needed which could be easily used by persons not familiar with computer science. Toward this end, care was taken to keep all input and output within the scope of engineering terminology. Also, a system of input checking and easily interpreted error messages was included. As a final step, the user's manual was prepared to provide a comprehensive guide to code application and input. The result of the above provisions is that TAC2D is a "black box" type of code in which the user should be detached from programming and computer system aspects of the problem solution.

The features most desired in codes such as TAC2D are generality, simplicity of input, and economy of computer time. Generality can usually be increased only by partially sacrificing the latter two features. TAC2D was formulated under the basic philosophy of obtaining a trade-off among all three features which would be an optimum for economical solution of thermal problems typically encountered in the nuclear field.

General purpose heat transfer codes are usually developed in terms of a network of points connected by thermal resistances. In most codes, the arrangement of these points may be purely arbitrary. A high degree of generality is obtained at the expense of input simplicity since a separate set of data must usually be supplied for each point. If, on the other hand, it is chosen to confine the problem within the geometry envelope of one of the



COORDINATE SYSTEMS FOR TAC2
FIGURE C-

three coordinated systems shown in Figure C-1, the input complexity may be greatly reduced. The entire geometry and subdivision can be defined by giving the coordinates of constant coordinate lines, or grid lines, such as those illustrated in the figure. If the points are defined as lying midway between adjacent grid lines, then a region of points can be established by giving the four bounding grid lines of that region. Other input data such as those required to specify the resistances can be given in condensed form by referring to these regions rather than to the individual points which they contain. The above approach was used because experience indicated that a majority of the two-dimensional thermal systems for which temperature calculations were performed could be modeled within one of the geometry envelopes shown in Figure C-1. Furthermore, the computational algorithm applied in the solution for the point temperatures is the most efficient known and could not have been used had complete generality been maintained in the arrangement of the points.

Some of the definitions and instructions[C-2] are presented in terms of Cartesian coordinates (Figure C-1) only. These may be translated to the other two systems by means of the following correspondences.

Circular coordinates

x = radial; y = theta

Cylindrical coordinates

x = radial; y = axial

C.3 VERIFICATION METHOD USED ON TAC2D

TAC2D is operational on Black & Veatch's Univac system and is designated as M01. Three test cases were run and compared to established results in several forms and from three sources. All results are contained in the M01 program manual and the M01 verification binders stored in the Black & Veatch computer group.

Test Case 1 was a right circular cylinder subject to convection and conduction. This was checked against analytical results[C-3] and was found to be in agreement.

Test Case 2 was a very complex HTGR blower impeller analysis [illegible] at Gulf General Atomic who originated TAC2D. The results were checke[illegible]ains the results obtained by Gulf General Atomic and given in the M01 User's Manual.

Test Case 3 was a rectangular slab subject to conduction and convecti with a normal coolant. The results were checked against both analytical results as well as the published results given in the TAC2D Verification Manual published by the Gulf General Atomic[C-4] under the heading of Bench-mark Problem 7.

All cases compared satisfactorily within 5 per cent or less of the theoretical or previously calculated results.

C.4 REFERENCES

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C-4. S. M. Morcos, and K. A. Williams, "Code Verification and Benc mark Problems," Part C, GA-A13415, June 1975.

APPENDIX D
ADLPIPE PROGRAM DESCRIPTION

APPENDIX D
ADLPIPE PROGRAM DESCRIPTION

D.1 BASIC APPROACH AND DESCRIPTION

ADLPIPE is a piping stress evaluation computer code developed by Arthur D. Little, Inc. This program uses the transfer matrix approach to analyze the flexibility of multiple branch and closed loop piping systems subject to thermal, uniform, and concentrated loadings, both static and dynamic. Dynamic response is obtained by the modal superposition method. All calculations are in accordance with the requirements of ANSI B31.1 Power Piping Code and the ASME Section III Boiler and Pressure Vessel Code.

The piping system may contain translational elastic (spring and solid hangers), torsional elastic (weak spring), and constant effort (loadings) restraints, flexible anchors (gimbals), flexible joints (sleeves), bellows expansion joints, components (valves), internal pressure, insulation and shielding on the system, arbitrary section beams, rigid body elements, and mitered elbows.

The input consists of geometry, physical properties, and loads required. Dynamic loads are input in the form of a response spectra, time history of forces in tabular form, or time-dependent forces as polynomial or trigonometric functions. The input of network point coordinates and straight member projections can be plotted.

Output for the structural options consist of the system geometry, forces and moments in the global coordinate system, rotations, translations, and attendant stresses for every element in the piping system. The program has the capability for storing results of various loading conditions on files to be combined in a subsequent run into the equations provided in the codes.

The version of ADLPIPE used for the piping analysis is version D. The analysis was run on the Babcock & Wilcox CDC-7600 computer facility at Lynchburg, Virginia.

D.2 ADLPIPE VERIFICATION

ADLPIPE version D is verified to ANSI B31.1 Power Piping Code and ASM Section III Boiler and Pressure Vessel Code. The program has been verifie by Arthur D. Little, Inc., with the following checks.

(1) All piping and non-piping members have been checked for correct intensification factors and stress indices application.

(2) The determination of moments, forces, deflections, and rotations has been checked against known results.

(3) All code equation solutions and summaries for ANSI B31.1 and ASME III have been checked.

In addition, Black & Veatch has performed the following verification of ADLPIPE version D.

(1) The formation of a stiffness matrix and resultant moments and forces were checked and compared to hand generated calculations

(2) The correct input and usage of enforced displacements were compared to hand generated results.

(3) The thermal deflections in all coordinate directions were compa to hand generated results.

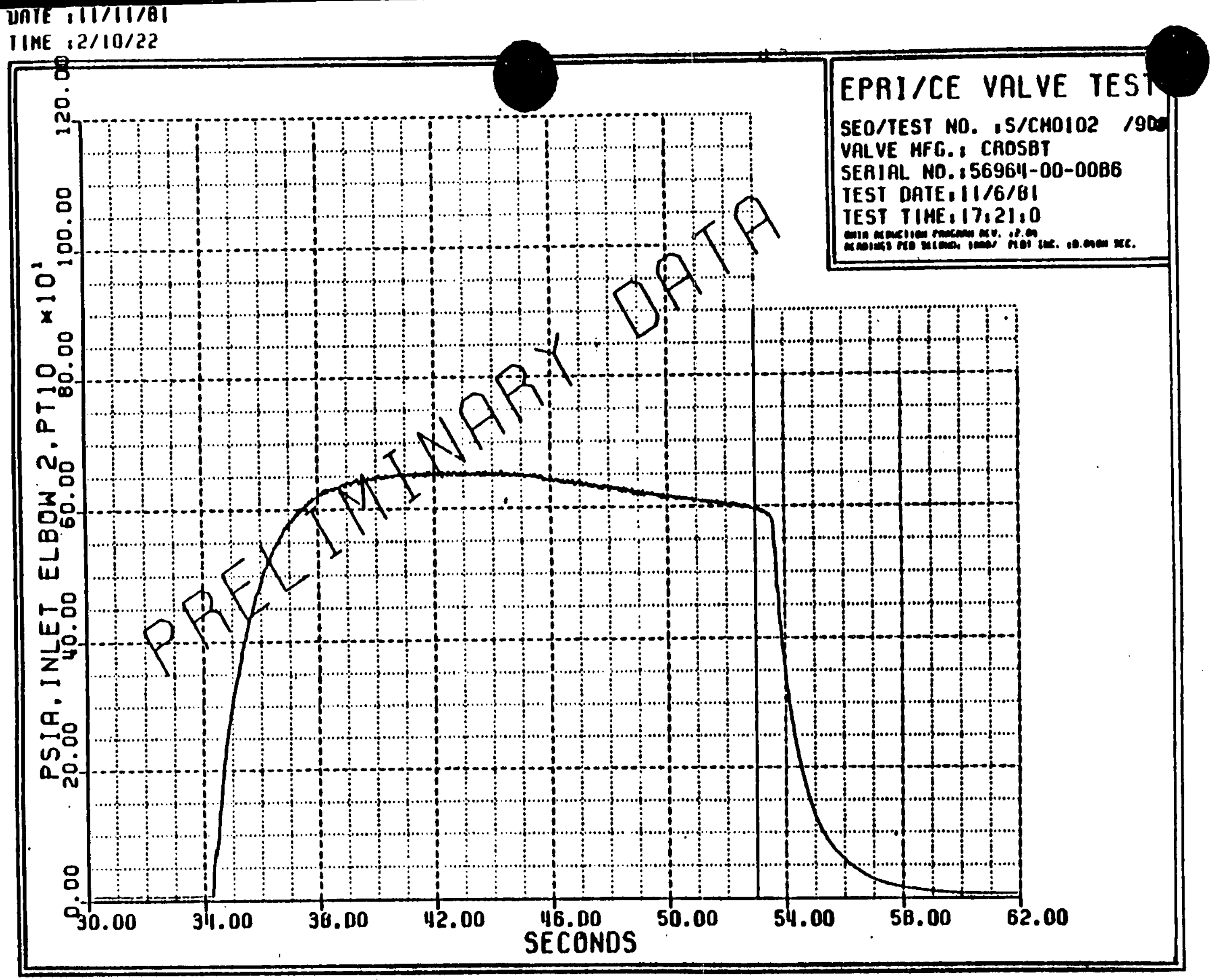
(4) The application of stress intensification factors and code equation stress were verified against ANSI B31.1 criteria.

(5) The dynamic modal summation technique was checked against Nucle Regulatory Guide 1.92.

(6) The dynamic analysis, including calculation of natural frequenc mode shapes, modal deflections, and moments, was verified agair a public domain computer program.

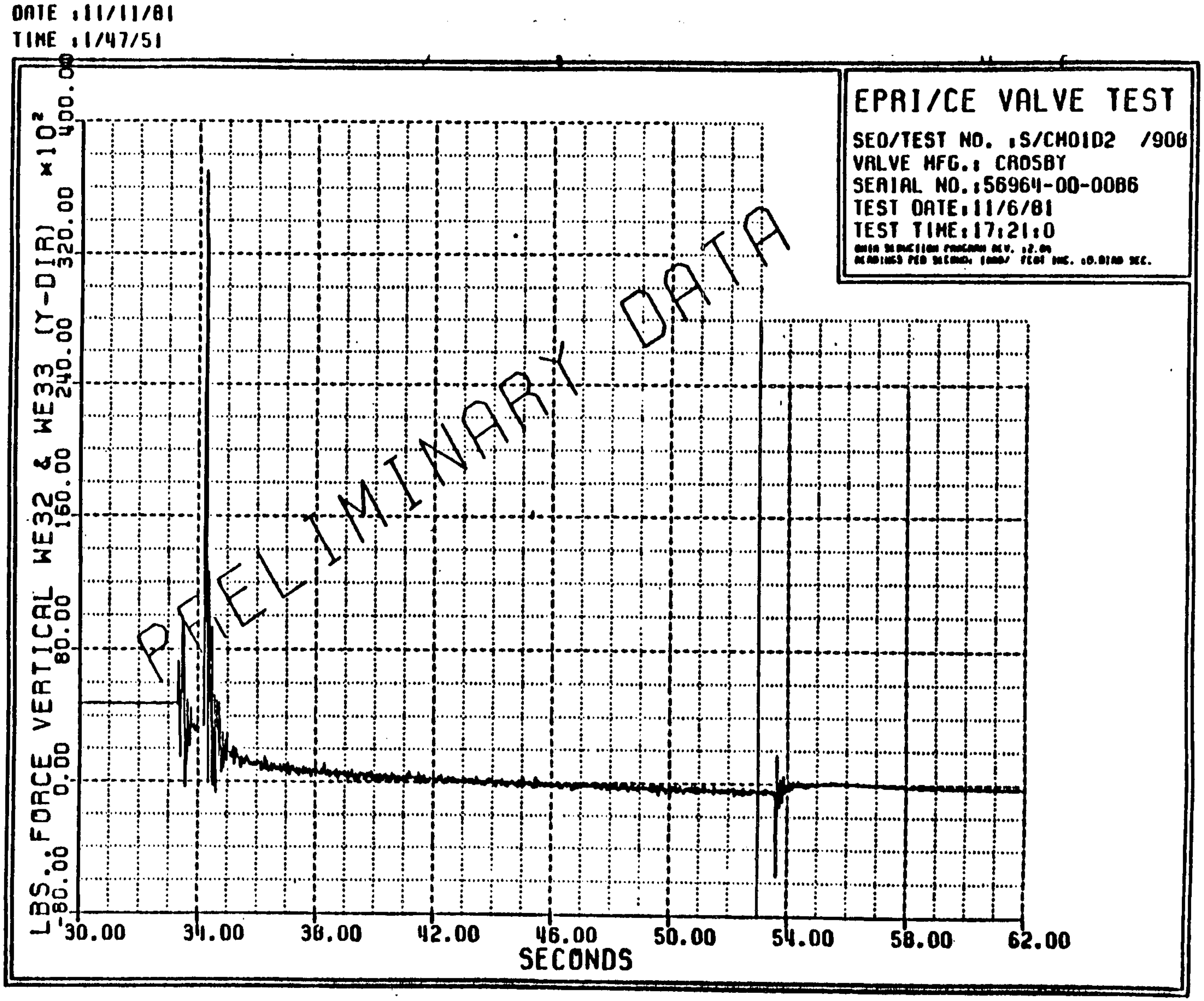
(7) The dynamic time history and seismic analysis load summary meth ology has been checked against hand generated results.

APPENDIX E
EXPERIMENTAL RESULTS FOR CE TEST 908



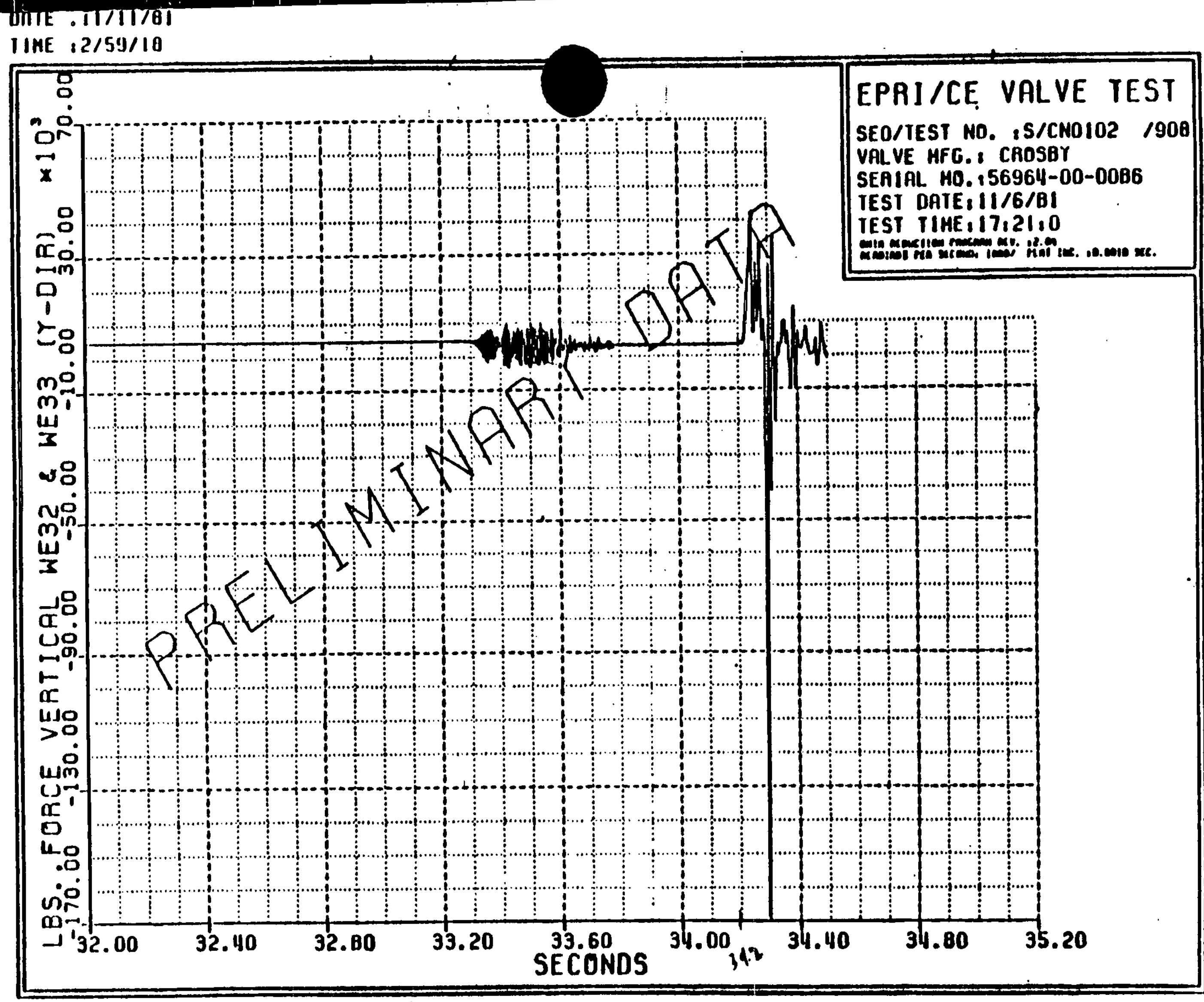
Source: Letter from Bernard Sano, EPRI Project Manager to Utility Technical and Licensing Contracts, Subject: Disseminative data for the Crosby 6M6 Safety Valve tested by EPRI at Combustion Engineering, January 12, 1982

PRESSURE IN VERTICAL DISCHARGE RUN AT P10, TEST 908
FIGURE E-1



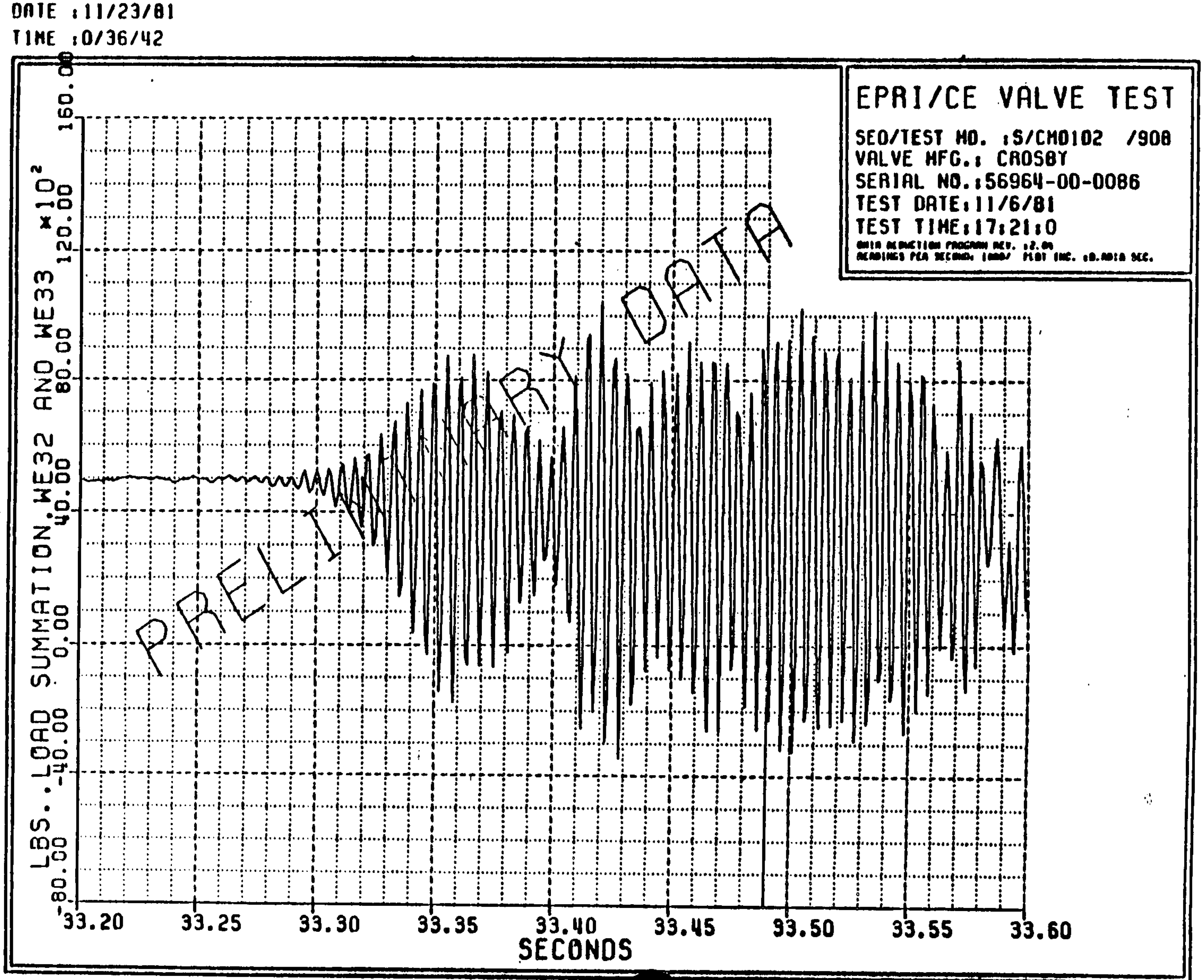
Source: Letter from Bernard Sano, EPRI Project Manager to Utility Technical and Licensing Contracts, Subject: Disseminative data for the Crosby 6M6 Safety Valve tested by EPRI at Combustion Engineering, Jan[illegible] 12, 1982

VERTICAL LOAD AT END OF FIRST VERTICAL DISCHARGE PIPE AT W32 AND W33, TEST 908

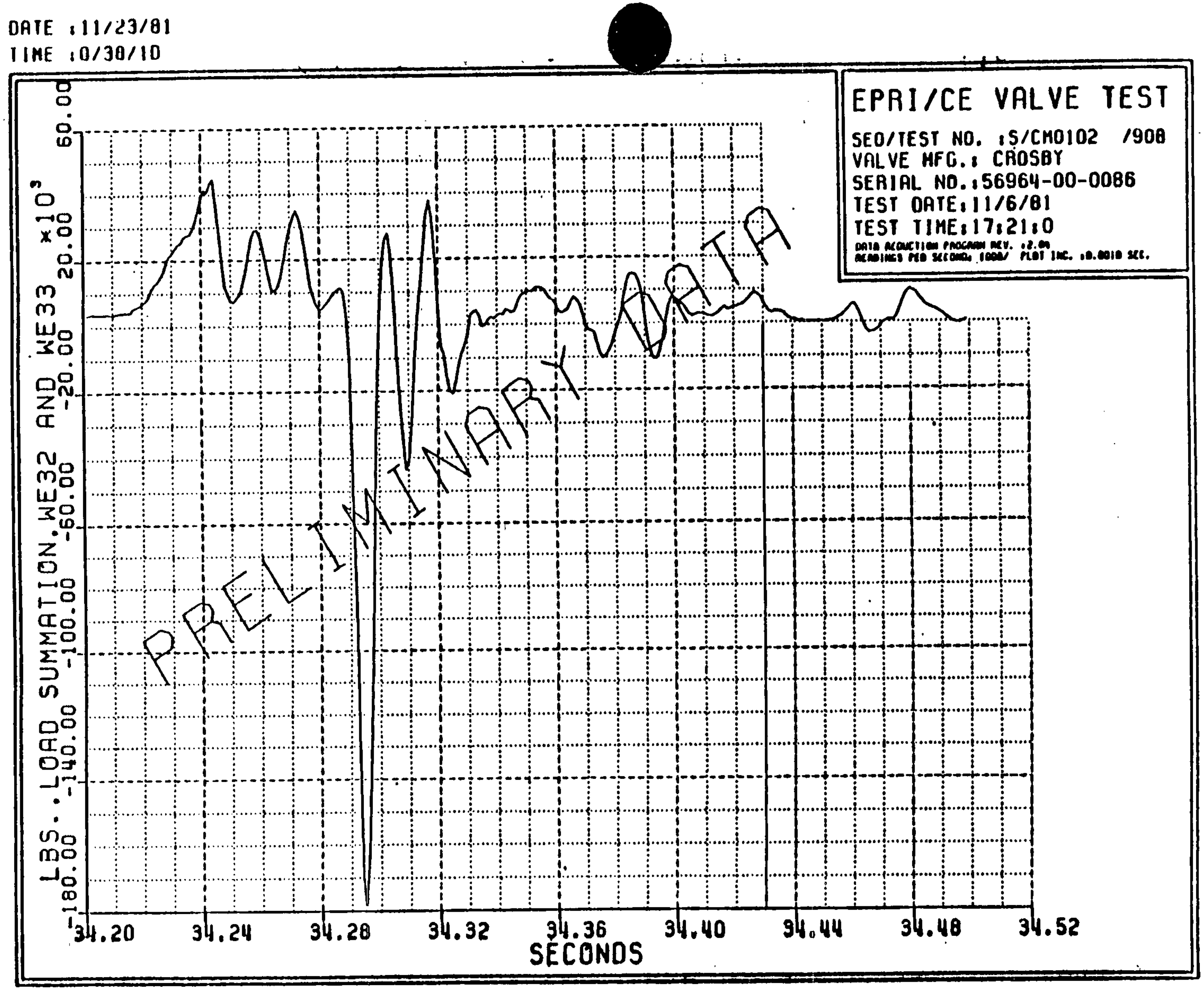


Source: Letter from Bernard Sano, EPRI Project Manager to Utility Technical and Licensing Contracts, Subject: Disseminative data for the Crosby 6M6 Safety Valve tested by EPRI at Combustion Engineering, January 12, 1982

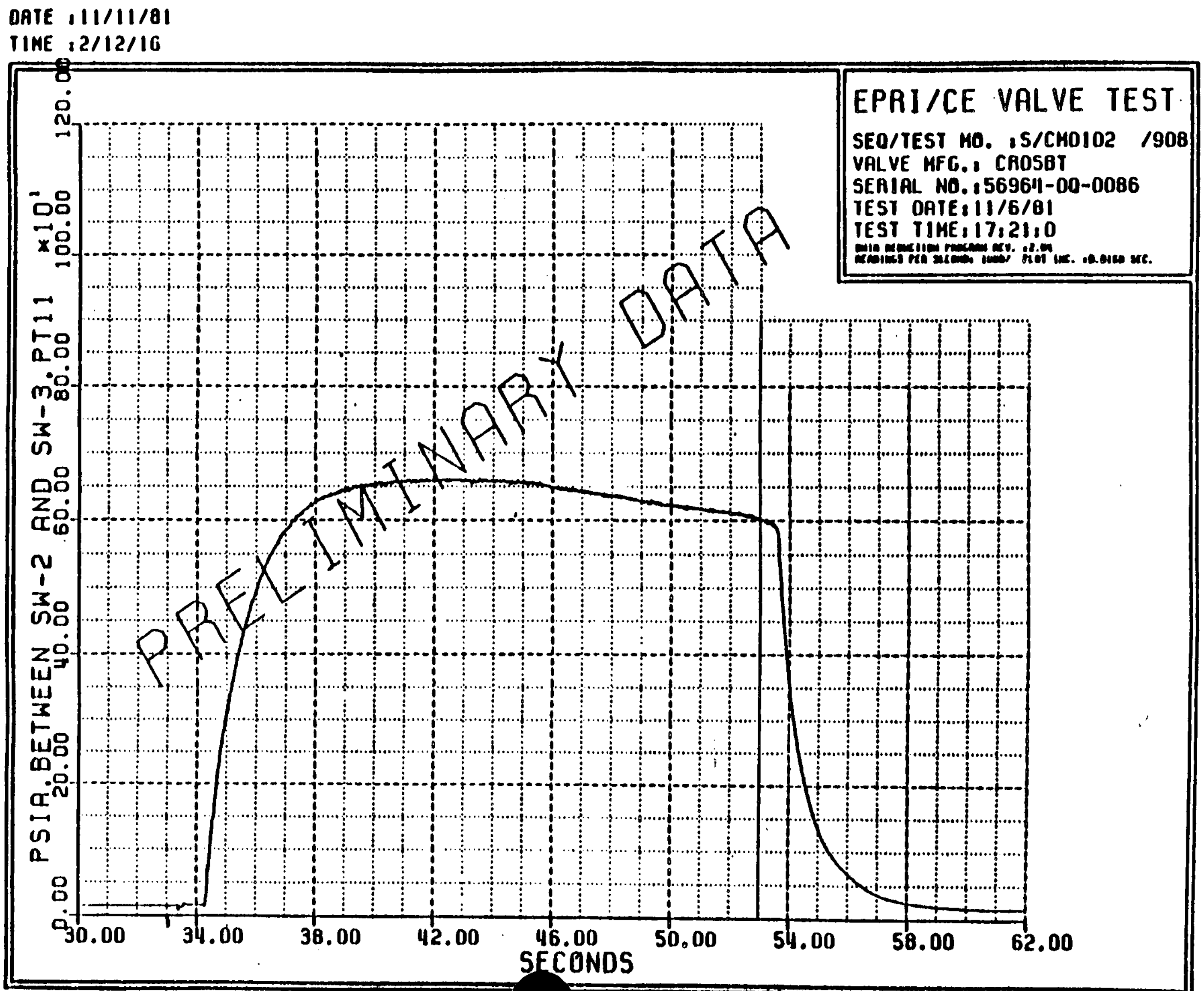
VERTICAL LOAD AT END OF FIRST VERTICAL DISCHARGE
PIPE AT W32 AND W33, TEST 908
FIGURE E-3



VERTICAL LOAD AT END OF FIRST VERTICAL
DISCHARGE PIPE, AT TEST 908
FIGURE E-4

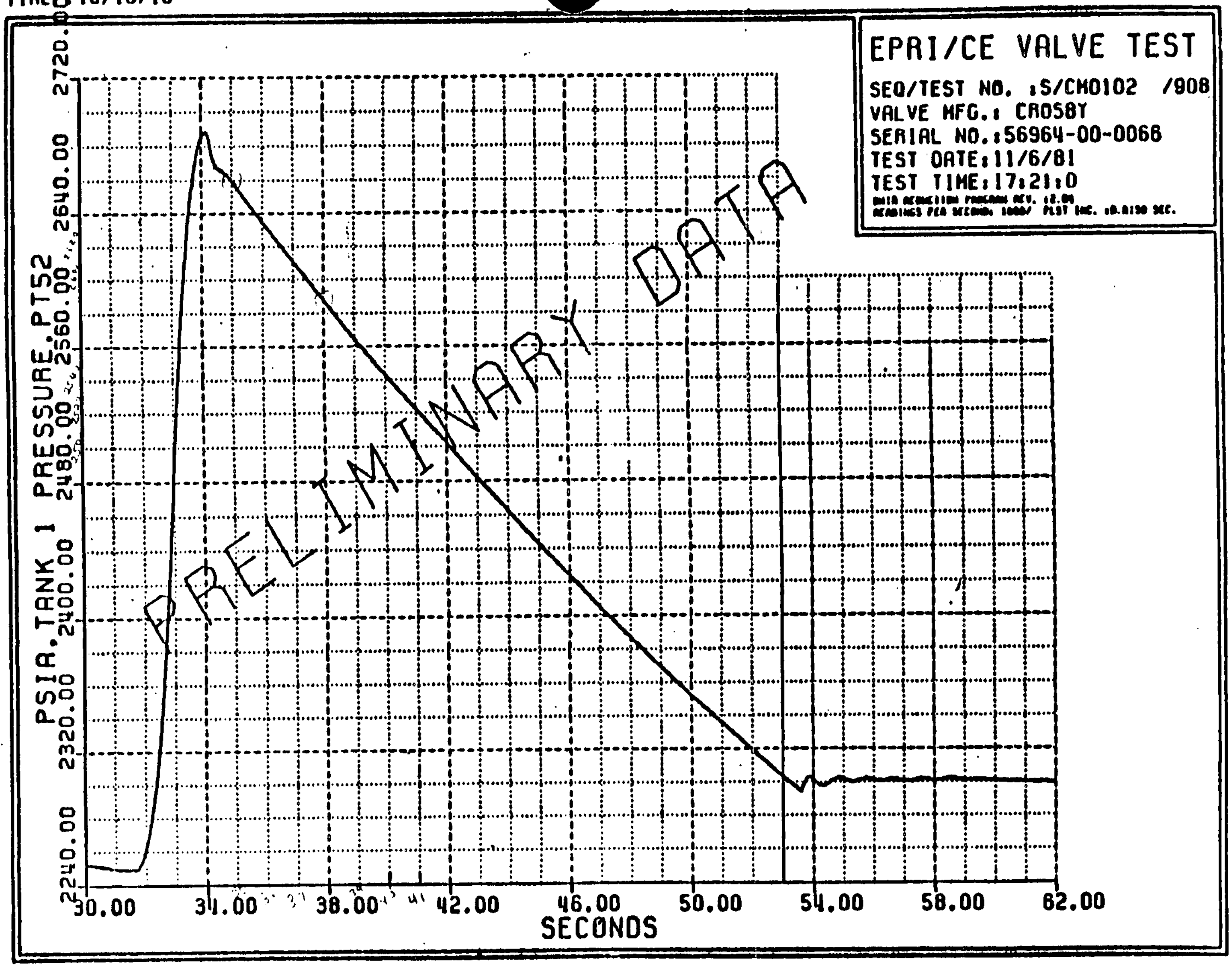


VERTICAL LOAD AT END OF FIRST VERTICAL
DISCHARGE PIPE, TEST 908
FIGURE E-5



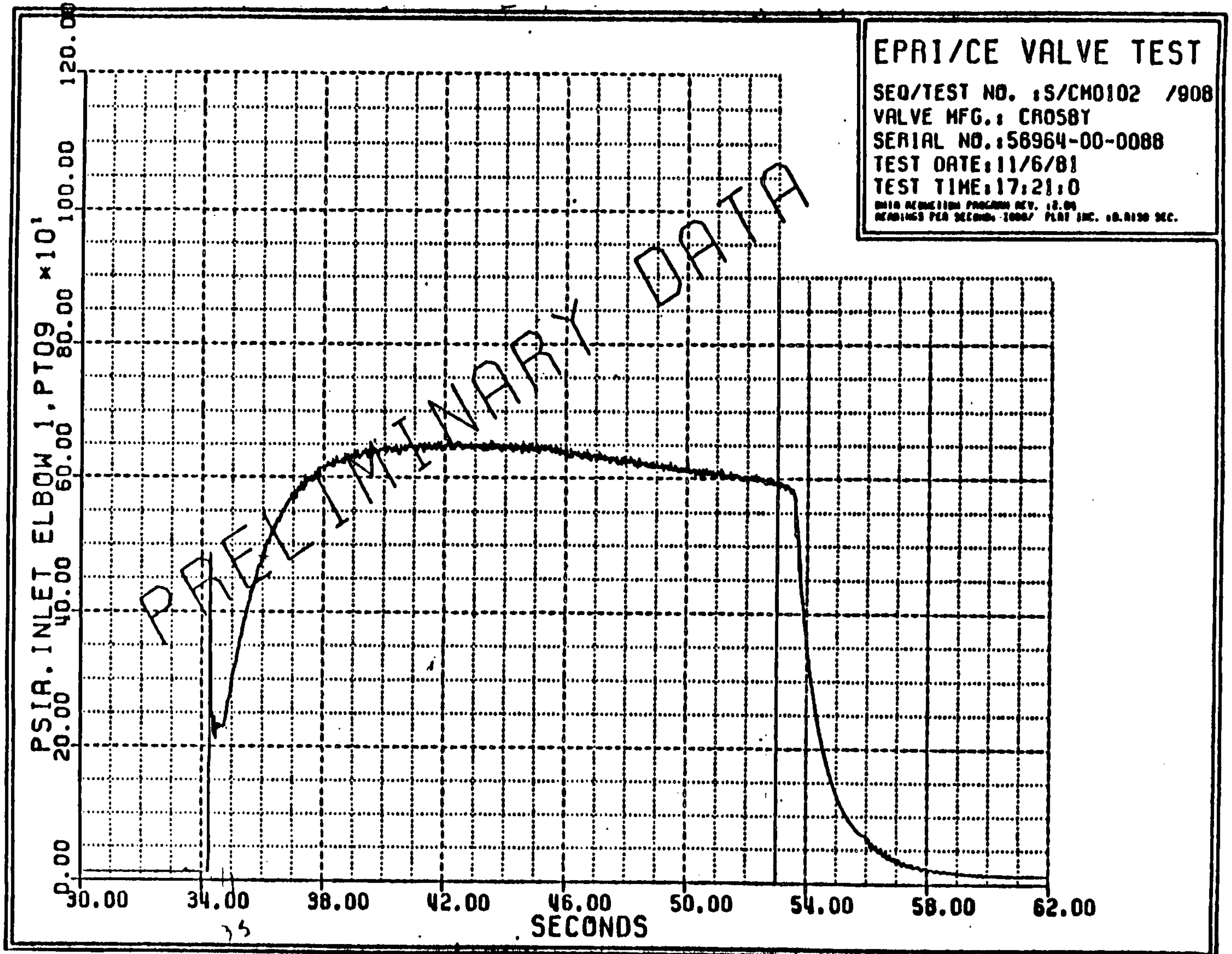
PRESSURE BETWEEN SW-2 AND SW-3, TEST 908
FIGURE E-6

DATE :11/6/81
TIME : 18/10/16

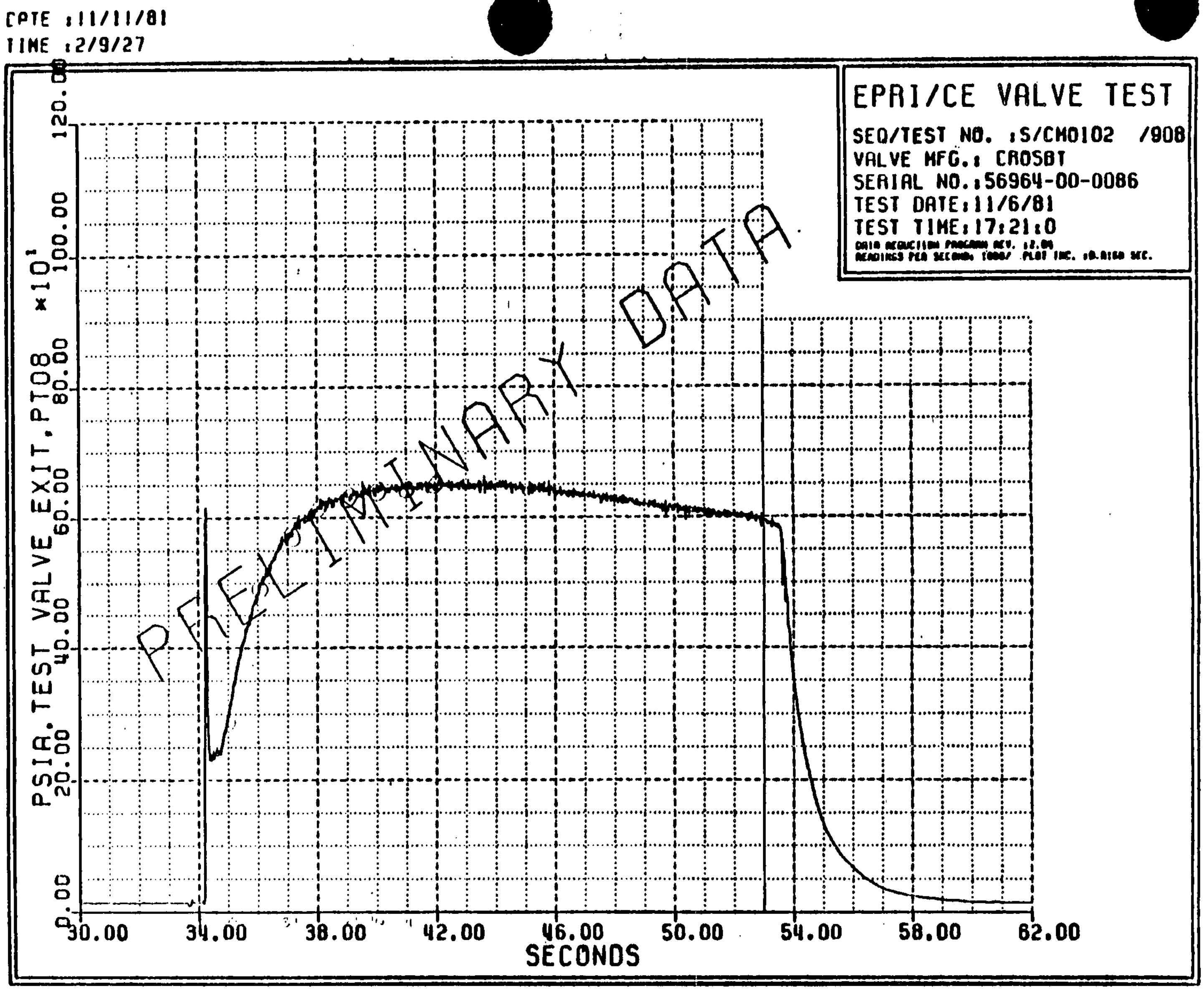


PRESSURE IN DRUM 1, TEST 908
FIGURE E-7

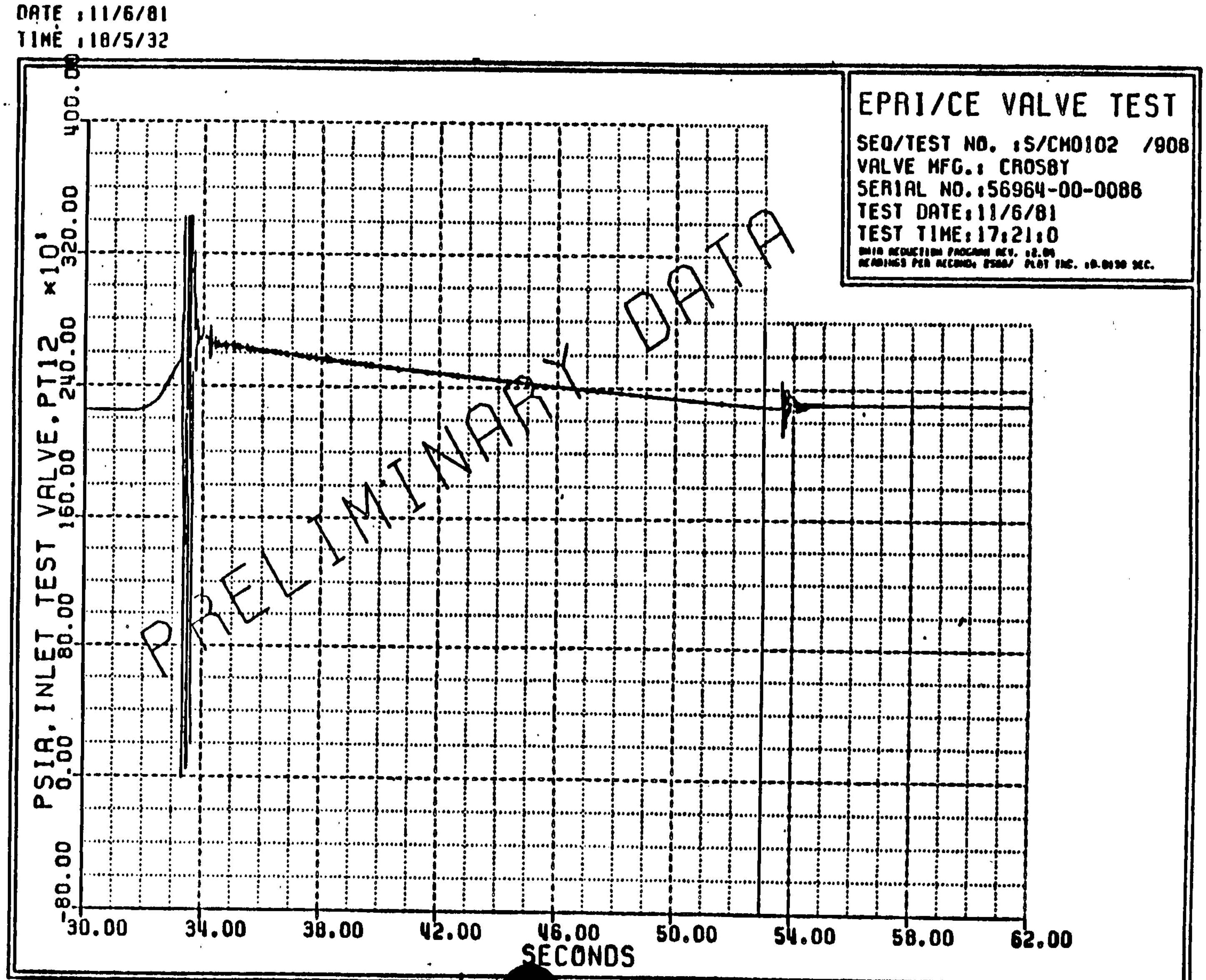
DATE :11/6/81
TIME :18/19/5



PRESSURE IN FIRST HORIZONTAL RU
DISCHARGE PIPE, TEST 908
FIGURE E-8



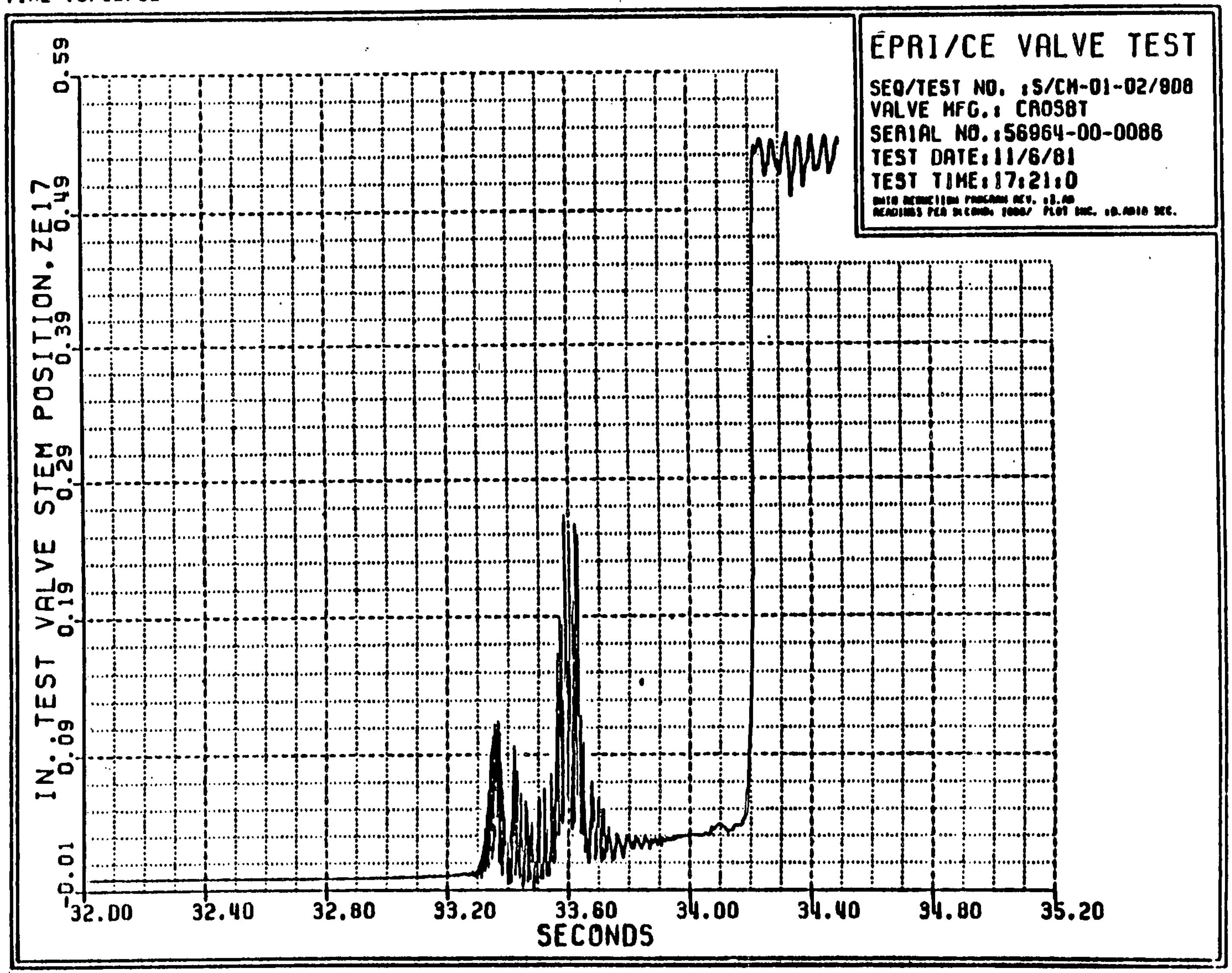
PRESSURE AT VALVE EXIT, TEST 908
FIGURE E-9



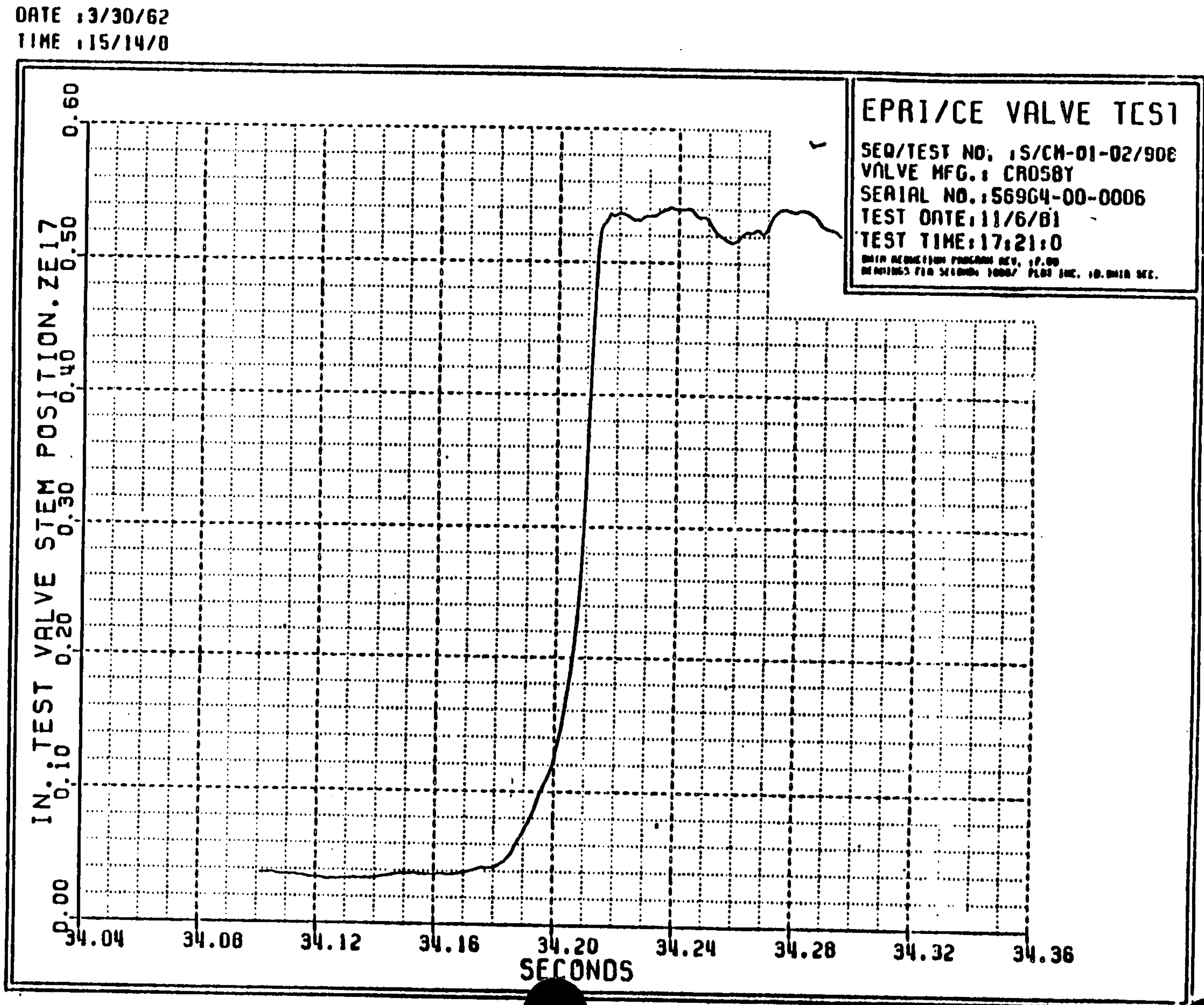
PRESSURE AT VALVE INLET, TEST

FIGURE E-10

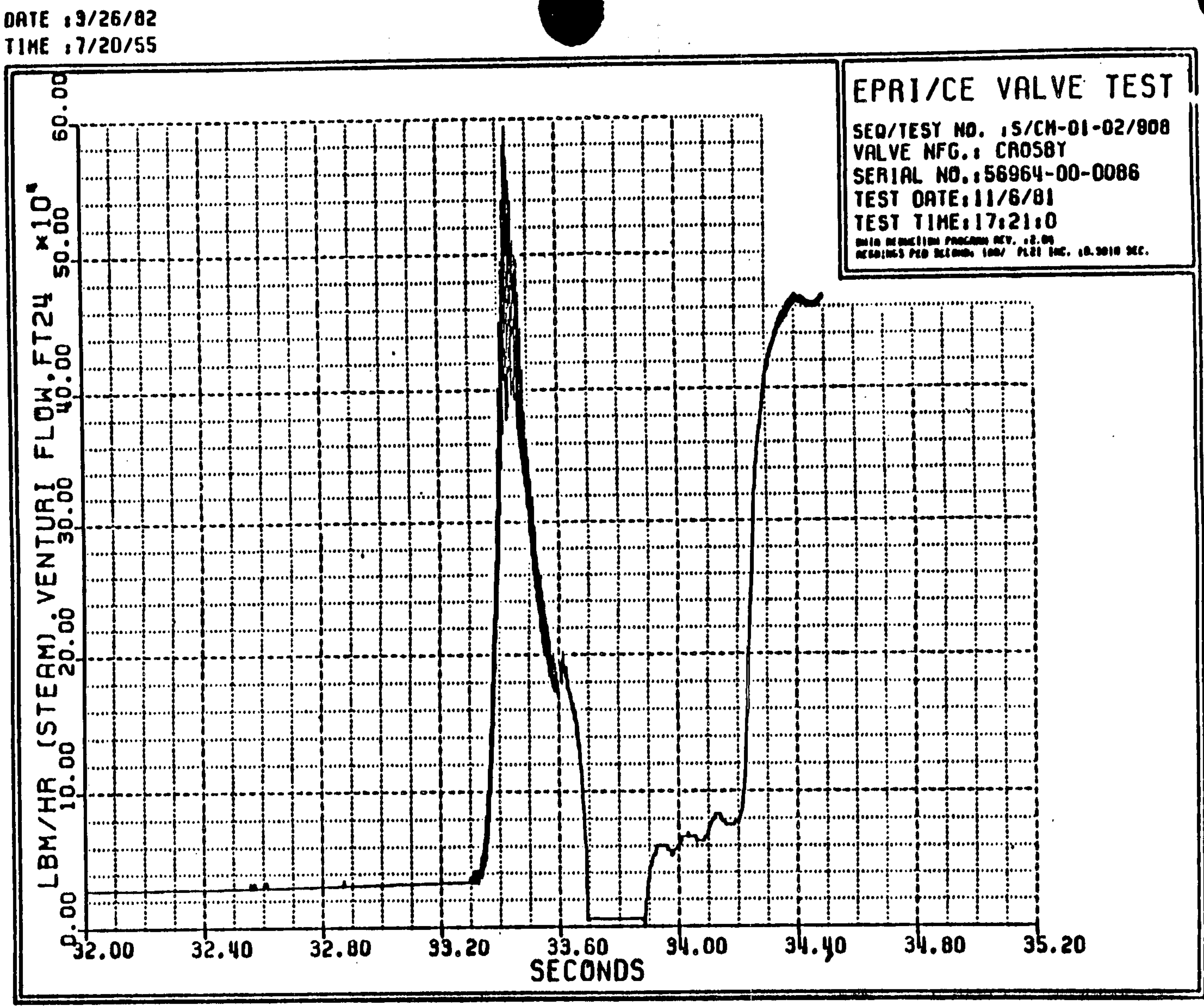
DATE :3/26/82
TIME :6/32/52



VALVE STEM POSITION, TEST 908
FIGURE E-11



VALVE STEM POSITION, TEST 908
FIGURE E-12



STEAM VENTURI FLOW, TEST 908
FIGURE E-13

APPENDIX F

RELAP5 INPUT FOR DOUBLE SAFETY VALVE ACTUATION SIMULATION

```
= KEWAUNEE  2 PSV -- 2 RUPTURE DISC -- DIF--MODE
100 NEW TRANSNT
102 BRITISH BRITISH
199  5
*   TIME STEP CONTROL
201  1.0000E-1  1.0C00E-07  1.0000E-03    1   1   50    100
*202  0.60E-01  1.00E-07  1.00E-03  1  1  50  100
302 P   38010000
303 TEMP  97010000
304  P  97010000
305 TEMP  36010000
306 P  36010000
307 TEMP  96010000
308 P 96010000
309 TEMP  38010000
310 P 38010000
311 TEMP 42010000
312 P 42010000
313 TEMP 76010000
314 P 76010000
315 TEMP  44010000
316  P  44010000
317  TEMP  114030000
318  P  114030000
319 P 48010000
320  P  114020000
321  RHO  114020000
322  TEMP  48010000
323  TEMP  48080000
324  P  48080000
325  TEMP  52010000
326  P  52010000
327  TEMP  52010000
328  P  52010000
329  TEMP  54500000
330  P  54500000
331  TEMP  60010000
332  P  60010000
333  P  97010000
334  P  95010000
335  RHO  97010000
336  TEMP  95010000
337  RHO  95010000
338  MFLOWJ  114020000
339  MFLOWJ  94000000
340 TEMP 114030000
341 P    114030000
342 P    114020000
343 P     48010000
344 P  195020000
345 TEMP 195020000
346 MFLOWJ 194000000
* TRIP CONTROL
505 TIME 0 GT NULL 0  11.0000E-01 L
506 P,95010000 GE NULL,0 285.0 L
507 P,95010000 LT NULL,0 .05 L
508 P,195020000 GE NULL,0  285.0 L
509 P,195020000 LT NULL,0   .05  L
600 505
*
```

```
* HYDRODYNAMIC COMPONENTS I
*
*PRESSURIZER
0010000 C-001    TMDPVOL
0010101   3.8480E+01  2.5980E+01  0.         0.        9.0
0010102   2.5980E+01  1.5000E-04  0.        10
0010200      2
*     TIME     PRESSURE     QUALITY --- KEWAUNEE LOCKED ROTOR
0010201  0.0    2686.0       1.0
0010202  .5    2737.0        1.0
0010203 1.0    2712.0        1.0
* HORIZONTAL PIPING  SEGMENT DOWNSTREAM FROM PSV
0360000 C-36      PIPE
0360001    3
0360101   2.0100E-01   3
0360301   7.0000E-01   3
0360601   0.           3
0360801  1.5000E-04  0.          3
0361001  10  3
0361101 1000   2
0361201  2   14.7  .01  0.  0.  2
0361202  3  14.7  204.2  0.0    0.          3
0361301  0.          0.        0.         2
*SECOND 45 DEGREE ELBOW DOWNSTREAM FROM PSV PP-3A
0370000 C-96-040  SNGLJUN
0370101 096010000 040000000
0370102  .201  .15  .15   0000
0370201    0  0.          0.         0.
* HORIZONTAL PIPING 10 INCH FROM 45 ELBOW TO REDUCER
0380000 C-38      PIPE
0380001    7
380101    .548   7
380301   .64  7
380601    0.0     7
0380801     1.50000E-04   0.0     7
0381001 00    7
0381101 1000    6
0381201  4  14.7  120. .948          0.          7
0381301  0.         0.        0.         6
*JUNCTION AT 6 INCH END OF REDUCER
0390000 C-40-38  SNGLJUN
0390101  040010000  038000000
0390102   .375  .94  .348        1000   0.         0.
0390201    0  0.          0.         0.
*6 INCH BY 10 INCH REDUCER
0400000 C-40      SNGLVOL
0400101   3.7500E-01 5.8300E-01  0.         0.        0
0400102   0.          1.5000E-04  0.        00
0400200  4  14.7  120.  .948        0.
*JUNCTION AT 10 INCH END OF REDUCER
0410000 C-38-42  SNGLJUN
0410101 038010000 042000000
0410102  .548  0.0          0.        1000   0.
0410201    0  0.          0.         0.
*HORIZONTAL SEGMENT DOWNSTREAM OF REDUCER
*CONNECTS DOWNSTREAM PIPING ADJACENT TO SECOND PSV D  HAR
0420000   C-42   SNGLVOL
0420101  .548  .60  0.  0.  0.  0.  .00015  0.  00
0420200  4  14.7  120.  .948  0.0
*
```

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0430000 C-42-44   SNGLJUN
0430101 042010000 044000000
0430102  .201  0.0  0.0  0100  0.  0.
0430201    0  0.          0.          0.
*DISCHARGE FROM SECOND PSV INTO MAIN PIPING RUN
0440000 C-44       BRANCH
0440001    0
0440101    2.0100E-01  8.3000E-01  0.           0.           0.
0440102    0.          1.5000E-04  0.          00
0440200  3  14.7  120.  0.0  0.0
*
*
1140000  C-114  PIPE
1140001  3
1140101  .548 3
1140301  .574  3
1140601  0.  3
1140801  .00015  0.  3
1141001  00  3
1141101  1000  2
1141201  4  14.7  120.  .948  0.  3
1141301  0.  0.  0.  2
*CONNECTS DOWNSTREAM PIPING FROM TWO SAFETY VALVES
0450000 C-44-46   SNGLJUN
0450101 044010000 046000000
0450102  .201  0.0  0.0          0100  0.           0.
0450201    0  0.          0.          0.
*HORIZONTAL SEGMENT UPSTREAM OF SECOND DISCHARGE ELBOW
0460000 C-46       PIPE
0460001    3
0460101    5.4800E-01   3
0460301   .38  1
0460302   .65  3
0460601    0.            3
0460801   1.5000E-04  0.           3
0461001 00    3
0461101 1000    2
0461201   3  14.7  120.  0.0  0.0  1
0461202 4 14.7 120. .948          0.          3
0461301  0.          0.          0.          2
*SECOND ELBOW IN PSV DOWNSTREAM PIPING
0470000 C-46-48   SNGLJUN
0470101 046010000 114000000
0470102  .548  .171  .171  1000  0.  0.
0470201    0  0.          0.          0.
*HORIZONTAL PIPE BETWEEN SECOND AND THIRD PSV DISCHARGE ELBOWS
0480000 C-48       PIPE
0480001   9
0480101    5.4800E-01  9
0480301    5.1000E-01  9
0480601    0.          9
0480801   1.5000E-04  0.          9
0481001 00  9
0481101 1000    8
0481201 4 14.7 120. .948          0.          9
0481301   0.          0.          0.          8
*THIRD ELBOW IN PSV DOWNSTREAM PIPING
0490000 C-48-50   SNGLJUN
0490101 048010000 050000000
0490102    5.4800E-01  1.7200E-01  1.7200E-01 1000    0.          0.
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0490201     0  0.              0.            0.
*FIRST VERTICAL SEGMENT IN PSV DOWNSTREAM PIPING
0500000 C-50      PIPE
0500001   5
0500101   5.4800E-01   5
0500301   5.2600E-01   5
0500601  -9.0000E+01   5
0500801  1.5000E-04   0.           5
0501001 00   5
0501101 1000   4
0501201 4 14.7 120. .948              0.                5
0501301  0.          0.           0.            4
*CONNECTS VERTICAL SEGMENTS
0510000 C-50-52   SNGLJUN
0510101 050010000 052000000
0510102  .548             0.           0.          1000    0.
0510201     0  0.              0.            0.
*PIPING TEE WHERE PORV FLOW ENTERS PSV 10 INCH VERTICAL DISC
0520000 C-52         SNGLVOL
0520101  .548 .5  0. -90.          0.
0520102   0.            1.5000E-04  0.           00
0520200   4  14.7  120.   .948             0.
*CONNECTS PORV-PSV TEE TO VERTICAL DISCHARGE PIPING
0530000 C-52-54   SNGLJUN
0530101 052010000 054000000
0530102   .548      .55  .55          1000    0.          0.
0530201     0  0.              0.            0.
*PSV 10 INCH VERTICAL  DISCHARGE SEGMENT TO FOURTH DISCHARGE
0540000 C-54      PIPE
0540001  95
0540101   5.4800E-01  95
0540301   5.5800E-01  95
0540601  -9.0000E+01  95
0540801  1.5000E-04  0.           95
0541001 00   95
0541101 1000   94
0541201 4 14.7 120. .948              0.               95
0541301  0.          0.           0.            94
*FOURTH ELBOW IN PSV DOWNSTREAM PIPING
0550000 C-54-56   SNGLJUN
0550101 054010000 056000000
0550102  .548          1.7200E-01  1.7200E-01 1000    0.
0550201     0  0.              0.            0.
*HORIZONTAL SEGMENT
0560000 C-56      PIPE
0560001  35
0560101   5.4800E-01  35
0560301   8.9700E-01  35
0560601   0.           35
0560801  1.5000E-04  0.           35
0561001 00   35
0561101 1000   34
0561201 4 14.7 120. .948              0.               35
0561301  0.          0.           0.            34
*16.6 DEGREE BEND IN DOWNSTREAM PIPING
0570000 C-56-58   SNGLJUN
0570101 056010000 058000000
0570102  .548          6.0000E-02  6.0000E-02 1000    0.
0570201     0  0.              0.            0.
*HORIZONTAL SEGMENT
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0580000 C-58      PIPE
0580001   7
0580101   5.4800E-01   7
0580301   9.9700E-01   7
0580601   0.           7
0580801  1.5000E-04  0.              7
0581001 00   7
0581101 1000   6
0581201 4 14.7 120. .948                 0.                7
0581301  0.             0.           0.          6
*FIFTH ELBOW IN DOWNSTREAM PIPING
0590000 C-58-60  SNGLJUN
0590101 058010000 060000000
0590102 .548           1.7200E-01  1.7200E-01 1000   0.        0.
0590201    0  0.          0.          0.
*VOLUME FROM RELIEF TANK ORIFICE TO AIR/WATER INTERFACE WITHIN TANK
0600000 C-60      PIPE
0600001   3
0600101   5.4800E-01   3
0600301   1.1100E+00   3
0600601  -4.5000E+01   3
0600801  1.5000E-04  0.              3
0601001 00   3
0601101 1000   2
0601201 4 14.7 120. .948                 0.                3
0601301  0.             0.           0.          2
*AIR/WATER INTERFACE WITHIN PRESSURE RELIEF TANK
0610000 C-60-62  SNGLJUN
0610101 060010000 062000000
0610102  .548           0.          0.          1000   0.        0.
0610201    0  0.          0.          0.
*VOLUME DIRECTLY BELOW WATER SURFACE IN RELIEF TANK
0620000 C-62      PIPE
0620001   2
0620101   5.4800E-01   2
0620301   1.0000E+00   2
0620601  -4.5000E+01   2
0620801  1.5000E-04  0.              2
0621001 00   2
0621101 1000   1
0621201 4  14.7  120.  .948              0.                2
0621301  0.             0.           0.          1
*45 DEGREE BEND IN RELIEF TANK
0630000 C-62-64  SNGLJUN
0630101 062010000 064000000
0630102  .548           1.0300E-01  1.0300E-01 1000   0.        0.
0630201    0  0.          0.          0.
*VOLUME OF DISCHARGE PIPING BELOW WATER IN PRESSURE RELIEF TANK
0640000 C-64      SNGLVOL
0640101  .548  1.65  0. -90.             0.
0640102   0.          1.5000E-04  0.          10
0640200      3  14.7  1.2000E+02  0.          0.
*CONNECTS C-64 TO C-66
0650000 C-64-66  SNGLJUN
0650101 064010000 066000000
0650102  .548           0.          0.          1000   0.        0.
0650201    0  0.          0.          0.
*90 DEGREE BEND IN RELIEF TANK
0660000 C-66      SNGLVOL
0660101 .548  1.5  0. -90.              0.
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0660102    0.               1.5000E-04   0.            10
0660200       3   14.7      1.2000E+02   0.             0
*90 DEGREE BEND IN RELIF TANK WATER
0670000 C-66-68   SNGLJUN
0670101 066010000 068000000
0670102   .548               1.7200E-01   1.7200E-01 1000   0.
0670201      0   0.            0.              0.
*BEND VOLUME
0680000 C-68      SNGLVOL
0680101    5.4800E-01   1.5000E+00   0.              0.              0.
0680102    0.               1.5000E-04   0.            10
0680200       3   14.7      1.2000E+02   0.             0.
*HORIZONTAL DISCHARGE SPARGER WITHIN RELIEF TANK
0690000 C-69      BRANCH
0690001       3
0690101    5.4800E-01   4.0800E+00   0.              0.              0.
0690102    0.               1.5000E-04   0.            10
0690200       3   14.7      1.2000E+02   0.             0.
0691101 068010000 069000000   5.4800E-01   0.              0.
0692101 069010000 073000000   2.7300E-01 1.89   1.71 0000
0693101   069010000   070000000   .548   0.0   0.0   1000
0692201   0.            0.            0.
0693201   0.            0.            0.
0691201    0.0    0.0     0.0
*HORIZONTAL DISCHARGE SPARGER WITHIN RELIEF TANK
0700000 C-70      BRANCH
0700001       2
0700101    5.4800E-01   4.0800E+00   0.              0.              0.
0700102    0.               1.5000E-04   0.            10
0700200       3   14.7      1.2000E+02   0.             0.
0701101 070010000 073000000   2.7300E-01   1.89   1.71 0000
0701201   0.            0.            0.
0702101 070010000 071000000   5.4800E-01   0.              0.
0702201   0.            0.            0.
*HORIZONTAL DISCHARGE SPARGER WITHIN RELIEF TANK
0710000 C-71      SNGLVOL
0710101    5.4800E-01   4.0800E+00   0.              0.              0.
0710102    0.               1.5000E-04   0.            10
0710200       3   14.7      1.2000E+02   0.             0.
*CONNECTS COMPONENT SPARGER 71 TO WATER IN RELIEF TANK
0720000 C-71-73   SNGLJUN
0720101 071010000 073000000
0720102    2.8500E-01   1.89   1.71  0000    1.0000E+00   1.0000E+00
0720201      0   0.            0.              0.
*WATER IN RELIEF TANK (REPRESENTS 75 % OF FREE VOLUME OF RELIEF
0730000 C-73      BRANCH
0730001   0
0730101    1.0665E+02   5.6290E+00   0.              0.              9.00
0730102    5.6290E+00   1.5000E-04   0.            00
0730200       3   14.7      1.2000E+02   0.             0.
*AIR/WATER INTERFACE WITHIN RELIEF TANK
0740000 C-73-75   SNGLJUN
0740101 073010000 075000000
0740102    1.0660E+02   0.              0.            1000    1.0000E+0
0740201      0   0.            0.              0.
*VOLUME OF AIR IN RELIEF TANK
0750000 C-75      SNGLVOL
0750101    1.0660E+02   1.8760E+00   0.              0.              9.0
0750102    1.8760E+00   1.5000E-04   0.            00
0750200       4   14.7      1.2000E+02   9.4800E-01   0.
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*HORIZONTAL SEGMENT DOWNSTREAM FROM SECOND PSV
0760000 C-76      PIPE
0760001    4
0760101    2.0100E-01    4
0760301    5.0000E-01    4
0760601    0.            4
0760801   1.5000E-04  0.          4
0761001 10    3
0761002  00   4
0761101 1000    3
0761201  2  14.7   .01  0.  0.  2
0761202  3  14.7  204.2  0.  0.  4
0761301  0.          0.          0.          3
*JUNCTION TO BRANCH COMPONENT 44
0770000 C-76-044  SNGLJUN
0770101 076010000 044000000
0770102  .201  0.0  0.0          0100   1.0000E+00  1.0000E+00
0770201    0  0.          0.          0.
*
*  INLET TO VALVE NOZZLE PSV  PR-3A
*
1980000  V-CASE  SNGLVOL
1980101  .017  .92  0.  0.  0.  0.  .00005  0.  11
1980200  2  2686.  1.0
*
2980000  V-INLET   SNGLJUN
2980101  99010000  198000000  .017  0.  0.  0100
2980201  1  0.  0.  0.


*
1780000  V-CASE  SNGLVOL
1780101  .017  .92  0.  0.  0.  0.  .00005  0.  11
1780200  2  2686.  1.0
*
2780000  V-INLET  SNGLJUN
2780101  79010000  178000000  .017  .0  0.  0100
2780201  1  0.  0.  0.
*
*  VALVE TABLE
*
20221000 REAC-T       0
20221001   0.           0.
20221002   .015  1.0000E+00
20221003  9.0  1.0
* CONTROL SYSTEM  INPUT
20500100  PSV  FUNCTION  1.0  0.0  0
20500101  TIME  0  210
*
*SAFETY VALVE
0780000 C178-76  VALVE
0780101  178010000  076000000
0780102   1.7000E-02  0.          0.          0100   1.0000E+00  1.0000
0780201    0  0.          0.          0.
0780300       SRVVLV
0780301     1
*VERTICAL LOOP SEAL SEGMENT UPSTREAM FROM PSV
*CONNECTS LOWER PART OF LOOP SEAL
0790000  C-79  SNGLVOL
0790101  .147  .8  0.  0.  0.0  0.  .00015  0.  00
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0790200  2  2686.  1.0
*
0800000 C-81-79  SNGLJUN
0800101 081010000 079000000
0800102   1.4700E-01  0.            0.            1000   1.000
0800201    0  0.            0.         0
*LOWER PART OF LOOP SEAL
0810000 C-81      SNGLVOL
0810101   1.4700E-01  5.8900E-01  0.            0.            0.
0810102   0.            1.5000E-04  0.          00
0810200  2  2686.  1.0  0.  0.
*CONNECTS LOWER LOOP SEAL TO VERTICAL PART OF LOOP SEAL
0820000 C-83-81  SNGLJUN
0820101 083010000 081000000
0820102   1.4700E-01  0.            0.            1000   1.0000E+00
0820201    0  0.            0.          0.
*VERTICAL PART OF LOOP SEAL
0830000 C-83      PIPE
0830001   2
0830101   1.4700E-01   2
0830301   5.4000E-01   1
0830302   6.3800E-01   2
0830601   9.0000E+01   2
0830801  1.5000E-04  0.            2
0831001 00   2
0831101 1000    1
0831201  2  2686.  1.0  0.  0.  1
0831202  2 2.686000E+03  1.0  0.            0.            0.
0831301  0.            0.            0.            1
*TOP 90 DEGREE BEND INTO PRESSURIZER
0840000 C-85-83  SNGLJUN
0840101 083010000 085000000
0840102   1.4700E-01  1.6000E-01  1.6000E-01 1000   1.0000E+00
0840201    0  0.            0.          0.
*VERTICAL PART OF PIPE FROM LOOP SEAL WATER
0850000 C-85      PIPE
0850001   2
0850101   1.4700E-01   2
0850201   1.4700E-01   1
0850301   7.0300E-01   2
0850601  -9.0000E+01   2
0850801  1.5000E-04  0.            2
0851001 00   2
0851101 1000    1
0851201 2  2.686000E+03  1.000000E+00  0.            0.
0851301  0.            0.            0.            1
*SECOND ELBOW VOLUME
0860000 C-87-85  SNGLJUN
0860101 087010000 085000000
0860102   1.4700E-01  0.            0.            1000   1.0000E+00
0860201    0  0.            0.          0.
*HORIZONTAL SEGMENT
0870000 C-87      PIPE
0870001   1
0870101   1.4700E-01   1
0870301   5.8400E-01   1
0870601   0.           1
0870801  1.5000E-04  0.            1
0871001 00   1
0871201 2  2.686000E+03  1.000000E+00  0.            0.
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*CONNECTS HORIZONTAL SEGMENTS
0880000 C-89-87  SNGLJUN
0880101 089010000 087000000
0880102   1.4700F-01  1.9500F-01   1.9500E-01 1000   1.0000E+00  1.0000E
[illegible]6201    0  0.          0.          0.
[illegible]IZONTAL SEGMENT
[illegible]0000 C-89      SNGLVOL
0890101   1.4700E-01  7.8500E-01  0.          0.          0.
0890102   0.          1.5000E-04  0.          00
0890200      2  2.6860E+03  1.0000E+00  0.          0.
*CONNECTS HORIZONTAL SEGMENT
0900000 C-91-89  SNGLJUN
0900101 091010000 089000000
0900102   1.4700E-01  0.          0.          1000   1.0000E+00  1.0000E
0900201    0  0.          0.          0.
*VERTICAL PIPE FROM PRESSURIZER TO FIRST LOOP SEAL ELBOW VOLUME
0910000 C-91      PIPE
0910001   3
0910101   1.4700E-01   3
0910201   1.4700E-01   2
0910301   1.0740E+00   3
0910601   9.0000E+01   3
0910801  1.5000E-04  0.          3
0911001 00   3
0911101 1000   2
0911201 2  2.686000E+03  1.000000E+00  0.          0.          3
0911301  0.          0.          0.          2
*CONNECTS LOOP SEAL PIPING TO PRESSURIZER
0920000 C-01-91  SNGLJUN
[illegible]101 001000000 091000000
0[illegible]102   1.4700E-01  5.9400E-01  9.9200E-01 0000   1.0000E+00  1.0000E
0920201    0  0.          0.          0.
*
* PRESSURIZER VAULT
*
0930000  C-93  SNGLVOL
0930101 90. 100.  0. 0. 0.0 0. .00015 0. 00
0930200  4 14.7  120.  .948
*
*  RUPTURE  DISC
*
0940000  RD  VALVE
0940101  095010000 093000000 .163 0. 0. 0100
0940201  0 0. 0. 0.
0940300  MTPVLV
**  CONTROL  VARIABLE  NUMBER
0940301  506  507   100.  0.0  2
*
*  RUPTURE  DISC  TABLE
20200200  NORMAREA
20200201  0.  0.
20200202  1.0  1.0
*  RUPTURE  DISC /BAFFLE  CAVITY
*
09CH800  C-95  SNGLVOL
0[illegible]01  .201  .51  0. 0. 0. 0. .00015  0. 0C
0[illegible]00  3  14.7  120.  0.0  0.0
*
*
*  PRESSURIZER VAULT
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*
1930000  C-193  SNGLVOL
1930101  90.  100.  0.  0.  0.  0.  .00015  0.
1930200  4  14.7  120.  .948
*
*  RUPURE DISC AT PR-3B
*
1940000  RD  VALVE
1940101  195010000  193000000  .163  0.  0. 0100
1940201  0  0.  0.  0.
1940300  MTRVLV
**  CONTROL  VARIABLE
1940301  508  509 100.  0.0  2
*
1950000  C-195  PIPE
1950001  2
1950101  .201  1
1950102  .188  2
1950301  .62  1
1950302  .62  2
1950601  0.  2
1950801  .00015  0.  2
1950901  .15  .15  1
1951001  00  2
1951101  0000  1
1951201  3  14.7  120.  0.0  0.0  1
1951202  4  14.7  120.  .948  0.0  2
1951301  0.  0.  0.  1
*
1960000  C-44-195  SNGLJUN
1960101  044010000  195000000
1960102  .201  0.0  0.0  0100
1960201  0  0.  0.  0.
*
*  INLET  TO DISCHARGE  PIPING
*
0960000  C-96  SNGLVOL
0960101  .201  .843  0.  0.  0.  0.  .00015  0.  00
0960200  3  14.7  120.  0.0  0.0
*
*  OUTLET  FROM  INACTVE  SAFETY VALVE
*
0970000  C-97  BRANCH
0970001  0
0970101  .201  .604  0. 0. 0. 0. .00015  0.  00
0970200  3  14.7  120.  0.0  0.0
**
*
*VALVE PR-2A
0980000 PR-2A   VALVE
0980101 198010000 036000000
0980102  1.7000E-02   0.0  0.0 0100  1.0000E+00  1.0000E+0
0980201   0  0.        0.        0.
0980300     SRVVLV
0980301     1
*VERTICAL LOOP SEAL SEGMENT UPSTREAM FROM PSV
0990000  C-99  SNGLVOL
0990101  .147  .8  0.  0.  0.0
0990102  0.  .00015  0.  00
0990200  2  2686.  1.0  0.  0.
```

```
*ELBOW JUNCTION TO BOTTOM OF LOOP SEAL
1000000 C-100      SNGLJUN
1000101 101010000 099000000
1000102   .147     0.           0.           1000   1.0000E+00  1.0000E+0
[illegible]0201     0  0.           0.           0.
[illegible]LBOW JUNCTION TO BOTTOM OF LOOP SEAL
1010000 C-101      SNGLVOL
1010101   1.4700E-01  5.8900E-01  0.           0.           0.
1010102   0.          1.5000E-04  0.           00
1010200   2  2686.  1.0  0.  0.
*JUNCTION TO CONNECT BOTTOM OF LOOP SEAL
1020000 C1-103   SNGLJUN
1020101 103010000 101000000
1020102   .147           1.6000E-01  1.6000E-01 1000   1.0000E+00  1.0000
1020201     0  0.           0.           0.
*HORIZONTAL LOOP SEAL PIPE
1030000 C-103      PIPE
1030001    2
1030101    1.4700E-01    2
1030301    6.8400E-01    1
1030302    6.3800E-01    2
1030601    0.            2
1030801   1.5000E-04   0.           2
1031001 00    2
1031101 1000    1
1031201   2   2686.   1.0   0.   0.   1
1031202   2   2686.   1.0   0.   0.   2
1031301   0.           0.           0.           1
[illegible]BOW TO CONNECT BOTTOM OF LOOP TO VERTICAL SEGMENT
[illegible]0000 C5-103   SNGLJUN
1040101 105010000 103000000
1040102   .147           1.6000E-01  1.6000E-01 1000   1.0000E+00  1.000
1040201     0  0.           0.           0.
*SECOND LOOP SEAL ELBOW AND VERTICAL SEGMENT
1050000 C-105      PIPE
1050001    2
1050101    1.4700E-01    2
1050301    1.0310E+00    2
1050601    0.            2
1050801   1.5000E-04   0.           2
1051001 00    2
1051101 1000    1
1051201 2  2.686000E+03  1.000000E+00  0.           0.           2
1051301   0.           0.           0.           1
*CONNECTS TOP OF LOOP SEAL PIPING
1060000 C7-105   SNGLJUN
1060101 107010000 105000000
1060102   .147     0.           0.           1000   1.0000E+00  1.0000E+0
1060201     0  0.           0.           0.
*HORIZONTAL SEGMENT AT TOP OF PIPING
1070000 C-107      SNGLVOL
1070101   1.4700E-01  5.8400E-01  0.           0.           0.
1070102   0.          1.5000E-04  0.           00
1070200       2  2.6860E+03  1.0000E+00  0.           0.
*[illegible]ST ELBOW JUNCTION
1[illegible]000 C9-107   SNGLJUN
1080101 109010000 107000000
1080102   .147           1.9500E-01  1.9500E-01 1000   1.0000E+00  1.0000
1080201     0  0.           0.           0.
*TOP OF LOOP SEAL
```

```
1090000 C-109    SNGLVOL
1090101   1.4700E-01  7.8500E-01  0.          0.          0.
1090102   0.          1.5000E-04  0.          00
1090200     2  2.6860E+03  1.0000E+00  0.        0.
*CONNECTS TOP OF LOOP TO PIPING DOWNSTREAM OF PRESSURIZER
1100000 C11-109  SNGLJUN
1100101 111010000 109000000
1100102   .147     0.          0.        1000   1.0000E+00  1.
1100201    0  0.         0.        0.
*VERTICAL PIPE FROM PRESSURIZER TO FIRST LOOP SEAL ELBOW VOLUME
1110000 C-111    PIPE
1110001   3
1110101   1.4700E-01   3
1110301   1.0740E+00   3
1110601   9.0000E+01   3
1110801  1.5000E-04  0.          3
1111001 00   3
1111101 1000   2
1111201 2  2.686000E+03  1.000000E+00  0.         0.
1111301  0.          0.        0.         2
*CONNECTS TO PRESSURIZER
1120000 C13-111  SNGLJUN
1120101 113000000 111000000
1120102   .147        5.9400E-01  5.9400E-01 0000   1.0000E+
1120201    0  0.         0.        0.
*PRESSURIZER
1130000 C-113    TMDPVOL
1130101     38.48  2.5980E+01  0.         0.         9.0000E+
1130102   2.5980E+01  1.5000E-04  0.         00
1130200     2
1130201   0.          2.6860E+03  1.0000E+00
1130202  .5  2737.0  1.0000E+00
1130203  1.0   2712.0  1.0000E+00
*
1190000  C-119  SNGLJUN
1190101  36010000  136000000
1190102  .201  .15  .15  1000
1190201  0  0.  0.  0.
*
1200000  C-120  SNGLJUN
1200101  136010000  97000000
1200102  .201  0.0  0.0  0100
1200201  0  0.  0.  0.
*
1210000  C-121  SNGLJUN
1210101  97010000  96000000
1210102  .201  0.0  0.0  0100
1210201  0  0.  0.  0.
*
1220000  C-122  SNGLJUN
1220101  97010000  95000000
1220102  .185  0.0  0.0  0100
1220201  0  0.  0.  0.
*
1230000  C-123  SNGLJUN
1230101  114010000  48000000
1230102  .137   0.0  0.0  0100
1230201  0  0.  0.  0.
*
1360000  C-136  SNGLVOL
```

```
1360101   .201   .854   0.   0.   0.
1360102   0.   .00015   0.   00
1360200   3   14.7   120.   0.   0.
.END OF CASE
```

APPENDIX G

RELAP5 INPUT FOR PORV ACTUATION SIMULATION

```
=KEWAUNEE TWO PORV SIMULATION--FOR THERMAL/HYDRAULIC LOADS
100 NEW TRANSNT
102 BRITISH BRITISH
109  10
*  IME STEP CONTROL
20  0.0000E-01  1.0000E-07  1.0000E-03    1    10    100    100
302 P    38010000
301 P 36010000
303 P    76010000
304 P    44010000
305 P    48010000
306 P    50010000
307 P    52010000
308 P    54010000
309 P    56010000
310 P    58010000
311 P    60010000
312 P    62010000
313 P    64010000
314 P    66010000
315 MFLOWJ  14000000
316 MFLOWJ   29000000
317 MFLOWJ   24000000
318 MFLOWJ   51000000
319 MFLOWJ   53000000
320 TEMP           36010000
321 TEMP           38010000
322 TEMP           23010000
323  MFLOWJ  14000000
32           13050000
325  FLOWJ  29000000
326  P      28060000
327 P 95010000
328  TEMP  95010000
329  MFLOWJ  94000000
330  MFLOWJ  47000000
331  P    76040000
* TRIP CONTROL
501 TIME 0 GT NULL 0   2.2350E+03 L
502 TIME 0 GT NULL 0   2.1000E+03 L
503 TIME 0 GT NULL 0   2.2350E+03 L
504 TIME 0 GT NULL 0   2.1000E+03 L
505 TIME 0 GT NULL 0  11.0000E-01 L
506 P,95010000 GE NULL,0 285.0 L
507 P,95010000 LT NULL,0  4.7  L
508 P,75010000 GT NULL, 0 99.7  L
600 505
*
* HYDRODYNAMIC COMPONENTS
*
*PRESSURIZER
010000 C-001      TMDPVOL
010101    3.8480E+01  2.5980E+01  0.         0.           9.0000E+01
010102    2.5980E+01  1.5000E-04  0.        10
010200      2
CON  TS PRESSURIZER TO FIRST HORIZONTAL PIPE
010  0.0  2471.8  1.0  .5  2480.  1.0
010202  7.5  2150.  1.0
020000 C-1-2      SNGLJUN
020101 001000000 003000000
```

```
0020102    3.8000E-02  .5          1.5000E+00 0000    1.0000E+00  1.0
0020201      0  0.          0.          0.
*VERTICAL PIPE FROM PRESSURIZER
0030000 C-3        PIPE
0030001    5
0030101    3.8000E-02    5
0030301    5.0800E-01    5
0030601    9.0000E+01    5
0030801  1.5000E-04   0.           5
0031001 00    5
0031101 1000    4
0031201 2   2471.8   1.000000E+00   0.             0.              5
0031301  0.          0.           0.          4
*FIRST 90 DEGREE ELBOW FROM PRESSURIZER
0040000 C-3-5      SNGLJUN
0040101 003010000 005000000
0040102    3.8000E-02  1.6000E-01   1.6000E-01 1000    1.0000E+00  1.0
0040201      0  0.          0.          0.
*HORIZONTAL PIPE FROM ELBOW TO FIRST PORV BRANCH
0050000 C-5        PIPE
0050001    6
0050101    3.8000E-02    6
0050301    5.2800E-01    6
0050601    0.            6
0050801  1.5000E-04   0.           6
0051001 00    6
0051101 1000    5
0051201 2   2471.8   1.000000E+00   0.             0.              6
0051301  0.          0.           0.          5
* CONNECTS C-5 TO C-7
0060000  C-5-7     SNGLJUN
0060101   005010000   007000000
0060102   .038   0.0   0.0   1000   1.   1.
0060201   0   0.   0.   0.
*BRANCH VOLUME TO SECOND PORV
0070000 C-7        BRANCH
0070001    0
0070101    3.8000E-02  5.0000E-01   0.             0.              0.
0070102    0.          1.5000E-04   0.          00
0070200      2   2471.8   1.0000E+00   0.             0.
*CONTINUE FROM BRANCH TO PR-2B PORV
0080000 C-7-9      SNGLJUN
0080101 007010000 009000000
0080102    3.8000E-02  0.           0.          1000    1.0000E+00  1.
0080201      0  0.          0.          0.
*HORIZONTAL PIPE FROM BRANCH VOLUME 7 TO ELOW LEADING TO PORV PR-2
0090000 C-9        PIPE
0090001    5
0090101    3.8000E-02    5
0090301    4.8400E-01    5
0090601    0.            5
0090801  1.5000E-04   0.           5
0091001 00    5
0091101 1000    4
0091201 2 2471.8   1.000000E+00   0.             0.              5
0091301  0.          0.           0.          4
*SECOND ELBOW IN PR-2B PORV BRANCH
0100000 C-10       SNGLJUN
0100101 009010000 011000000
0100102    .038            1.6000E-01   1.6000E-01 1000    1.0000E+00
```

```
0100201     0  0.             0.             0.
*VOLUME GOING TO PORV PR-2B
0110000 C-11      SNGLVOL
0110101   3.8000E-02  8.0100E-01   0.             0.           0.
0110102   0.            1.5000E-04   0.            00
011    0     2  2471.8  1.0000E+00   0.            0.
*OP    GATE VALVE IN FIRST BRANCH TO PR-2B PORV
0120000 C-11-13   SNGLJUN
0120101 011010000 013000000
0120102   .038           0.            0.             1000    1.0000E+00   1.0000E+00
0120201     0  0.             0.             0.
*VOLUME LEADING TO PORV PR-2B
0130000 C-13      PIPE
0130001   5
0130101   3.8000E-02    5
0130301   5.4300E-01    5
0130601   0.            5
0130801  1.5000E-04   0.            5
0131001 00    5
0131101 1000    4
0131201 2  2471.8  1.000000E+00   0.            0.            5
0131301  0.            0.            0.           4
*PORV  PR-2B
0140000 PR-2B     VALVE
0140101 013010000 015000000
0140102   .010  0.            0.           0100    1.0000E+00   1.0000E+00
0140201     0  0.             0.             C.
0140300        SRVVLV
0140301 001
       TROL   INPUT
050    0    PORV   FUNCTION  1.0  0.0   0
C500101     TIME    0   210

VOLUME FROM PR-2B PORV TO BRANCH VOLUME 17
150000 C-15      PIPE
150001    3
150101    8.8000E-02    3
150301    4.9700E-01    3
150601    0.            3
150801  1.5000E-04   0.            3
151001 00    3
151101 1000    2
151201 4   14.7  120.  .948          0.            3
151301  0.            0.            0.           2
CONNECTS VOLUME 15 TO BRANCH 17
160000 C-15-17   SNGLJUN
160101 015010000 017000000
160102  .088           0.            0.             1000    1.0000E+00   1.0000E+00
160201      0  0.             0.             0.
OLUME WHICH JOINS FLOW FROM TWO PORV'S
170000 C-17      BRANCH
170001    0
170101    8.8000E-02  5.0000E-01   0.             0.           0.
170102    0.            1.5000E-04   0.            00
170200   4   14.7   120.   .948          0.
ON    S BRANCH 17 TO VOLUME 19
80     -17-19   SNGLJUN
801    017010000 019000000
80102    8.8000E-02  0.            0.            1000    1.0000E+00   1.0000E+00
80201      0  0.             0.             0.
```

```
*HORIZONTAL PIPE FROM BRANCH 17 TO THIRD ELBOW
0190000 C-19      SNGLVOL
0190101    8.8000E-02  4.9300E-01  0.              0.              0.
0190102    0.             1.5000E-04  0.           00
0190200  4  14.7  120.  .948                0.
*THIED 90 DEGREE ELBOW
0200000 C-19-21  SNGLJUN
0200101 019010000 021000000
0200102    8.8000E-02  1.7200E-01  1.7200E-01 1000    1.0000E+00  1.0
0200201      0  0.           0.           0.
*VERTICAL SEGMENT DOWNSTREAM PIPING
0210000 C-21      PIPE
0210001    2
0210101    8.8000E-02    2
0210301    4.9300E-01    2
0210601   -9.0000E+01    2
0210801   1.5000E-04   0.           2
0211001  00    2
0211101 1000    1
0211201 4  14.7  120.  .948                0.                 2
0211301  0.          0.          0.          1
*CONNECTS TO 45 DEGREE ELBOW
0220000 C-21-23  SNGLJUN
0220101 021010000 023000000
0220102    8.8000E-02  1.0300E-01  1.0300E-01 1000    1.0000E+00  1.
0220201      0  0.           0.           0.
*PIPE SEGMENT INCLUDED AT 45 DEGREES
0230000 C-23      PIPE
0230001    4
0230101    8.8000E-02    4
0230301    4.7700E-01    4
0230601   -4.5000E+01    4
0230801   1.5000E-04   0.           4
0231001  00    4
0231101 1000    3
0231201 4  14.7  120.  .948                0.                 4
0231301  0.          0.          0.          3
*TEE JUNCTION TO 10 INCH VERTICAL RUN
0240000 C-23-52  SNGLJUN
0240101 023010000 052000000
0240102    8.8000E-02  1.43  8.0600E-01 0000    1.0000E+00  1.0000E
0240201      0  0.           0.           0.
*CONNECTS BRANCH 7 TO VOLUME 26 LEADING TO PR-2A PORV
0250000 C-7-26   SNGLJUN
0250101 007010000 026000000
0250102    3.8000E-02  0.           0.           1000    1.0000E+00  1
0250201      0  0.           0.           0.
*HORIZONTAL PIPE FROMBRANCH 7 TO GATE VALVE IN PR-2A PORV
0260000 C-26      SNGLVOL
0260101    3.8000E-02  7.8500E-01  0.              0.              0.
0260102    0.             1.5000E-04  0.           00
0260200       2  2471.8  1.0000E+00  0.           0.
*OPEN GATE VALVE IN PR-2A PORV BRANCH
0270000 C-26-28  SNGLJUN
0270101 026010000 028000000
0270102    3.8000E-02  0.           0.           1000    1.0000E+00  1
0270201      0  0.           0.           0.
*HORIZONTAL PIPE FROM GATE VALVE TO PORV IN PR-2A BRANCH
0280000 C-28      PIPE
0280001    6
```

```
0280101    3.8000E-02    6
0280301    4.8900E-01    6
0280601    0.            6
0280801   1.5000E-04   0.              6
0281001  00    6
0281101  1000    5
0281201  2   2471.8   1.000000E+00   0.              0.              6
0281301   0.             0.              0.              5
*PORV  PR-2A
0290000  C-28-30   VALVE
0290101  028010000  030000000
0290102    .010   0.             0.            0100    1.0000E+00   1.0000E+00
0290201     0   0.             0.            0.
0290300         SRVVLV
0290301   001
*HORIZONTAL PIPE FROM PR-2A TO SECOND ELBOW IN BRANCH
0300000  C-30       PIPE
0300001     2
0300101     5.1000E-02    2
0300301     4.5000E-01    2
0300601     0.            2
0300801   1.5000E-04   0.              2
0301001  00    2
0301101  1000    1
0301201  4   14.7   120.   .948              0.              2
0301301   0.             0.             0.            1
*SECOND ELBOW IN PR-2A BRANCH
0310000  C-30-32   SNGLJUN
0310101  030010000  032000000
0310102     5.1000E-02   1.7300E-01   1.7300E-01  1000    1.0000E+00   1.0000E+00
0310201      0   0.            0.            0.
*PIPE FROM SECOND ELBOW TO 45 DEGREE ELBOW IN PR-2A BRANCH
0320000  C-32       PIPE
0320001     3
0320101     5.1000E-02    3
0320301     6.1400E-01    3
0320601     0.            3
0320801   1.5000E-04   0.              3
0321001  00    3
0321101  1000    2
0321201   4   14.7   120.   .948   0.0   3
0321301   0.0   0.0   0.0   2
*45 DEGREE ELBOW IN PR-2A BRANCH
0330000  C-32-34   SNGLJUN
0330101  032010000  034000000
0330102     5.1000E-02   1.0400E-01   1.0400E-01  1000    0.            0.
0330201      0   0.            0.            0.
*PIPE FROM 45 DEGREE ELBOW TO BRANCH VOLUME 19 IN PR-2A PIPING RUN
0340000  C-34       PIPE
0340001     2
0340101     5.1000E-02    2
0340301     5.7600E-01    2
0340601     0.            2
0340801   1.5000E-04   0.              2
0341001  00    2
0341101  1000    1
0341201  4   14.7   120.   .948              0.              2
0341301   0.             0.             0.            1
*CONNECTS PR-2A BRANCH TO MAIN RUN PR-2B
0350000  C-35-17   SNGLJUN
```

```
0350101 034010000 017000000
0350102   5.1000E-02  0.          0.          1000   0.
0350201     0  0.          0.          0.
*HORIZONTAL PIPING SEGMENT DOWNSTREAM FROM PSV
0360000 C-36      PIPE
0360001   3
0360101   2.0100E-01   3
0360301   5.0000E-01   3
0360601   0.           3
0360801  1.5000E-04  0.        3
0361001 00   3
0361101 1000   2
0361201 4  14.7  120.  .948          0.          3
0361301  0.          0.          0.         2
*FIRST 90 DEGREE ELBOW DOWNSTREAM FROM PSV
0370000 C-96-97  SNGLJUN
0370101 096010000 097000000
0370102   2.0100E-01  1.7200E-01  1.7200E-01 1000   0.
0370201     0  0.          0.          0.
*HORIZONTAL PIPING FROM FIRST ELBOW TO REDUCER
0380000 C-38      PIPE
0380001   10
380101    .201    10
380301    .529    10
380601    0.0     10
0380801    1.50000E-04   0.0      10
0381001 00   10
0381101 1000   9
0381201  4  14.7  120.  .948          0.          10
0381301  0.          0.          0.         9
*JUNCTION AT 6 INCH END OF REDUCER
0390000 C-38-40  SNGLJUN
0390101 038010000 040000000
0390102   .201  0.0  .1        1000   0.          0.
0390201     0  0.          0.          0.
*6 INCH BY 10 INCH REDUCER
0400000 C-40      SNGLVOL
0400101   3.7500E-01  5.0000E-01  0.          0.          0.
0400102   0.          1.5000E-04  0.          00
0400200  4  14.7  120.  .948          0.
*JUNCTION AT 10 INCH END OF REDUCER
0410000 C-40-42  SNGLJUN
0410101 040010000 042000000
0410102  .375  .94          0.          1000   0.          0.
0410201     0  0.          0.          0.
*HORIZONTAL SEGMENT DOWNSTREAM OF REDUCER
0420000 C-42      PIPE
0420001   3
0420101   5.4800E-01   3
0420301   5.7700E-01   3
0420601   0.           3
0420801  1.5000E-04  0.        3
0421001 00   3
0421101 1000   2
0421201 4  14.7  120.  .948          0.          3
0421301  0.          0.          0.         2
*CONNECTS DOWNSTREAM PIPING ADJACENT TO SECOND PSV DIS  GE
0430000 C-42-44  SNGLJUN
0430101 042010000 044000000
0430102 .546          0.          0.          1000   0.
```

```
0430201     0  0.          0.          0.
*DISCHARGE FROM SECOND PSV INTO MAIN PIPING RUN
0440000 C-44      BRANCH
0440001    0
0440101    5.4800E-01  5.0000E-01  0.          0.          0.
  0102    0.          1.5000E-04  0.          00
  0200  4  14.7  120.  .948          0.
*CONNECTS DOWNSTREAM PIPING FROM TWO SAFETY VALVES
0450000 C-44-46   SNGLJUN
0450101 044010000 046000000
0450102   .548    .934   .934          1000   0.          0.
0450201     0  0.          0.          0.
*HORIZONTAL SEGMENT UPSTREAM OF SECOND DISCHARGE ELBOW
0460000 C-46      PIPE
0460001    5
0460101    5.4800E-01   5
0460301    5.7600E-01   5
0460601    0.           5
0460801  1.5000E-04  0.          5
0461001 00   5
0461101 1000    4
0461201 4  14.7  120.  .948          0.          5
0461301   0.          0.          0.          4
*SECOND ELBOW IN PSV DOWNSTREAM PIPING
0470000 C-46-48   SNGLJUN
0470101 046010000 048000000
0470102   .137    .9   .9   1000   0.          0.
0470201     0  0.          0.          0.
*HORIZONTAL PIPE BETWEEN SECOND AND THIRD PSV DISCHARGE ELBOWS
  0000 C-48      PIPE
  001   10
0480101    5.4800E-01  10
0480301    6.2100E-01  10
0480601    0.          10
0480801  1.5000E-04  0.          10
0481001 00  10
0481101 1000    9
0481201 4  14.7  120.  .948          0.          10
0481301   0.          0.          0.          9
*THIRD ELBOW IN PSV DOWNSTREAM PIPING
0490000 C-48-50   SNGLJUN
0490101 048010000 050000000
0490102   5.4800E-01  1.7200E-01  1.7200E-01 1000   0.          0.
0490201     0  0.          0.          0.
*FIRST VERTICAL SEGMENT IN PSV DOWNSTREAM PIPING
0500000 C-50      PIPE
0500001    5
0500101    5.4800E-01   5
0500301    5.2600E-01   5
0500601   -9.0000E+01   5
0500801  1.5000E-04  0.          5
0501001 00    5
0501101 1000    4
0501201 4  14.7  120.  .948          0.          5
0501301   0.          0.          0.          4
*  NECTS VERTICAL SEGMENTS
   000 C-50-52   SNGLJUN
  101 050010000 052000000
0510102   .548          0.          0.          1000   0.          0.
0510201     0  0.          0.          0.
```

```
*PIPING TEE WHERE PORV FLOW ENTERS PSV 10 INCH VERTICAL DISCHARGE PI
0520000 C-52      BRANCH
0520001  0
0520101  .548 .5  0. -90.         0.
0520102   0.           1.5000E-04  0.        00
0520200  4  14.7  120.  .948          0.
*CONNECTS PORV-PSV TEE TO VERTICAL DISCHARGE PIPING
0530000 C-52-54  SNGLJUN
0530101 052010000 054000000
0530102   .548   .55  .55         1000   0.         0.
0530201    0  0.         0.         0.
*PSV 10 INCH VERTICAL  DISCHARGE SEGMENT TO FOURTH DISCHARGE ELBOW
0540000 C-54      PIPE
0540001  95
0540101   5.4800E-01  95
0540301   5.5800E-01  95
0540601  -9.0000E+01  95
0540801  1.5000E-04  0.        95
0541001 00  95
0541101 1000  94
0541201 4  14.7  120.  .948           0.          95
0541301  0.        0.        0.       94
*FOURTH ELBOW IN PSV DOWNSTREAM PIPING
0550000 C-54-56  SNGLJUN
0550101 054010000 056000000
0550102  .548          1.7200E-01  1.7200E-01 1000   0.         0.
0550201    0  0.        0.        0.
*HORIZONTAL SEGMENT
0560000 C-56      PIPE
0560001  35
0560101   5.4800E-01  35
0560301   8.9700E-01  35
0560601   0.          35
0560801  1.5000E-04  0.        35
0561001 00  35
0561101 1000  34
0561201 4  14.7  120.  .948           0.          35
0561301  0.        0.        0.       34
*16.6 DEGREE BEND IN DOWNSTREAM PIPING
0570000 C-56-58  SNGLJUN
0570101 056010000 058000000
0570102  .548          6.0000E-02  6.0000E-02 1000   0.         0
0570201    0  0.        0.        0.
*HORIZONTAL SEGMENT
0580000 C-58      PIPE
0580001   7
0580101   5.4800E-01   7
0580301   9.9700E-01   7
0580601   0.           7
0580801  1.5000E-04  0.         7
0581001 00   7
0581101 1000   6
0581201 4  14.7  120.  .948           0.           7
0581301  0.        0.        0.        6
*FIFTH ELBOW IN DOWNSTREAM PIPING
0590000 C-58-60  SNGLJUN
0590101 058010000 060000000
0590102 .548           1.7200E-01  1.7200E-01 1000   0.         0
0590201    0  0.        0.        0.
*VOLUME FROM RELIEF TANK ORIFICE TO AIR/WATER INTERFACE WITHIN TA
```

```
0600000 C-60      PIPE
0600001   3
0600101   5.4800E-01   3
0600301   1.1100E+00   3
0600601  -4.5000E+01   3
0600801  1.5000E-04  0.          3
0601001 00   3
0601101 1000   2
0601201 4  14.7  120.  .948          0.          3
0601301  0.            0.          0.           2
*AIR/WATER INTERFACE WITHIN PRESSURE RELIEF TANK
0610000 C-60-62  SNGLJUN
0610101 060010000 062000000
0610102  .548           0.          0.          1000   0.        0.
0610201     0  0.          0.          0.
*VOLUME DIRECTLY BELOW WATER SURFACE IN RELIEF TANK
0620000 C-62      PIPE
0620001   2
0620101   5.4800E-01   2
0620301   1.0000E+00   2
0620601  -4.5000E+01   2
0620801  1.5000E-04  0.          2
0621001 00   2
0621101 1000   1
0621201 2  1.470000E+01 1.0  0.          0.          2
0621301  0.            0.          0.          1
*45 DEGREE BEND IN RELIEF TANK
0630000 C-62-64  SNGLJUN
0630101 062010000 064000000
0630102  .548          1.0300E-01  1.0300E-01 1000   0.        0.
0630201     0  0.          0.          0.
*VOLUME OF DISCHARGE PIPING BELOW WATER IN PRESSURE RELIEF TANK
0640000 C-64      SNGLVOL
0640101  .548  1.65  0. -90.          0.
0640102   0.           1.5000E-04  0.          00
0640200      3  1.4700E+01  1.2000E+02  0.          0.
*CONNECTS C-64 TO C-66
0650000  C-64-66  SNGLJUN
0650101 064010000 066000000
0650102  .548           0.          0.          1000   0.        0.
0650201     0  0.          0.          0.
*90 DEGREE BEND IN RELIEF TANK
0660000 C-66      SNGLVOL
0660101 .548  1.5  0. -90.          0.
0660102   0.           1.5000E-04  0.          00
0660200      3  1.4700E+01  1.2000E+02  0.          0.
*90 DEGREE BEND IN RELIF TANK WATER
0670000 C-66-68  SNGLJUN
0670101 066010000 068000000
0670102  .548          1.7200E-01  1.7200E-01 1000   0.        0.
0670201     0  0.          0.          0.
*BEND VOLUME
0680000 C-68      SNGLVOL
0680101   5.4800E-01  1.5000E+00  0.          0.          0.
0680102   0.          1.5000E-04  0.          00
0680200     3  1.4700E+01  1.2000E+02  0.          0.
*HORIZONTAL DISCHARGE SPARGER WITHIN RELIEF TANK
0690000 C-69      BRANCH
0690001   3
0690101   5.4800E-01  4.0800E+00  0.          0.          0.
```

```
0690102   0.            1.5000E-04  0.          00
0690200     3  1.4700E+01  1.2000E+02  0.          0.
0691101 068010000 069000000   5.4800E-01  0.          0.
0692101 069010000 073000000   2.7300E-01 1.89  1.71 0000
0693101  069010000  070000000  .548   0.0   0.0   1000
0692201  0.          0.          0.
0693201  0.          0.          0.
0691201   0.0   0.0    0.0
*HORIZONTAL DISCHARGE SPARGER WITHIN RELIEF TANK
0700000 C-70      BRANCH
0700001     2
0700101   5.4800E-01  4.0800E+00  0.          0.          0.
0700102   0.            1.5000E-04  0.          00
0700200     3  1.4700E+01  1.2000E+02  0.          0.
0701101 070010000 073000000   2.7300E-01  1.89  1.71  0000
0701201  0.          0.          0.
0702101 070010000 071000000   5.4800E-01  0.          0.
0702201  0.          0.          0.
*HORIZONTAL DISCHARGE SPARGER WITHIN RELIEF TANK
0710000 C-71      SNGLVOL
0710101   5.4800E-01  4.0800E+00  0.          0.          0.
0710102   0.            1.5000E-04  0.          00
0710200     3  1.4700E+01  1.2000E+02  0.          0.
*CONNECTS COMPONENT SPARGER 71 TO WATER IN RELIEF TANK
0720000 C-71-73   SNGLJUN
0720101 071010000 073000000
0720102   2.8500E-01  1.89  1.71  0000   1.0000E+00  1.0000E+00
0720201    0  0.          0.          0.
*WATER IN RELIEF TANK (REPRESENTS 75 % OF FREE VOLUME OF RELIEF
0730000 C-73      BRANCH
0730001   0
0730101   1.0665E+02  5.6290E+00  0.          0.          .0000
0730102   5.6290E+00  1.5000E-04  0.          00
0730200     3  1.4700E+01  1.2000E+02  0.          0.
*AIR/WATER INTERFACE WITHIN RELIEF TANK
0740000 C-73-75   SNGLJUN
0740101 073010000 075000000
0740102   1.0660E+02  0.          0.          1000   1.0000E+00
0740201    0  0.          0.          0.
*VOLUME OF AIR IN RELIEF TANK
0750000 C-75      SNGLVOL
0750101   1.0660E+02  1.8760E+00  0.          0.          9.0000
0750102   1.8760E+00  1.5000E-04  0.          00
0750200     4  1.4700E+01  1.2000E+02  9.4800E-01  0.
*HORIZONTAL SEGMENT DOWNSTREAM FROM SECOND PSV
0760000 C-76      PIPE
0760001     4
0760101   2.0100E-01    4
0760301   5.0000E-01    4
0760601   0.            4
0760801  1.5000E-04  0.          4
0761001 00     4
0761101 1000     3
0761201 4  14.7  120.  .948          0.          4
0761301  0.          0.          0.          3
*JUNCTION TO BRANCH COMPONENT 44
0770000 C-76-44   SNGLJUN
0770101 076010000 044000000
0770102  .201  .89 3.3       1000   1.0000E+00  1.0000E+00
0770201    0  0.          0.          0.
```

```
*
* PRESSURIZER VAULT
*
0930000  C-93  SNGLVOL
0930101 90. 100.  0. 0. 0. 0. .00015 0. 00
0930200  4 14.7  120.  .948
*
*  RUPTURE  DISC
*
0940000  RD  VALVE
0940101  095010000 093000000 .19 0. 0. 0100
0940201  0 0. 0. 0.
0940300   MTRVLV
**  CONTROL  VARIABLE  NUMBER
0940301  506  507   25.  0.0  2
*
*  RUPTURE  DISC   TABLE
20200200  NORMAREA
20200201  0.  0.
20200202  1.0  1.0
*  RUPTURE  DISC  BAFFLE  CAVITY
*
0950000  C-95  BRANCH
0950001  0
0950101  .201  1.00  0. 0. 0. 0. .00015  0. 00
0950200  4  14.7  120.  .948
*
*  INLET  TO DISCHARGE  PIPING
*
0960000  C-96  BRANCH
0960001  3
0960101  .201  .529  0.  0. 0. 0. .00015  0.  00
0960200  4  14.7  120.  .948
0961101  96010000  97000000 .1005  .575 .575 0000
0961201  0.0  0.0  0
0962101  96010000  95000000 .1005  .575 .575 0000
0962201  0.0  0.0  0
0963101  96010000  38000000  .201   0.  0.   0000
0963201  0.0  0.0  0
*
*  OUTLET  FROM  INACTVE  SAFETY VALVE
*
0970000  C-97  BRANCH
0970001  2
0970101  .201  .5  0. 0. 0. 0. .00015  0.  00
0970200  4  14.7  120.  .948
0971101 97010000  36000000  .201  .0  .0  0000
0971201  0.0  0.0  0
0972101  97010000  95000000  .1005 24.75 24.75  0000
0972201  0.0  0.0  0
**
*
* PRESSURE RELIEF TANK RUPTURE DISC
*
1150000  RD  VALVE
1150101  075010000   093000000
1150102  .548  0.  0.  0100
1150201  0  0.  0.  0.
1150300  MTRVLV
**  CONTROL  VARIABLE  NUMBER
```

```
1150301   508   507   25.0   0.0   2
*
*
20221000 REAC-T       0
20221001    0.           0.
20221002    5.0000E-01   1.0000E+00
20221003    1.0000E+01   1.0000E+00
.END OF CASE
```

APPENDIX H

ADLPIPE INPUT FOR DOUBLE SAFETY VALVE ACTUATION SIMULATION

GE	S/RV PIPING KEWAUNSE GKWOPF 2 RUP DISK							
AN			1036.2622	656.0156	14.0620			
[illegible]			101.	1.	1.	1.	1.	1.
[illegible]			4731.1165	656.0056	16.3860			
[illegible]			471.	1.	1.	1.	1.	1.
AN			68-8.0432	600.9089	30.0693			
RE			681.	1.	1.	1.	1.	1.
AN			9437.5568	656.0132	17.1633			
RE			941.	1.	1.	1.	1.	1.
SE								
PI		10	256.625	.718	25.15			3.78
RU		10	12.13912	.22396	-.17551			
MA		10	12					27.4
EL		12	14			9.		
RU		14	16	3.4375				
EL		16	801			6.	45.	
EL		801	17			6.		
TA		17	8021.0284		.7105			
EL		17	802			9.	45.	
EL		802	18			9.		
RU		18	20	-2.5208				
EL		20	803			9.	45.	
EL		803	21			9.		
TA		21	8041.2341		.8526			
EL		21	804			9.	45.	
EL		804	22			9.		
SK		804	22.8227		.5684		1.	
SP	RC-H8	804	221680000.					
RU		22	23	.76				
RU	FLG	23	24	.5733				
CH		23	246.625	1.436				24.3
[illegible]	PR-3A	24	25	.9375		6.625	1.436	.01
[illegible]	PR-3A	25	26	.3958		6.625	1.436	.01
VA	PR-3A	26	805.0398		.0732	6.625	1.436	684.
SE								
VA	PR-3A	25	27.4473		.8239	6.625	1.436	.01
RU	FLG	27	228.1839		.3387			
CH		27	228					16.6
RU		228	28.1492		.2746			
CH		228	286.625	.28	26.6			1.58
MA		228	2818800.	16600.				28.3
PR		228	28700.					
EL		28	806			9.	22.5	
EL		806	29			9.		
RU	H7-NEW	29	229-.1306		.4409			
RU		229	230-.0418		.1412			
TE		230	841-.1331		.4494			
SE								
TE		841	231-.1331		.4494			
RU	RPD	231	842-.1183		.3995			
CH		231	842					.01
WE		231	842250.					
SE								
TE		841	232-.4494		-.1331			
CH		841	232					1.58
RU		232	233-.2996		-.0888			
EL		233	843			9.	22.5	
EL		843	234			9.		
RU		234	400-.2746		.1491			

[illegible]		400	401-.5126		.2783	10.75	.365	3.37
PS		400	401875.					
RU		401	235-.7323		.3976			
CH		401	23510.75	.365	26.9			
MA		401	23518800.	18100.				
SE								
RU		235	236	-.01				
RU	RC-H40	236	237	-.9067				
RB		236	237					
SE								
RU		235	403-.7323		.3976			
RU		403	33-2.3841		1.2945			
RU	RC-H6	33	807-.6225		.3380			
CH		33	807					8.7
SE								
RU		807	900.4523		.8331			
CH		807	9006.625	.28	26.6			1.58
MA		807	90018800.	16600.				28.3
PR		807	900700.					
EL		900	852			9.	22.5	
EL		852	901			9.		
RU		901	853.6991		.2071			
WE		901	853250.					
SE								
RU		807	34-.3032		-.5584			
CH		807	346.625	.28	26.6			1.58
PR		807	34700.					
MA		807	3418800.	16600.				28.3
RU	FLG	34	35-.1839		-.3387			
PR		34	352485.					
CH		34	356.625	1.436	25.15			16.6
MA		34	3518750.	16000.				27.4
VA	PR-3E	35	36-.4473		-.8239	6.625	1.436	[illegible]
SE								
VA	PR-3B	36	37	.3958		6.625	1.436	.01
VA	PR-3B	37	808.0398		.0732	6.625	1.436	684.
SE								
VA	PR-3B	36	38	-.9375		6.625	1.436	.01
RU	FLG	38	138	-.5733				
CH		38	138					24.3
SK		38	138.4772		.8788		1.	
SP	RC-H9	38	1381680000.					
RU		138	39	-.76				
CH		138	396.625	.718	25.15			3.78
EL		39	809			9.	45.	
EL		809	40			9.		
TA		809	40-.7157		-1.3182			
EL		40	810			9.	45.	
EL		810	41			9.		
RU		41	42	2.5208				
EL		42	811			9.	45.	
EL		811	43			9.		
TA		811	43-.5964		-1.09852			
EL		43	812			6.	45.	
EL		812	44			6.		
RU		44	45	-3.4479				
EL		45	46			9.		
RU		46	47.22396	-.22396				
SE								
RU		807	50-.6225		.3380			

MA		807	5018800.	18100.				28.3
PR		807	50875.					
[illegible]		807	5010.75	.365	26.9			8.7
[illegible]		50	52-1.0992		.5968			
CH		50	52					3.37
EL		52	813			15.	45.	
EL		813	53			15.		
RU		53	253-.5965		-1.0985			
RU		253	844-.2386		-.4394			
CH		253	84410.75	.73				37.8
RU		844	254-.2386		-.4394			
RU		254	55-2.0279		-3.7351			
CH		254	5510.75	.365	26.4			3.37
MA		254	5518750.	16300.				27.4
EL		55	814			15.	45.	
EL	RC-H5	814	56			15.		
RU	RC-H37	56	57	-1.8333				
RU		57	815	-1.125				
SE								
RU		815	816	-8.4387				
RU		816	817	-9.0				
RU		817	850	-9.0				
RU		850	59	-2.78015				
SE								
RU		59	559.2386		.4394			
RU		559	560.2386		.4394			
RB		559	560					
SE								
RU	RC-H3	59	60	-3.75				
SP	RC-H4	59	60700000.		700000.			
RU		60	818	-2.0				
RU		818	851	-9.0				
RU	[illegible]39	851	61	-8.5				
RU		61	161	-1.5				
EL		161	819			15.	45.	
EL		819	62			15.		
RU	RC-H38	62	63-1.7344		.7113			
RU	RC-H2	63	64-3.5156		1.4419			
SE								
RU		64	820-4.0021		1.6414			
RU		820	821-9.2521		3.7946			
RU	RC-H1	821	65-4.9416		2.0267			
RU		65	265-5.8596		2.4032			
EL		265	822			15.	8.3	
EL		822	266			15.		
RU		266	66-7.2141		.7201			
EL		66	823			15.	45.	
EL		823	67			15.		
RU		67	68.1580	-1.5910	1.5831			
SE								
RU		815	70.3936	.4479	-.2137			
MA		815	7018750.	14950.				27.4
PR		815	70700.					
RU		70	700.0001	.0001	-.0001			
RU		700	71.4119	.4687	-.2236			
CH		700	714.5	.237	26.4			.899
EL		71	824			6.	22.5	
EL		824	72			6.		
RU		72	173	1.1042				
EL		173	825			6.	45.	

EL		825	174			6.		
RU		174	73.4394		-.2386			
RU		73	826.2197		-.1193			
SE								
RU		826	74.8788		-.4772			
RO		74	75.2929		-.1591	3.5	.437	1.19
RU		75	750.4010	.0439	-.2177			
VA	PR-2B	750	76.4465	.0489	-.2424	3.5	.874	.01
MA		750	7618750.	14300.				27.4
PR		750	762510.					
SE								
VA	PR-2B	76	77	1.		3.5	.874	.01
VA	PR-2B	77	827	1.6083		3.5	.874	480.
SE								
VA	PR-2B	76	78.4465	.0489	-.2424	3.5	.874	.01
RU	RC-H11	78	80.7381	.0808	-.4008			
CH		78	80		25.15			
RU		80	81.7381	.0808	-.4008			
VA	PR-1B	81	82.4374	.0479	-.2375	3.5	.874	.01
SE								
VA	PR-1B	82	83	.5		3.5	.874	.01
VA	PR-1B	83	828	.33		3.5	.874	527.
SE								
VA	PR-1B	82	84.4374	.0479	-.2375	3.5	.874	.01
RU		84	85.3281	.0359	-.1781			
EL		85	829			4.5	45.	
EL		829	86			4.5		
RU		86	871.1780		2.1696			
TE		87	830.1342		.2472			
SE								
TE		830	89.1342		.2472			
RU		89	901.2974		2.3892			
EL		90	831			4.5	45.	
EL		831	91			4.5		
RU		91	92	-2.7937				
EL		92	93			4.5		
RU		93	94-.1082	-.1179	-.0468			
SE								
TE		830	95-.2461	-.0262	.1336			
VA	PR-1A	95	96-.4375	-.0466	.2376	3.5	.874	.01
SE								
VA	PR-1A	96	97	.5		3.5	.874	.01
VA	PR-1A	97	832	.33		3.5	.874	527.
SE								
VA	PR-1A	96	98-.4375	-.0466	.2376	3.5	.874	.01
RU	RC-H12	98	99-.8385	-.0892	.4553			
RU		99	100-.8385	-.0892	.4553			
VA	PR-2A	100	101-.4466	-.0475	.2425	3.5	.874	.01
SE								
VA	PR-2A	101	102	1.		3.5	.874	.01
VA	PR-2A	102	833	1.6083		3.5	.874	480
SE								
VA	PR-2A	101	103-.4466	-.0475	.2425	3.5	.874	.01
RU		103	704-.4010	-.0427	.2178			
CH		103	7043.5	.216	26.4			.63
MA		103	70418750.	14950.				27.
PR		103	704700.					
RU		704	104-.3296		.1790			
EL		104	834			4.5	45.	
EL		834	105			4.5		

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RU        105  106-.9196                        -1.6935
EL        106  8355                                         4.5          22.5
          835  107                                          4.5
          107  707-.8616                        -.2552
          707  826-.2542                        -.0753
CH        707  8264.5           .237            26.4                                    .899
EN
EX       2 SAFETY COLD FKW24F--2 PSV
B31       1977        24.         2485.         1.2         18750.      16000.      1.
VI                    0.0         .001          .4          0.02        300.        1.
TBLE        10   10    -1.
```

X	1	6	0.000E+00	0.450E-02	0.575E-02	0.700E-02	0.825E-02	0.950E-02
X	7	12	0.107E-01	0.120E-01	0.132E-01	0.145E-01	0.157E-01	0.170E-01
X	13	18	0.176E-01	0.182E-01	0.189E-01	0.195E-01	0.201E-01	0.207E-01
X	19	24	0.214E-01	0.219E-01	0.225E-01	0.242E-01	0.249E-01	0.255E-01
X	25	30	0.261E-01	0.267E-01	0.274E-01	0.280E-01	0.286E-01	0.292E-01
X	31	36	0.299E-01	0.307E-01	0.320E-01	0.332E-01	0.345E-01	0.357E-01
X	37	42	0.366E-01	0.380E-01	0.392E-01	0.401E-01	0.410E-01	0.417E-01
X	43	48	0.430E-01	0.442E-01	0.455E-01	0.467E-01	0.480E-01	0.492E-01
X	49	54	0.505E-01	0.517E-01	0.530E-01	0.542E-01	0.555E-01	0.567E-01
X	55	60	0.580E-01	0.592E-01	0.605E-01	0.617E-01	0.630E-01	0.642E-01
X	61	66	0.655E-01	0.667E-01	0.680E-01	0.692E-01	0.705E-01	0.717E-01
X	67	72	0.730E-01	0.742E-01	0.755E-01	0.767E-01	0.780E-01	0.792E-01
X	73	78	0.805E-01	0.817E-01	0.830E-01	0.842E-01	0.855E-01	0.867E-01
X	79	84	0.880E-01	0.892E-01	0.905E-01	0.917E-01	0.930E-01	0.942E-01
X	85	90	0.955E-01	0.967E-01	0.980E-01	0.992E-01	0.100E+00	0.102E+00
X	91	96	0.103E+00	0.104E+00	0.105E+00	0.107E+00	0.107E+00	0.108E+00
X	97	102	0.109E+00	0.110E+00	0.111E+00	0.113E+00	0.114E+00	0.114E+00
X	103	108	0.115E+00	0.116E+00	0.117E+00	0.119E+00	0.120E+00	0.121E+00
X	109	114	0.122E+00	0.124E+00	0.125E+00	0.126E+00	0.127E+00	0.129E+00
X	115	120	0.130E+00	0.131E+00	0.132E+00	0.134E+00	0.135E+00	0.136E+00
X	121	126	0.137E+00	0.139E+00	0.140E+00	0.141E+00	0.142E+00	0.144E+00
X	127	132	0.145E+00	0.146E+00	0.147E+00	0.149E+00	0.150E+00	0.151E+00
X	133	138	0.152E+00	0.154E+00	0.155E+00	0.156E+00	0.157E+00	0.158E+00
X	139	144	0.159E+00	0.160E+00	0.161E+00	0.162E+00	0.164E+00	0.165E+00
X	145	150	0.166E+00	0.167E+00	0.169E+00	0.170E+00	0.171E+00	0.172E+00
X	151	156	0.174E+00	0.175E+00	0.176E+00	0.177E+00	0.179E+00	0.180E+00
X	157	162	0.181E+00	0.182E+00	0.184E+00	0.185E+00	0.186E+00	0.187E+00
X	163	168	0.189E+00	0.190E+00	0.191E+00	0.192E+00	0.195E+00	0.197E+00
X	169	174	0.200E+00	0.202E+00	0.205E+00	0.207E+00	0.210E+00	0.212E+00
X	175	180	0.215E+00	0.217E+00	0.220E+00	0.222E+00	0.225E+00	0.227E+00
X	181	186	0.230E+00	0.232E+00	0.235E+00	0.237E+00	0.240E+00	0.242E+00
X	187	192	0.245E+00	0.247E+00	0.250E+00	0.252E+00	0.255E+00	0.257E+00
X	193	198	0.260E+00	0.262E+00	0.263E+00	0.264E+00	0.266E+00	0.267E+00
X	199	204	0.268E+00	0.269E+00	0.271E+00	0.272E+00	0.273E+00	0.274E+00
X	205	210	0.276E+00	0.277E+00	0.278E+00	0.279E+00	0.281E+00	0.282E+00
X	211	216	0.283E+00	0.284E+00	0.286E+00	0.287E+00	0.288E+00	0.289E+00
X	217	222	0.291E+00	0.292E+00	0.293E+00	0.294E+00	0.296E+00	0.297E+00
X	223	228	0.298E+00	0.299E+00	0.301E+00	0.302E+00	0.303E+00	0.304E+00
X	229	234	0.306E+00	0.307E+00	0.308E+00	0.309E+00	0.311E+00	0.312E+00
X	235	240	0.313E+00	0.314E+00	0.316E+00	0.317E+00	0.318E+00	0.319E+00
X	241	246	0.321E+00	0.322E+00	0.323E+00	0.324E+00	0.326E+00	0.327E+00
X	247	252	0.328E+00	0.329E+00	0.331E+00	0.332E+00	0.333E+00	0.334E+00
X	253	258	0.336E+00	0.337E+00	0.338E+00	0.339E+00	0.341E+00	0.342E+00
X	259	264	0.343E+00	0.344E+00	0.346E+00	0.347E+00	0.348E+00	0.349E+00
X	265	270	0.351E+00	0.352E+00	0.353E+00	0.354E+00	0.356E+00	0.357E+00
X	271	276	0.358E+00	0.359E+00	0.361E+00	0.362E+00	0.363E+00	0.364E+00
X	277	282	0.366E+00	0.367E+00	0.368E+00	0.369E+00	0.371E+00	0.372E+00
X	283	288	0.373E+00	0.374E+00	0.376E+00	0.377E+00	0.378E+00	0.379E+00
X	289	294	0.381E+00	0.382E+00	0.383E+00	0.384E+00	0.386E+00	0.387E+00

X	295	300	0.388E+00	0.389E+00	0.391E+00	0.392E+00	0.393E+00	0.394E
X	301	306	0.396E+00	0.397E+00	0.398E+00	0.399E+00	0.401E+0[illegible]	[illegible]02E
X	307	312	0.403E+00	0.404E+00	0.406E+00	0.407E+00	0.408E+0[illegible]	[illegible]09E
X	313	318	0.411E+00	0.412E+00	0.413E+00	0.414E+00	0.416E+00	0.417E
X	319	324	0.418E+00	0.419E+00	0.421E+00	0.422E+00	0.423E+00	0.424E
X	325	330	0.425E+00	0.426E+00	0.427E+00	0.428E+00	0.430E+00	0.431E
X	331	336	0.432E+00	0.433E+00	0.435E+00	0.436E+00	0.437E+00	0.438E
X	337	342	0.440E+00	0.441E+00	0.442E+00	0.443E+00	0.445E+00	0.446E
X	343	348	0.447E+00	0.448E+00	0.450E+00	0.451E+00	0.452E+00	0.453E
X	349	354	0.455E+00	0.456E+00	0.457E+00	0.458E+00	0.460E+00	0.461E
X	355	360	0.462E+00	0.463E+00	0.465E+00	0.466E+00	0.467E+00	0.468E
X	361	366	0.470E+00	0.471E+00	0.472E+00	0.473E+00	0.475E+00	0.476E
X	367	372	0.477E+00	0.478E+00	0.480E+00	0.481E+00	0.482E+00	0.483E
X	373	378	0.485E+00	0.486E+00	0.487E+00	0.488E+00	0.490E+00	0.491E
X	379	384	0.492E+00	0.493E+00	0.495E+00	0.496E+00	0.497E+00	0.498E
X	385	390	0.500E+00	0.501E+00	0.502E+00	0.503E+00	0.505E+00	0.506E
X	391	393	0.507E+00	0.508E+00	0.510E+00			
Y	1	6	0.000E+00	-0.132E+04	-0.217E+04	-0.336E+04	-0.396E+04	-0.364E
Y	7	12	-0.218E+04	-0.110E+04	-0.783E+03	-0.103E+04	-0.759E+03	0.181E
Y	13	18	0.170E+02	0.787E+03	0.862E+03	0.963E+03	0.110E+04	0.122
Y	19	24	0.162E+04	0.187E+04	0.275E+04	0.428E+04	0.366E+04	0.243
Y	25	30	0.143E+04	0.857E+03	0.760E+03	0.650E+03	0.601E+03	0.437
Y	31	36	0.187E+03	0.865E+02	-0.395E+02	0.113E+03	0.191E+03	0.152
Y	37	42	0.979E+02	0.966E+02	0.805E+02	0.369E+02	0.472E+02	0.315
Y	43	48	0.238E+02	0.138E+02	-0.212E+01	-0.770E+01	-0.199E+02	-0.192
Y	49	54	-0.245E+02	-0.188E+02	-0.205E+02	-0.131E+02	-0.144E+02	-0.572
Y	55	60	-0.506E+01	0.504E+01	0.576E+01	0.142E+02	0.119E+02	0.176
Y	61	66	0.130E+02	0.160E+02	0.912E+01	0.107E+02	0.268E+01	0.361
Y	67	72	-0.466E+01	-0.358E+01	-0.109E+02	-0.814E+01	-0.135E+02	-0.888
Y	73	78	-0.122E+02	-0.564E+01	-0.804E+01	-0.122E+01	-0.335E+01	0.356
Y	79	84	0.120E+01	0.744E+01	0.424E+01	0.965E+01	0.519E+[illegible]	[illegible].899
Y	85	90	0.311E+01	0.613E+01	-0.125E+00	0.262E+01	-0.365E+[illegible]	[illegible]656
Y	91	96	-0.651E+01	-0.285E+01	-0.786E+01	-0.330E+01	0.381E+0[illegible]	[illegible].644
Y	97	102	-0.782E+01	-0.983E+00	-0.431E+01	0.145E+01	-0.195E+01	0.941
Y	103	108	-0.128E+02	0.725E+01	0.527E+01	0.739E+00	0.558E+01	0.948
Y	109	114	0.504E+01	-0.242E+00	0.346E+01	-0.198E+01	0.173E+01	-0.362
Y	115	120	0.270E+00	-0.479E+01	-0.544E+00	-0.518E+01	-0.484E+00	-0.467
Y	121	126	0.386E+00	-0.358E+01	0.161E+01	-0.233E+01	0.278E+01	-0.131
Y	127	132	0.360E+01	-0.763E+00	0.383E+01	-0.939E+00	0.347E+01	-0.146
Y	133	138	0.272E+01	-0.231E+01	0.183E+01	-0.564E+01	0.335E+01	-0.121
Y	139	144	-0.189E+01	-0.116E+01	0.222E+00	-0.414E+01	0.828E+00	-0.339
Y	145	150	0.149E+01	-0.277E+01	0.210E+01	-0.219E+01	0.260E+01	-0.181
Y	151	156	0.286E+01	-0.170E+01	0.283E+01	-0.187E+01	0.253E+01	-0.224
Y	157	162	0.212E+01	-0.267E+01	0.172E+01	-0.302E+01	0.147E+01	0.700
Y	163	168	0.106E+01	-0.945E+01	-0.499E+01	-0.897E+01	-0.245E+01	-0.125
Y	169	174	0.180E+01	-0.913E+01	0.315E+01	-0.998E+01	0.387E+00	-0.11
Y	175	180	0.120E+01	-0.895E+01	0.341E+01	-0.872E+01	0.595E+01	-0.46
Y	181	186	0.537E+01	-0.606E+01	0.566E+01	-0.642E+01	0.501E+01	-0.65
Y	187	192	0.558E+01	-0.597E+01	0.579E+01	-0.576E+01	0.525E+01	-0.60
Y	193	198	0.720E+01	-0.216E+01	-0.129E+02	0.142E+01	0.674E+01	0.12
Y	199	204	0.627E+01	0.140E+01	0.611E+01	0.575E+00	0.497E+01	-0.38
Y	205	210	0.471E+01	0.222E+00	0.470E+01	-0.143E+01	0.256E+01	-0.28
Y	211	216	0.241E+01	-0.181E+01	0.373E+01	-0.922E+00	0.398E+01	-0.99
Y	217	222	0.381E+01	-0.117E+01	0.360E+01	-0.144E+01	0.326E+01	-0.17
Y	223	228	0.301E+01	-0.193E+01	0.289E+01	-0.202E+01	0.281E+01	-0.20
Y	229	234	0.273E+01	-0.215E+01	0.270E+01	-0.220E+01	0.267E+01	-0.21
Y	235	240	0.265E+01	-0.220E+01	0.265E+01	-0.223E+01	0.258E+01	-0.22
Y	241	246	0.264E+01	-0.218E+01	0.267E+01	-0.218E+01	0.258E+01	-0.22
Y	247	252	0.257E+01	-0.228E+01	0.254E+01	-0.235E+01	0.250E+01	-0.23
Y	253	258	0.244E+01	-0.229E+01	0.251E+01	-0.251E+01	0.234E+01	-0.23

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Y           259   264 0.245E+01-0.255E+01 0.226E+01-0.249E+01 0.244E+01-0.235E+01
Y           265   270 0.243E+01-0.248E+01 0.227E+01-0.261E+01 0.220E+01-0.264E+01
            271   276 0.218E+01-0.266E+01 0.216E+01-0.267E+01 0.215E+01-0.267E+01
Y           277   282 0.216E+01-0.267E+01 0.215E+01-0.268E+01 0.214E+01-0.269E+01
Y           283   288 0.216E+01-0.272E+01 0.214E+01-0.269E+01 0.213E+01-0.271E+01
Y           289   294 0.212E+01-0.272E+01 0.212E+01-0.272E+01 0.211E+01-0.272E+01
Y           295   300 0.210E+01-0.272E+01 0.212E+01-0.273E+01 0.211E+01-0.273E+01
Y           301   306 0.211E+01-0.272E+01 0.212E+01-0.272E+01 0.211E+01-0.270E+01
Y           307   312 0.209E+01-0.273E+01 0.211E+01-0.273E+01 0.212E+01-0.273E+01
Y           313   318 0.212E+01-0.273E+01 0.212E+01-0.273E+01 0.211E+01-0.274E+01
Y           319   324 0.211E+01-0.273E+01 0.212E+01-0.273E+01 0.211E+01-0.273E+01
Y           325   330 0.316E+01-0.145E+02 0.627E+01 0.260E+01 0.582E+00-0.354E+01
Y           331   336 0.187E+01-0.281E+01 0.202E+01-0.285E+01 0.205E+01-0.281E+01
Y           337   342 0.207E+01-0.281E+01 0.207E+01-0.274E+01 0.217E+01-0.267E+01
Y           343   348 0.213E+01-0.271E+01 0.213E+01-0.273E+01 0.213E+01-0.273E+01
Y           349   354 0.214E+01-0.274E+01 0.212E+01-0.274E+01 0.212E+01-0.275E+01
Y           355   360 0.212E+01-0.275E+01 0.212E+01-0.275E+01 0.212E+01-0.275E+01
Y           361   366 0.213E+01-0.275E+01 0.213E+01-0.274E+01 0.213E+01-0.274E+01
Y           367   372 0.213E+01-0.274E+01 0.213E+01-0.275E+01 0.213E+01-0.275E+01
Y           373   378 0.213E+01-0.275E+01 0.213E+01-0.275E+01 0.213E+01-0.275E+01
Y           379   384 0.212E+01-0.275E+01 0.213E+01-0.276E+01 0.213E+01-0.275E+01
Y           385   390 0.214E+01-0.274E+01 0.212E+01-0.275E+01 0.214E+01-0.273E+01
Y           391   393 0.224E+01-0.249E+01 0.254E+01
TBLE         20    10    -1.
Y             1     6 0.000E+00-0.159E+03-0.355E+03-0.105E+04-0.243E+04-0.417E+04
Y             7    12-0.563E+04-0.650E+04-0.711E+04-0.769E+04-0.119E+05-0.134E+05
Y            13    18-0.161E+05-0.113E+05-0.830E+04-0.589E+04-0.382E+04 0.151E+04
Y            19    24 0.501E+04 0.134E+05 0.124E+05 0.220E+04 0.102E+05 0.147E+05
Y            25    30 0.239E+05 0.245E+05 0.753E+04 0.994E+04 0.186E+05 0.120E+05
Y            31    36 0.123E+04 0.394E+04 0.133E+04 0.760E+03 0.482E+03 0.308E+03
Y            37    42 0.159E+03 0.356E+02 0.165E+02 0.105E+02-0.163E+02-0.203E+02
Y            43    48-0.186E+02-0.163E+02-0.420E+01 0.246E+02 0.495E+02 0.512E+02
Y            49    54 0.413E+02 0.356E+02 0.359E+02 0.342E+02 0.205E+02-0.257E+01
Y            55    60-0.224E+02-0.293E+02-0.220E+02-0.566E+01 0.120E+02 0.250E+02
Y            61    66 0.347E+02 0.438E+02 0.384E+02 0.123E+02-0.246E+02-0.459E+02
Y            67    72-0.528E+02-0.521E+02-0.411E+02-0.171E+02 0.269E+01 0.140E+02
Y            73    78 0.258E+02 0.301E+02 0.284E+02 0.165E+02-0.114E+02-0.422E+02
Y            79    84-0.559E+02-0.563E+02-0.436E+02-0.219E+02 0.382E+00 0.136E+02
Y            85    90 0.181E+02 0.193E+02 0.243E+02 0.275E+02 0.260E+02 0.151E+02
Y            91    96-0.800E+01-0.391E+02-0.572E+02-0.573E+02-0.323E+02-0.511E+02
Y            97   102-0.358E+02-0.153E+02-0.168E+01 0.659E+01 0.128E+02 0.950E+01
Y           103   108 0.174E+02 0.234E+02 0.250E+02 0.297E+02 0.366E+02 0.335E+02
Y           109   114 0.204E+02-0.435E+00-0.236E+02-0.341E+02-0.305E+02-0.185E+02
Y           115   120-0.735E+01-0.195E+01-0.350E+01-0.476E+01-0.205E+01-0.199E+00
Y           121   126-0.339E+01-0.140E+02-0.260E+02-0.315E+02-0.285E+02-0.254E+02
Y           127   132-0.251E+02-0.220E+02-0.203E+02-0.178E+02-0.152E+02-0.119E+02
Y           133   138-0.851E+01-0.537E+01-0.297E+01-0.791E+00-0.178E+01 0.291E+01
Y           139   144 0.238E+01 0.400E+01 0.170E+01-0.678E+00-0.163E+01-0.217E+01
Y           145   150 0.566E+00 0.570E+01 0.681E+01 0.620E+00-0.803E+01-0.143E+02
Y           151   156-0.165E+02-0.161E+02-0.142E+02-0.116E+02-0.976E+01-0.903E+01
Y           157   162-0.939E+01-0.104E+02-0.111E+02-0.113E+02 0.717E+02 0.250E+01
Y           163   168-0.959E+01-0.209E+02-0.206E+02-0.165E+02-0.203E+02-0.142E+02
Y           169   174-0.180E+02-0.152E+02-0.885E+01-0.119E+02-0.219E+02-0.134E+02
Y           175   180-0.117E+02-0.319E+01-0.662E+01-0.900E+01 0.575E+00 0.438E+01
Y           181   186-0.196E+01-0.165E+00-0.258E+00-0.688E+00-0.184E+01-0.115E+01
Y           187   192-0.140E+00 0.375E+00 0.458E+00 0.279E+01 0.508E-01 0.184E+01
Y           193   198 0.562E+01 0.531E+01 0.539E+01 0.399E+01 0.956E+01 0.105E+02
Y           199   204 0.114E+02 0.116E+02 0.108E+02 0.950E+01 0.811E+01 0.595E+01
Y           205   210 0.544E+01 0.707E+01 0.672E+01 0.498E+01 0.371E+01 0.245E+01
Y           211   216 0.262E+01 0.392E+01 0.460E+01 0.546E+01 0.478E+01 0.519E+01
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Y          217  222 0.390E+01 0.469E+01 0.329E+01 0.411E+01 0.242E+01 0.35
Y          223  228 0.189E+01 0.313E+01 0.146E+01 0.306E+01 0.124E+00 0.29
Y          229  234 0.892E+00 0.277E+01 0.821E+00 0.270E+01 0.607E[illegible].27
Y          235  240 0.529E+00 0.278E+01 0.544E+00 0.276E+01 0.372E[illegible].27
Y          241  246 0.352E+00 0.279E+01 0.524E+00 0.177E+01 0.129E+[illegible]0 .15
Y          247  252 0.128E+01 0.121E+01 0.129E+01 0.967E+00 0.115E+01 0.97
Y          253  258 0.551E+00 0.116E+01 0.118E+01 0.406E+00 0.302E+00 0.10
Y          259  264 0.974E+00 0.587E+00 0.310E+00 0.394E+00 0.430E+00 0.41
Y          265  270 0.546E+00 0.335E+00 0.674E-01 0.464E-01-0.383E-01-0.25
Y          271  276-0.137E+00-0.508E-01-0.174E+00-0.113E+00-0.194E+00-0.19
Y          277  282-0.134E+00-0.117E+00-0.163E+00-0.260E+00-0.195E+00-0.31
Y          283  288-0.266E+00-0.218E+00-0.307E+00-0.228E+00-0.355E+00-0.20
Y          289  294-0.358E+00-0.219E+00-0.377E+00-0.281E+00-0.210E+00-0.39
Y          295  300-0.306E+00-0.373E+00-0.305E+00-0.318E+00-0.325E+00-0.29
Y          301  306-0.325E+00-0.342E+00-0.323E+00-0.357E+00-0.245E+00-0.29
Y          307  312-0.328E+00-0.377E+00-0.251E+00-0.345E+00-0.357E+00-0.28
Y          313  318-0.327E+00-0.362E+00-0.322E+00-0.278E+00-0.388E+00-0.25
Y          319  324-0.334E+00-0.362E+00-0.239E+00-0.435E+00-0.316E+00-0.29
Y          325  330-0.360E+00-0.172E+01-0.863E+01 0.101E+02 0.130E+01-0.12
Y          331  336-0.114E+01-0.716E+00-0.600E+00-0.695E+00-0.516E+00-0.31
Y          337  342-0.384E+00-0.434E+00-0.327E+00-0.367E+00-0.209E+00-0.30
Y          343  348-0.247E+00-0.279E+00-0.366E+00-0.235E+00-0.389E+00-0.26
Y          349  354-0.332E+00-0.308E+00-0.299E+00-0.315E+00-0.387E+00-0.29
Y          355  360-0.381E+00-0.240E+00-0.407E+00-0.283E+00-0.399E+00-0.25
Y          361  366-0.385E+00-0.320E+00-0.325E+00-0.354E+00-0.254E+00-0.35
Y          367  372-0.322E+00-0.317E+00-0.390E+00-0.240E+00-0.387E+00-0.30
Y          373  378-0.328E+00-0.375E+00-0.321E+00-0.293E+00-0.338E+00-0.35
Y          379  384-0.274E+00-0.368E+00-0.393E+00-0.325E+00-0.335E+00-0.35
Y          385  390-0.311E+00-0.297E+00-0.349E+00-0.305E+00-0.318E+00-0.35
Y          391  393-0.287E+00-0.222E+00-0.433E-02
TBLE        30   10    -1.
Y            1    6 0.000E+00-0.802E+02-0.198E+03-0.587E+03-0.139E[illegible]0.24
Y            7   12-0.330E+04-0.384E+04-0.432E+04-0.489E+04-0.477E[illegible].47
Y           13   18-0.641E+04-0.546E+04-0.535E+04-0.503E+04-0.451E+[illegible]0.37
Y           19   24-0.277E+04-0.191E+04 0.427E+03 0.411E+04 0.583E+04 0.70
Y           25   30 0.793E+04 0.941E+04 0.737E+04 0.877E+04 0.884E+04 0.79
Y           31   36 0.678E+04 0.489E+04 0.282E+04 0.191E+04 0.733E+03 0.21
Y           37   42 0.152E+03 0.611E+02 0.105E+03 0.121E+03 0.667E+02 0.81
Y           43   48 0.667E+02 0.481E+02 0.127E+02-0.380E+02-0.665E+02-0.62
Y           49   54-0.503E+02-0.436E+02-0.400E+02-0.327E+02-0.194E+02-0.41
Y           55   60 0.971E+01 0.163E+02 0.146E+02 0.640E+01-0.211E+01-0.69
Y           61   66-0.102E+02-0.133E+02-0.856E+01 0.227E+01 0.243E+02 0.36
Y           67   72 0.410E+02 0.394E+02 0.249E+02-0.314E+01-0.179E+02-0.26
Y           73   78-0.327E+02-0.300E+02-0.241E+02-0.130E+02 0.873E+01 0.36
Y           79   84 0.478E+02 0.524E+02 0.411E+02 0.178E+02-0.132E+01-0.10
Y           85   90-0.113E+02-0.133E+02-0.187E+02-0.229E+02-0.203E+02-0.10
Y           91   96 0.109E+02 0.405E+02 0.547E+02 0.487E+02 0.959E+02 0.15
Y           97  102 0.211E+02 0.205E+01-0.825E+01-0.131E+02-0.166E+02-0.29
Y          103  108-0.212E+02-0.196E+02-0.190E+02-0.275E+02-0.311E+02-0.24
Y          109  114-0.986E+01 0.102E+02 0.315E+02 0.366E+02 0.271E+02 0.12
Y          115  120 0.779E+00-0.236E+01 0.132E+01 0.157E+01-0.240E+01-0.36
Y          121  126 0.237E+01 0.166E+02 0.300E+02 0.335E+02 0.287E+02 0.25
Y          127  132 0.270E+02 0.253E+02 0.218E+02 0.199E+02 0.166E+02 0.12
Y          133  138 0.821E+01 0.460E+01 0.160E+01-0.151E+01-0.284E+01-0.58
Y          139  144-0.403E+01-0.471E+01-0.158E+01-0.492E+00 0.451E+00 0.70
Y          145  150-0.412E+01-0.101E+02-0.763E+01 0.311E+01 0.138E+02 0.19
Y          151  156 0.200E+02 0.183E+02 0.152E+02 0.122E+02 0.103E+02 0.10
Y          157  162 0.109E+02 0.121E+02 0.122E+02 0.122E+02 0.548E+02 0.48
Y          163  168 0.181E+02 0.248E+02 0.184E+02 0.116E+02 0.122E+02 0.14
Y          169  174 0.267E+02 0.491E+02 0.429E+02 0.315E+02 0.161E+01-0.78
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Y          175   180-0.853E+01 0.180E+02-0.190E+02-0.683E+01 0.959E+01 0.169E+00
Y          181   186 0.995E+00 0.393E+01 0.155E+01-0.181E+01-0.372E+01-0.243E+01
           187   192 0.174E-01-0.137E+00 0.123E+01-0.103E+02-0.233E+02-0.243E+02
           193   198-0.202E+02-0.176E+02-0.154E+02-0.215E+02-0.166E+02-0.104E+02
           199   204-0.693E+01-0.632E+01-0.696E+01-0.787E+01-0.764E+01-0.119E+01
Y          205   210 0.454E+01 0.426E+00-0.579E+01-0.109E+02-0.145E+02-0.127E+02
Y          211   216-0.945E+01-0.711E+01-0.594E+01-0.532E+01-0.472E+01-0.399E+01
Y          217   222-0.333E+01-0.305E+01-0.312E+01-0.332E+01-0.338E+01-0.337E+01
Y          223   228-0.326E+01-0.316E+01-0.309E+01-0.304E+01-0.296E+01-0.293E+01
Y          229   234-0.283E+01-0.283E+01-0.282E+01-0.284E+01-0.280E+01-0.281E+01
Y          235   240-0.269E+01-0.280E+01-0.325E+01-0.331E+01-0.304E+01-0.279E+01
Y          241   246-0.252E+01-0.232E+01-0.241E+01-0.236E+01-0.180E+01-0.231E+01
Y          247   252-0.182E+01-0.191E+01-0.210E+01-0.146E+01-0.210E+01-0.159E+01
Y          253   258-0.791E-01-0.139E+01-0.268E+01-0.104E+01 0.213E+00-0.136E+01
Y          259   264-0.250E+01-0.213E+01-0.120E+01-0.270E+00 0.222E+00 0.210E+00
Y          265   270-0.144E+00-0.290E+00-0.295E+00-0.280E+00-0.283E+00-0.235E+00
Y          271   276-0.255E+00-0.340E+00-0.317E+00-0.228E+00-0.146E+00-0.104E+00
Y          277   282-0.115E+00-0.146E+00-0.166E+00-0.136E+00-0.140E+00-0.805E-01
Y          283   288-0.385E-01-0.124E-01-0.343E-01-0.123E+00-0.743E-01-0.103E+00
Y          289   294-0.429E-01-0.351E-01-0.465E-01-0.585E-01-0.103E+00-0.431E-01
Y          295   300-0.491E-01-0.526E-01-0.691E-01-0.518E-01-0.963E-01-0.356E-01
Y          301   306-0.376E-01-0.146E-01-0.483E-01-0.628E-01-0.765E-01-0.649E-01
Y          307   312-0.285E-01-0.352E-01-0.105E+00-0.117E+00-0.468E-01-0.435E-01
Y          313   318 0.163E-01-0.102E-02-0.578E-01-0.121E+00-0.881E-01-0.520E-01
Y          319   324-0.404E-01-0.271E-01-0.686E-01-0.276E-01-0.822E-01-0.116E+00
Y          325   330-0.554E-01-0.317E-01-0.293E+01-0.805E+00 0.316E+01 0.163E+01
Y          331   336 0.461E+00-0.430E+00-0.420E+00-0.575E-01-0.117E+00-0.424E+00
Y          337   342-0.510E+00-0.345E+00-0.159E+00-0.280E-02 0.216E-01 0.846E-01
Y          343   348-0.228E-01-0.518E-01-0.468E-01-0.598E-01-0.385E-01-0.930E-01
Y          349   354-0.927E-01-0.477E-01-0.383E-01-0.501E-01 0.582E-03-0.449E-01
Y          355   360-0.718E-01-0.799E-01-0.466E-01-0.721E-01-0.337E-01-0.492E-01
Y          361   366-0.300E-01-0.144E-01-0.386E-01-0.452E-01-0.758E-01-0.360E-01
           367   372-0.466E-01-0.366E-01-0.348E-01-0.639E-01-0.469E-01-0.516E-01
           373   378-0.458E-01-0.279E-02-0.263E-01-0.753E-01-0.607E-01-0.352E-01
Y          379   384-0.540E-01-0.545E-01-0.356E-01-0.228E-01-0.232E-01-0.145E-01
Y          385   390-0.382E-01-0.282E-01-0.589E-01-0.594E-01-0.762E-01-0.334E-01
Y          391   393-0.258E-01 0.153E-01 0.970E-01
TBLE        40    10   -1.
Y            1     6 0.000E+00-0.231E+04-0.344E+04-0.600E+04-0.755E+04-0.783E+04
Y            7    12-0.786E+04-0.736E+04-0.444E+04 0.773E+03 0.721E+04 0.118E+05
Y           13    18 0.118E+05 0.142E+05 0.705E+04 0.594E+04-0.765E+03 0.133E+04
Y           19    24 0.124E+04 0.439E+03 0.759E+03 0.527E+03-0.128E+03-0.302E+03
Y           25    30 0.400E+03 0.180E+03 0.610E+02 0.702E+02-0.542E+02 0.986E+02
Y           31    36 0.307E+02 0.674E+02 0.247E+02 0.582E+02-0.455E+01 0.887E+02
Y           37    42-0.408E+02 0.245E+02-0.675E+02-0.218E+03-0.969E+02-0.519E+02
Y           43    48-0.116E+03-0.837E+02-0.578E+02 0.509E+02 0.523E+02 0.133E+02
Y           49    54-0.483E+02-0.107E+03-0.101E+03-0.844E+02-0.560E+02-0.466E+02
Y           55    60 0.895E+01 0.176E+03 0.145E+03 0.346E+02 0.436E+02 0.447E+02
Y           61    66 0.102E+02-0.425E+02-0.636E+02-0.730E+02-0.762E+02-0.997E+02
Y           67    72 0.387E+02 0.173E+03 0.130E+03 0.643E+02-0.138E+02-0.761E+02
Y           73    78-0.114E+03-0.141E+03-0.829E+02-0.491E+02-0.791E+02-0.700E+02
Y           79    84-0.294E+01 0.924E+02 0.227E+03 0.129E+03 0.656E+02-0.127E+02
Y           85    90-0.862E+02-0.134E+03-0.120E+03-0.816E+02-0.372E+02-0.306E+02
Y           91    96 0.619E+01-0.648E+02 0.577E+02 0.132E+03-0.362E+04-0.118E+05
Y           97   102-0.607E+03-0.495E+03-0.517E+03-0.804E+03-0.956E+03-0.633E+03
Y          103   108-0.969E+03-0.165E+04 0.257E+04 0.217E+04-0.276E+04-0.110E+04
Y          109   114 0.273E+03 0.140E+04 0.206E+04 0.246E+03-0.222E+04-0.580E+03
Y          115   120 0.117E+04 0.130E+04 0.267E+03-0.440E+03-0.471E+03 0.282E+03
Y          121   126 0.380E+03 0.638E+03-0.101E+02 0.541E+03 0.381E+03-0.345E+02
Y          127   132 0.206E+03-0.154E+03 0.183E+03-0.678E+02 0.138E+03-0.301E+03
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Y	133	138	0.544E+01	0.145E+03	0.275E+03	0.522E+02	0.110E+03	0.39
Y	139	144	0.362E+03	0.179E+03	-0.154E+04	-0.756E+03	0.220E+[illegible]	0.27
Y	145	150	0.208E+03	0.258E+03	0.250E+03	0.468E+03	0.250E[illegible]	[illegible].27
Y	151	156	0.208E+03	0.249E+03	0.210E+03	0.279E+03	0.204E[illegible]	[illegible].29
Y	157	162	0.225E+03	0.241E+03	0.230E+03	0.246E+03	0.202E+[illegible]	0.34
Y	163	168	0.487E+03	0.283E+03	0.152E+03	0.143E+03	0.247E+03	0.76
Y	169	174	0.154E+03	0.737E+02	0.429E+02	0.460E+02	-0.506E+02	-0.13
Y	175	180	-0.131E+03	0.273E+01	0.694E+02	0.608E+02	0.366E+02	0.27
Y	181	186	0.942E+01	0.156E+02	-0.117E+02	-0.177E+01	-0.220E+01	0.30
Y	187	192	0.532E+02	0.634E+02	-0.166E+02	-0.528E+02	-0.169E+03	0.21
Y	193	198	-0.147E+02	0.296E+02	0.112E+02	0.368E+02	0.286E+02	0.30
Y	199	204	0.242E+02	0.256E+02	0.545E+01	0.209E+02	0.102E+02	0.14
Y	205	210	0.699E+01	0.158E+01	-0.118E+01	0.665E+01	0.358E+01	0.11
Y	211	216	0.660E+01	0.126E+02	0.602E+01	0.119E+02	0.577E+01	0.11
Y	217	222	0.557E+01	0.110E+02	0.452E+01	0.946E+01	0.300E+01	0.82
Y	223	228	0.185E+01	0.697E+01	0.664E+00	0.608E+01	-0.243E+00	0.52
Y	229	234	-0.125E+01	0.461E+01	-0.152E+01	0.382E+01	0.110E+00	-0.29
Y	235	240	0.356E+01	-0.397E+01	0.427E+01	-0.478E+01	0.511E+01	0.26
Y	241	246	0.253E+00	0.878E+00	-0.108E+02	0.124E+02	-0.614E+01	0.60
Y	247	252	-0.450E+01	0.490E+00	0.226E+01	0.139E+01	-0.571E+01	0.1
Y	253	258	0.329E+01	0.232E-01	-0.520E+01	0.214E+01	-0.276E+01	0.3
Y	259	264	-0.236E+01	0.301E+01	-0.227E+01	0.293E+01	-0.329E+01	0.3
Y	265	270	-0.297E+01	0.295E+01	-0.300E+01	0.278E+01	-0.310E+01	0.2
Y	271	276	-0.300E+01	0.246E+01	-0.309E+01	0.272E+01	-0.309E+01	0.2
Y	277	282	-0.329E+01	0.262E+01	-0.344E+01	0.249E+01	-0.314E+01	0.2
Y	283	288	-0.326E+01	0.255E+01	-0.347E+01	0.251E+01	-0.324E+01	0.2
Y	289	294	-0.316E+01	0.239E+01	-0.343E+01	0.256E+01	-0.318E+01	0.2
Y	295	300	-0.321E+01	0.239E+01	-0.343E+01	0.252E+01	-0.338E+01	0.2
Y	301	306	-0.332E+01	0.257E+01	-0.338E+01	0.234E+01	-0.321E+01	0.2
Y	307	312	-0.313E+01	0.234E+01	-0.328E+01	0.232E+01	-0.323E+01	0.2
Y	313	318	-0.349E+01	0.234E+01	-0.308E+01	0.229E+01	-0.341E+01	0.2
Y	319	324	-0.332E+01	0.240E+01	-0.342E+01	0.233E+01	-0.318[illegible]	0.2
Y	325	330	-0.967E+01	-0.111E+02	0.479E+01	0.116E+02	-0.600[illegible]	0.1
Y	331	336	-0.412E+01	0.246E+01	-0.284E+01	0.253E+01	-0.360[illegible]	0.2
Y	337	342	-0.349E+01	0.239E+01	-0.335E+01	0.260E+01	-0.358E+01	0.2
Y	343	348	-0.318E+01	0.220E+01	-0.331E+01	0.255E+01	-0.325E+01	0.2
Y	349	354	-0.356E+01	0.268E+01	-0.362E+01	0.260E+01	-0.352E+01	0.2
Y	355	360	-0.337E+01	0.238E+01	-0.341E+01	0.251E+01	-0.320E+01	0.2
Y	361	366	-0.332E+01	0.238E+01	-0.337E+01	0.245E+01	-0.324E+01	0.
Y	367	372	-0.329E+01	0.242E+01	-0.359E+01	0.260E+01	-0.336E+01	0.
Y	373	378	-0.336E+01	0.241E+01	-0.343E+01	0.271E+01	-0.361E+01	0.
Y	379	384	-0.309E+01	0.220E+01	-0.330E+01	0.237E+01	-0.335E+01	0.
Y	385	390	-0.322E+01	0.237E+01	-0.339E+01	0.238E+01	-0.322E+01	0.
Y	391	393	-0.304E+01	0.198E+01	-0.115E+01			
TBLE	50	10	-1.					
Y	1	6	0.000E+00	-0.172E+02	-0.847E+02	-0.273E+03	-0.524E+03	-0.
Y	7	12	-0.113E+04	-0.168E+04	-0.247E+04	-0.331E+04	-0.366E+04	-0.
Y	13	18	-0.288E+04	-0.181E+04	-0.115E+04	-0.127E+03	0.281E+04	0.
Y	19	24	0.116E+05	0.427E+04	0.262E+04	0.405E+03	0.290E+03	-0.
Y	25	30	-0.629E+03	-0.103E+04	-0.175E+04	0.703E+04	-0.436E+04	-0.
Y	31	36	0.808E+03	-0.111E+04	-0.124E+04	-0.623E+03	-0.147E+04	0.
Y	37	42	-0.173E+04	0.256E+04	0.281E+04	0.431E+03	0.228E+04	0.
Y	43	48	-0.254E+03	0.879E+03	0.174E+02	-0.713E+01	-0.416E+02	-0.
Y	49	54	-0.681E+02	-0.612E+02	-0.736E+02	-0.683E+02	-0.700E+02	-0.
Y	55	60	-0.404E+02	0.130E+03	0.124E+03	0.301E+02	0.557E+02	0.
Y	61	66	0.509E+02	0.382E+00	-0.440E+02	-0.822E+02	-0.103E+03	-0.
Y	67	72	-0.385E+02	0.112E+03	0.274E+02	-0.743E+01	0.712E+01	-0.
Y	73	78	-0.118E+03	-0.108E+03	-0.444E+02	-0.178E+02	-0.655E+02	-0.
Y	79	84	-0.352E+02	0.189E+02	0.179E+03	0.740E+02	0.509E+02	0.
Y	85	90	0.159E+02	-0.184E+02	-0.520E+02	-0.499E+02	-0.298E+02	-0.

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Y        91    96 0.837E+02-0.248E+03 0.196E+03 0.939E+02-0.988E+01-0.324E+04
Y        97   102-0.229E+04-0.165E+04-0.287E+04 0.507E+03 0.217E+04-0.942E+04
        103   108-0.176E+04 0.264E+04-0.467E+04 0.526E+04-0.434E+04 0.420E+04
        109   114-0.436E+04 0.437E+04-0.398E+04 0.472E+04-0.401E+04 0.355E+04
        115   120-0.401E+04 0.399E+04-0.370E+04 0.420E+04-0.368E+04 0.362E+04
Y       121   126-0.370E+04 0.390E+04-0.352E+04 0.377E+04-0.325E+04 0.343E+04
Y       127   132-0.316E+04 0.320E+04-0.321E+04 0.318E+04-0.319E+04 0.321E+04
Y       133   138-0.326E+04 0.317E+04-0.322E+04 0.349E+04-0.803E+03-0.217E+04
Y       139   144-0.566E+03 0.299E+04-0.325E+04 0.243E+04-0.347E+04 0.293E+04
Y       145   150-0.365E+04 0.355E+04-0.371E+04 0.392E+04-0.355E+04 0.391E+04
Y       151   156-0.338E+04 0.370E+04-0.320E+04 0.347E+04-0.300E+04 0.333E+04
Y       157   162-0.276E+04 0.304E+04-0.256E+04 0.287E+04-0.236E+04 0.271E+04
Y       163   168-0.137E+04 0.220E+04-0.129E+04 0.116E+04 0.335E+03 0.811E+02
Y       169   174 0.181E+03-0.189E+03 0.194E+03-0.207E+03 0.247E+03-0.113E+03
Y       175   180 0.216E+02-0.322E+02 0.458E+02 0.573E+02 0.338E+02 0.265E+02
Y       181   186 0.184E+02 0.240E+02 0.171E+02 0.153E+02 0.311E+02 0.270E+02
Y       187   192 0.630E+02 0.108E+03 0.382E+02-0.211E+02-0.170E+03 0.109E+03
Y       193   198 0.627E+02 0.340E+02 0.276E+02 0.224E+02 0.317E+02 0.305E+02
Y       199   204 0.277E+02 0.271E+02 0.366E+02 0.881E+01 0.252E+02 0.312E+02
Y       205   210 0.329E+02 0.190E+02 0.206E+02 0.201E+02 0.166E+02 0.176E+02
Y       211   216 0.187E+02 0.166E+02 0.161E+02 0.141E+02 0.147E+02 0.130E+02
Y       217   222 0.133E+02 0.112E+02 0.109E+02 0.100E+02 0.927E+01 0.851E+01
Y       223   228 0.768E+01 0.708E+01 0.642E+01 0.566E+01 0.520E+01 0.469E+01
Y       229   234 0.423E+01 0.380E+01 0.317E+01 0.305E+01 0.245E+01 0.923E+00
Y       235   240 0.273E+01-0.405E+00 0.227E+01-0.179E+00 0.287E+01-0.166E+01
Y       241   246 0.779E+01-0.613E+01 0.160E+01 0.250E+01-0.193E+01 0.776E+01
Y       247   252-0.616E+01 0.423E+00 0.949E+01-0.733E+01-0.101E+00 0.630E+00
Y       253   258 0.826E+01-0.633E+01-0.296E-01 0.495E+00 0.106E+01 0.426E+00
Y       259   264-0.492E-01 0.725E+00 0.111E+01 0.106E+01 0.920E+00 0.775E+00
Y       265   270 0.210E+00 0.395E+00 0.670E+00 0.612E+00 0.377E+00 0.410E+00
Y       271   276 0.242E+00 0.238E+00 0.262E+00 0.903E-01 0.242E+00 0.221E+00
        277   282 0.158E+00 0.595E-01 0.210E+00-0.344E-01-0.169E+00 0.161E+00
        283   288 0.293E-01-0.133E+00 0.773E-01-0.290E+00-0.367E-01-0.404E-03
        289   294-0.948E-01-0.175E+00 0.614E-02-0.302E+00-0.826E-01 0.583E-01
Y       295   300-0.180E+00-0.272E-01-0.318E+00-0.214E+00-0.252E-01-0.129E+00
Y       301   306-0.116E+00-0.310E+00-0.158E+00-0.107E+00-0.184E+00 0.616E-01
Y       307   312-0.195E+00-0.240E+00-0.402E+00-0.222E+00 0.155E-01-0.334E-01
Y       313   318-0.175E+00-0.151E+00-0.452E+00-0.298E-01-0.132E+00-0.305E+00
Y       319   324-0.158E+00 0.545E-01-0.741E-01-0.340E+00-0.253E+00-0.326E-02
Y       325   330-0.115E+00-0.994E+00-0.101E+01 0.202E+01 0.354E+00-0.137E+01
Y       331   336-0.111E+01 0.109E+00 0.110E+00-0.365E-01-0.190E+00-0.155E+00
Y       337   342-0.280E+00-0.185E+00-0.913E-01-0.160E+00-0.215E-01-0.287E+00
Y       343   348-0.222E+00 0.888E-01-0.178E+00-0.164E+00-0.286E+00-0.156E+00
Y       349   354-0.117E+00-0.248E+00 0.241E-01-0.272E+00-0.145E-01-0.197E+00
Y       355   360-0.168E+00-0.273E+00-0.171E-01-0.214E+00-0.182E+00-0.184E+00
Y       361   366-0.147E+00-0.125E+00-0.136E+00-0.280E+00 0.136E-01-0.239E+00
Y       367   372-0.884E-01-0.789E-01-0.177E+00-0.270E+00-0.158E+00 0.311E-02
Y       373   378-0.141E+00-0.236E+00-0.705E-01-0.321E+00 0.142E-01-0.177E+00
Y       379   384-0.146E+00-0.164E+00-0.270E+00-0.115E+00-0.438E-01-0.136E+00
Y       385   390-0.188E+00-0.166E+00-0.680E-01-0.210E+00-0.186E+00-0.931E-01
Y       391   393-0.229E+00-0.144E+01-0.133E+02
TBLE     60    10    -1.
Y         1     6 0.000E+00-0.433E+03-0.367E+03-0.138E+04-0.256E+04-0.354E+04
Y         7    12-0.430E+04-0.497E+04-0.523E+04-0.420E+04-0.109E+04 0.160E+04
Y        13    18 0.115E+04 0.306E+04-0.308E+04-0.491E+04-0.162E+05-0.119E+05
Y        19    24-0.126E+05-0.145E+05-0.113E+05-0.474E+04-0.107E+05-0.587E+04
Y        25    30-0.197E+04-0.214E+02 0.203E+04 0.419E+04 0.482E+04 0.646E+04
Y        31    36 0.156E+05 0.151E+05 0.131E+05 0.107E+05 0.698E+04 0.264E+04
Y        37    42-0.978E+03 0.161E+05-0.223E+04-0.590E+04-0.376E+04-0.685E+04
Y        43    48-0.933E+04-0.960E+04-0.662E+04-0.614E+04-0.613E+04-0.557E+04
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Y         49   54-0.431E+04-0.310E+04-0.217E+04-0.154E+04-0.133E+04-0.14
Y         55   60-0.126E+04 0.223E+04 0.106E+04 0.216E+03 0.410E+04 0.62
Y         61   66 0.474E+04 0.228E+04 0.211E+03-0.177E+04-0.341E     .35
Y         67   72-0.248E+04 0.742E+02 0.143E+04 0.315E+04 0.195E     .16
Y         73   78 0.163E+04 0.307E+03 0.188E+03-0.333E+02-0.317E+    .24
Y         79   84-0.692E+03-0.114E+04-0.519E+03 0.156E+04 0.297E+04 0.26
Y         85   90 0.974E+03 0.180E+04 0.168E+04-0.768E+01-0.955E+03-0.88
Y         91   96-0.927E+03-0.134E+04-0.152E+04-0.137E+04-0.650E+04-0.23
Y         97  102-0.195E+04-0.575E+04-0.602E+04-0.555E+04-0.491E+04-0.29
Y        103  108-0.333E+04-0.343E+04 0.511E+04 0.648E+04-0.181E+04-0.55
Y        109  114 0.167E+04 0.415E+04 0.585E+04 0.266E+04-0.166E+04 0.32
Y        115  120 0.322E+04 0.373E+04 0.200E+04 0.530E+03 0.305E+03 0.15
Y        121  126 0.195E+04 0.254E+04 0.156E+04 0.257E+04 0.209E+04 0.14
Y        127  132 0.162E+04 0.861E+03 0.124E+04 0.784E+03 0.103E+04 0.1
Y        133  138 0.945E+03 0.874E+03 0.152E+04 0.891E+03 0.128E+04 0.1
Y        139  144 0.153E+04 0.119E+04-0.142E+04-0.942E+03 0.348E+03 0.5
Y        145  150 0.577E+03 0.851E+03 0.974E+03 0.148E+04 0.124E+04 0.1
Y        151  156 0.123E+04 0.129E+04 0.129E+04 0.141E+04 0.139E+04 0.1
Y        157  162 0.148E+04 0.146E+04 0.147E+04 0.151E+04 0.157E+04 0.1
Y        163  168 0.201E+04 0.153E+04 0.123E+04 0.110E+04 0.952E+03 0.7
Y        169  174 0.120E+04 0.858E+03 0.690E+03 0.511E+03-0.672E+02-0.1
Y        175  180-0.607E+03-0.260E+03 0.214E+03 0.187E+03 0.990E+02 0.1
Y        181  186 0.128E+03 0.406E+02-0.359E+02-0.775E+02-0.261E+02-0.9
Y        187  192 0.116E+03 0.594E+02-0.165E+03-0.479E+03-0.692E+03-0.3
Y        193  198-0.208E+03-0.964E+02 0.345E+01 0.237E+02 0.388E+02 0.3
Y        199  204 0.141E+02-0.104E+02 0.169E+02 0.126E+03 0.722E+02 0.1
Y        205  210-0.726E+02-0.999E+02-0.868E+02-0.589E+02-0.239E+02-0.6
Y        211  216-0.341E+01-0.200E+01 0.336E+01 0.150E+02 0.229E+02 0.2
Y        217  222 0.259E+02 0.237E+02 0.202E+02 0.173E+02 0.150E+02 0.1
Y        223  228 0.103E+02 0.722E+01 0.442E+01 0.300E+01 0.693E+00-0.
Y        229  234-0.325E+01-0.425E+01-0.487E+01-0.663E+01-0.556E+01-0.
Y        235  240 0.476E+01-0.317E+02 0.811E+01-0.320E+02 0.153   2-0.
Y        241  246 0.685E+01-0.125E+02-0.309E+02 0.264E+02-0.25      0.
Y        247  252-0.385E+01-0.235E+02 0.127E+02 0.621E+01-0.203    -0.
Y        253  258 0.226E+02-0.621E+01-0.148E+02-0.114E+02-0.110E+02-0.
Y        259  264 0.249E+01 0.634E+01 0.806E+01 0.416E+01 0.743E+00 0.
Y        265  270-0.116E+00 0.143E+01 0.596E+00 0.645E+00 0.190E+00-0.
Y        271  276-0.723E+00-0.691E+00 0.140E+00 0.392E+00-0.259E+00-0.
Y        277  282-0.797E+00-0.181E+00-0.113E+01-0.286E+00 0.104E+01-0.
Y        283  288-0.499E+00-0.324E+00-0.112E+01 0.607E+00 0.123E+00-0.
Y        289  294-0.373E+00-0.893E-01-0.105E+01 0.325E+00-0.644E-01-0.
Y        295  300-0.211E+00-0.115E+01-0.816E-01 0.209E+00-0.646E+00-0.
Y        301  306-0.639E+00 0.633E-01-0.446E+00-0.768E+00-0.868E-01-0.
Y        307  312-0.730E+00-0.669E+00 0.366E+00 0.201E+00-0.504E+00-0.
Y        313  318-0.107E+01-0.950E+00 0.629E+00-0.687E+00-0.658E+00 0.
Y        319  324-0.588E+00-0.152E+01-0.151E+01-0.391E+00 0.238E+00-0.
Y        325  330-0.120E+01-0.177E+01-0.106E+01-0.329E+01-0.189E+01 0
Y        331  336 0.452E+01 0.522E+01 0.256E+01-0.269E+01-0.495E+01-0
Y        337  342-0.145E+01-0.108E+00 0.113E+00-0.338E+00-0.161E+01-0
Y        343  348 0.110E+00-0.130E+01-0.544E+00-0.317E+00-0.161E+00-0
Y        349  354-0.742E+00 0.153E+00-0.127E+01-0.150E+00-0.125E+01-0
Y        355  360-0.525E+00-0.139E+00-0.762E+00-0.266E+00-0.293E+00-0
Y        361  366-0.694E+00-0.602E+00-0.651E+00 0.348E-01-0.875E+00-0
Y        367  372-0.688E+00-0.106E+01-0.981E+00 0.189E+00-0.221E+00-0
Y        373  378-0.714E+00-0.407E+00-0.755E+00 0.280E+00-0.129E+01-0
Y        379  384-0.193E+00-0.999E+00 0.231E-01-0.600E+00-0.731E+00-0
Y        385  390-0.369E+00-0.623E+00-0.885E+00-0.473E+00-0.102E+00-0
Y        391  393 0.257E-01 0.533E+02 0.112E+03
TBLE      70   10    -1.
Y          1    6 0.000E+00 0.176E+02 0.155E+00-0.127E+01 0.118E+02 0
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	7	12	-0.103E+02	-0.118E+02	-0.131E+02	-0.140E+02	-0.202E+02	-0.343E+02
	13	18	-0.665E+02	-0.934E+02	-0.153E+03	-0.262E+03	-0.450E+03	-0.759E+03
	19	24	-0.126E+04	-0.192E+04	-0.262E+04	-0.780E+04	-0.965E+04	-0.109E+05
Y	25	30	-0.117E+05	-0.119E+05	-0.121E+05	-0.124E+05	-0.124E+05	-0.121E+05
Y	31	36	-0.114E+05	-0.933E+04	-0.845E+04	-0.632E+04	-0.361E+04	-0.717E+03
Y	37	42	0.171E+04	-0.213E+04	0.956E+04	0.748E+04	0.176E+05	-0.618E+04
Y	43	48	0.492E+04	0.699E+04	0.146E+03	0.729E+04	-0.104E+04	0.320E+03
Y	49	54	0.386E+03	-0.200E+03	-0.994E+02	-0.157E+03	-0.205E+03	-0.253E+03
Y	55	60	0.484E+03	-0.106E+04	0.222E+04	-0.311E+03	-0.178E+04	0.156E+04
Y	61	66	0.108E+04	0.897E+03	0.823E+03	0.666E+03	0.442E+03	0.918E+02
Y	67	72	-0.313E+03	-0.576E+03	-0.549E+03	-0.136E+03	-0.502E+03	-0.132E+04
Y	73	78	-0.207E+04	-0.240E+04	-0.222E+04	-0.185E+04	-0.164E+04	-0.180E+04
Y	79	84	-0.205E+04	-0.196E+04	-0.831E+03	-0.654E+03	-0.393E+03	0.124E+04
Y	85	90	0.371E+04	0.585E+04	0.779E+04	0.876E+04	0.842E+04	0.704E+04
Y	91	96	0.525E+04	0.358E+04	0.186E+04	0.129E+04	0.109E+04	0.713E+03
Y	97	102	0.715E+03	0.386E+03	-0.843E+02	-0.375E+03	-0.637E+03	-0.594E+03
Y	103	108	-0.673E+03	-0.728E+03	-0.656E+03	-0.773E+03	-0.522E+03	0.100E+03
Y	109	114	-0.109E+04	-0.552E+03	-0.767E+03	-0.835E+03	-0.139E+04	-0.191E+04
Y	115	120	-0.213E+04	-0.200E+04	-0.176E+04	-0.164E+04	-0.166E+04	-0.167E+04
Y	121	126	-0.165E+04	-0.164E+04	-0.162E+04	-0.159E+04	-0.151E+04	-0.144E+04
Y	127	132	-0.128E+04	-0.879E+03	-0.648E+03	-0.490E+03	-0.240E+03	-0.360E+02
Y	133	138	0.888E+02	0.153E+03	0.168E+03	0.179E+03	-0.873E+02	0.260E+02
Y	139	144	-0.253E+03	-0.403E+03	-0.629E+03	-0.606E+03	-0.554E+03	-0.436E+03
Y	145	150	-0.333E+03	-0.288E+03	-0.299E+03	-0.349E+03	-0.416E+03	-0.486E+03
Y	151	156	-0.561E+03	-0.808E+03	-0.109E+04	-0.125E+04	-0.137E+04	-0.140E+04
Y	157	162	-0.134E+04	-0.122E+04	-0.107E+04	-0.857E+03	-0.604E+03	-0.316E+03
Y	163	168	-0.358E+02	0.194E+03	0.401E+03	0.611E+03	0.870E+03	0.105E+04
Y	169	174	0.119E+04	0.139E+04	0.147E+04	0.142E+04	0.128E+04	0.109E+04
Y	175	180	0.780E+03	0.529E+03	0.410E+03	0.302E+03	0.243E+03	0.273E+03
Y	181	186	0.323E+03	0.374E+03	0.405E+03	0.400E+03	0.637E+03	0.894E+03
	187	192	-0.236E+03	0.740E+03	0.175E+03	0.141E+03	0.985E+02	0.993E+02
	193	198	0.379E+03	0.534E+03	0.835E+03	0.113E+04	0.117E+04	0.109E+04
	199	204	0.102E+04	0.957E+03	0.874E+03	0.777E+03	0.699E+03	0.522E+03
Y	205	210	0.435E+03	0.363E+03	0.288E+03	0.241E+03	0.218E+03	0.203E+03
Y	211	216	0.188E+03	0.172E+03	0.164E+03	0.166E+03	0.163E+03	0.141E+03
Y	217	222	0.101E+03	0.584E+02	0.316E+02	0.270E+02	0.380E+02	0.531E+02
Y	223	228	0.644E+02	0.701E+02	0.704E+02	0.678E+02	0.637E+02	0.588E+02
Y	229	234	0.539E+02	0.495E+02	0.458E+02	0.428E+02	0.397E+02	0.358E+02
Y	235	240	0.335E+02	0.365E+02	0.286E+02	0.325E+02	0.254E+02	0.300E+02
Y	241	246	0.171E+02	0.340E+02	0.137E+02	0.225E+02	0.252E+02	0.908E+01
Y	247	252	0.289E+02	0.127E+02	0.112E+02	0.301E+02	0.953E+01	0.630E+01
Y	253	258	0.160E+02	0.248E+02	0.206E+01	0.704E+01	0.115E+02	0.100E+02
Y	259	264	0.982E+01	0.951E+01	0.935E+01	0.934E+01	0.845E+01	0.689E+01
Y	265	270	0.984E+01	0.599E+01	0.710E+01	0.634E+01	0.576E+01	0.563E+01
Y	271	276	0.519E+01	0.455E+01	0.464E+01	0.335E+01	-0.103E+01	0.550E+01
Y	277	282	0.452E+01	0.243E+01	0.303E+01	0.309E+01	0.384E+01	0.390E+01
Y	283	288	0.373E+01	0.398E+01	0.430E+01	0.442E+01	0.505E+01	0.484E+01
Y	289	294	0.478E+01	0.513E+01	0.485E+01	0.432E+01	0.451E+01	0.343E+01
Y	295	300	0.296E+01	0.238E+01	0.150E+01	0.119E+01	-0.245E-01	-0.775E+00
Y	301	306	-0.125E+01	-0.185E+01	-0.196E+01	-0.259E+01	-0.252E+01	-0.274E+01
Y	307	312	-0.301E+01	-0.247E+01	-0.223E+01	-0.173E+01	-0.175E+01	-0.200E+01
Y	313	318	-0.155E+01	-0.122E+01	-0.114E+01	-0.681E+00	-0.109E+01	-0.414E+00
Y	319	324	-0.118E+00	-0.326E+00	-0.225E+00	0.278E+00	0.102E+01	0.699E+00
Y	325	330	0.418E+01	-0.241E+01	0.787E+00	-0.205E+00	0.200E+01	0.283E+01
Y	331	336	0.174E+01	0.140E+01	0.228E+01	0.306E+01	0.270E+01	0.260E+01
Y	337	342	0.263E+01	0.253E+01	0.220E+01	0.109E+01	-0.260E+00	-0.191E+01
Y	343	348	-0.351E+01	-0.577E+01	-0.794E+01	-0.867E+01	-0.979E+01	-0.984E+01
Y	349	354	-0.971E+01	-0.907E+01	-0.789E+01	-0.692E+01	-0.530E+01	-0.430E+01
Y	355	360	-0.283E+01	-0.171E+01	-0.488E+00	0.495E-01	0.973E+00	0.159E+01
Y	361	366	0.188E+01	0.227E+01	0.238E+01	0.259E+01	0.267E+01	0.219E+01

```
Y          367  372 0.250E+01 0.199E+01 0.179E+01 0.208E+01 0.210E+01 0.176
Y          373  378 0.195E+01 0.248E+01 0.281E+01 0.292E+01 0.323E+[illegible].294
Y          379  384 0.310E+01 0.229E+01 0.194E+01 0.111E+01-0.481E-[illegible].932
Y          385  390-0.142E+01-0.165E+01-0.197E+01-0.204E+01-0.166E+[illegible].185
Y          391  393 0.200E+03 0.531E+03 0.326E+03
TBLE        80   10    -1.
Y            1    6 0.000E+00-0.196E+01-0.315E+01-0.103E+02-0.190E+02-0.112
Y            7   12-0.290E+01-0.620E+01-0.723E+01-0.744E+01-0.113E+02-0.148
Y           13   18-0.197E+02-0.180E+02-0.200E+02-0.220E+02-0.236E+02-0.252
Y           19   24-0.279E+02-0.318E+02-0.289E+02-0.510E+02-0.567E+02-0.64
Y           25   30-0.728E+02-0.833E+02-0.972E+02-0.112E+03-0.123E+03-0.12
Y           31   36-0.125E+03-0.109E+03-0.130E+03-0.139E+03-0.145E+03-0.15
Y           37   42-0.180E+03-0.141E+03-0.181E+03-0.226E+03-0.183E+03-0.22
Y           43   48-0.260E+03-0.313E+03-0.387E+03-0.478E+03-0.576E+03-0.66
Y           49   54-0.733E+03-0.788E+03-0.832E+03-0.870E+03-0.906E+03-0.94
Y           55   60-0.994E+03-0.105E+04-0.111E+04-0.115E+04-0.116E+04-0.11
Y           61   66-0.107E+04-0.998E+03-0.928E+03-0.864E+03-0.804E+03-0.74
Y           67   72-0.701E+03-0.665E+03-0.639E+03-0.624E+03-0.619E+03-0.62
Y           73   78-0.629E+03-0.646E+03-0.675E+03-0.713E+03-0.773E+03-0.88
Y           79   84-0.108E+04-0.139E+04-0.189E+04-0.266E+04-0.378E+04-0.53
Y           85   90-0.741E+04-0.968E+04-0.117E+05-0.127E+05-0.124E+05-0.11
Y           91   96-0.936E+04-0.764E+04-0.604E+04-0.458E+04-0.168E+05 0.15
Y           97  102-0.252E+04-0.186E+04-0.169E+04-0.207E+04-0.258E+04-0.79
Y          103  108-0.326E+04-0.200E+04-0.351E+04-0.348E+04-0.337E+04-0.32
Y          109  114-0.318E+04-0.310E+04-0.303E+04-0.297E+04-0.293E+04-0.29
Y          115  120-0.289E+04-0.282E+04-0.281E+04-0.274E+04-0.269E+04-0.26
Y          121  126-0.256E+04-0.252E+04-0.248E+04-0.246E+04-0.247E+04-0.24
Y          127  132-0.253E+04-0.260E+04-0.268E+04-0.281E+04-0.298E+04-0.31
Y          133  138-0.321E+04-0.323E+04-0.322E+04-0.307E+04-0.315E+04-0.26
Y          139  144-0.293E+04-0.257E+04-0.231E+04-0.221E+04-0.222E+04-0.2
Y          145  150-0.246E+04-0.261E+04-0.274E+04-0.287E+04-0.301E[illegible]-0.3
Y          151  156-0.318E+04-0.320E+04-0.317E+04-0.309E+04-0.303[illegible]0.3
Y          157  162-0.302E+04-0.312E+04-0.327E+04-0.346E+04-0.368E[illegible]-0.3
Y          163  168-0.411E+04-0.433E+04-0.450E+04-0.463E+04-0.467E+04-0.4
Y          169  174-0.488E+04-0.478E+04-0.464E+04-0.449E+04-0.433E+04-0.4
Y          175  180-0.387E+04-0.358E+04-0.329E+04-0.301E+04-0.278E+04-0.2
Y          181  186-0.237E+04-0.214E+04-0.186E+04-0.152E+04-0.109E+04-0.5
Y          187  192 0.151E+03 0.952E+03 0.160E+04 0.205E+04 0.299E+04 0.4
Y          193  198 0.685E+04 0.791E+04 0.845E+04 0.822E+04 0.772E+04 0.7
Y          199  204 0.614E+04 0.521E+04 0.430E+04 0.349E+04 0.273E+04 0.2
Y          205  210 0.162E+04 0.118E+04 0.848E+03 0.608E+03 0.469E+03 0.4
Y          211  216 0.457E+03 0.524E+03 -0.544E+03 0.574E+03 0.614E+03 0.6
Y          217  222 0.718E+03 0.781E+03 0.848E+03 0.926E+03 0.102E+04 0.1
Y          223  228 0.127E+04 0.142E+04 0.156E+04 0.170E+04 0.183E+04 0.1
Y          229  234 0.202E+04 0.210E+04 0.215E+04 0.219E+04 0.222E+04 0.2
Y          235  240 0.227E+04 0.230E+04 0.234E+04 0.240E+04 0.248E+04 0.2
Y          241  246 0.271E+04 0.286E+04 0.304E+04 0.324E+04 0.345E+04 0.3
Y          247  252 0.390E+04 0.413E+04 0.434E+04 0.454E+04 0.471E+04 0.
Y          253  258 0.499E+04 0.511E+04 0.520E+04 0.528E+04 0.535E+04 0.
Y          259  264 0.547E+04 0.552E+04 0.556E+04 0.559E+04 0.560E+04 0.
Y          265  270 0.556E+04 0.555E+04 0.550E+04 0.544E+04 0.537E+04 0.
Y          271  276 0.518E+04 0.507E+04 0.495E+04 0.481E+04 0.467E+04 0.
Y          277  282 0.437E+04 0.424E+04 0.411E+04 0.400E+04 0.390E+04 0.
Y          283  288 0.372E+04 0.364E+04 0.352E+04 0.335E+04 0.303E+04 0.
Y          289  294 0.207E+04 0.189E+04 0.184E+04 0.179E+04 0.174E+04 0.
Y          295  300 0.160E+04 0.153E+04 0.144E+04 0.136E+04 0.127E+04 0.
Y          301  306 0.108E+04 0.996E+03 0.911E+03 0.830E+03 0.754E+03 0.
Y          307  312 0.617E+03 0.557E+03 0.501E+03 0.451E+03 0.406E+03 0.
Y          313  318 0.329E+03 0.298E+03 0.270E+03 0.246E+03 0.226E+03 0.
Y          319  324 0.194E+03 0.182E+03 0.171E+03 0.163E+03 0.157E+03 0.
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Y	325	330	0.198E+03	0.932E+02	0.141E+03	0.137E+03	0.132E+03	0.126E+03
Y	331	336	0.120E+03	0.116E+03	0.113E+03	0.111E+03	0.107E+03	0.104E+03
	337	342	0.998E+02	0.948E+02	0.870E+02	0.795E+02	0.708E+02	0.638E+02
	343	348	0.562E+02	0.507E+02	0.456E+02	0.427E+02	0.410E+02	0.427E+02
Y	349	354	0.457E+02	0.521E+02	0.600E+02	0.698E+02	0.806E+02	0.933E+02
Y	355	360	0.106E+03	0.119E+03	0.132E+03	0.145E+03	0.158E+03	0.169E+03
Y	361	366	0.180E+03	0.189E+03	0.197E+03	0.202E+03	0.206E+03	0.207E+03
Y	367	372	0.206E+03	0.202E+03	0.196E+03	0.185E+03	0.173E+03	0.155E+03
Y	373	378	0.137E+03	0.113E+03	0.904E+02	0.626E+02	0.359E+02	0.577E+01
Y	379	384	-0.249E+02	-0.578E+02	-0.914E+02	-0.126E+03	-0.161E+03	-0.196E+03
Y	385	390	-0.233E+03	-0.271E+03	-0.309E+03	-0.349E+03	-0.388E+03	-0.426E+03
Y	391	393	-0.463E+03	-0.494E+03	-0.423E+03			
TBLE	90	10	-1.					
Y	1	6	0.000E+00	-0.821E-01	-0.707E-01	0.258E+00	0.225E+01	0.809E+01
Y	7	12	0.148E+02	0.105E+02	-0.702E+01	-0.203E+02	-0.171E+02	-0.671E+01
Y	13	18	-0.269E+01	-0.179E+01	-0.198E+01	-0.199E+01	-0.162E+01	-0.107E+01
Y	19	24	-0.518E+00	-0.416E-02	0.404E+00	0.207E+01	0.202E+01	0.179E+01
Y	25	30	0.158E+01	0.146E+01	0.139E+01	0.128E+01	0.112E+01	0.922E+00
Y	31	36	0.705E+00	0.338E+00	-0.316E+00	-0.183E+01	-0.410E+01	-0.624E+01
Y	37	42	-0.748E+01	-0.269E+01	0.134E+01	0.765E+01	0.815E+01	0.104E+02
Y	43	48	0.918E+01	0.562E+01	0.217E+01	0.134E+00	-0.108E+01	-0.244E+01
Y	49	54	-0.423E+01	-0.619E+01	-0.794E+01	-0.914E+01	-0.954E+01	-0.921E+01
Y	55	60	-0.866E+01	-0.843E+01	-0.888E+01	-0.102E+02	-0.125E+02	-0.160E+02
Y	61	66	-0.208E+02	-0.278E+02	-0.377E+02	-0.513E+02	-0.683E+02	-0.868E+02
Y	67	72	-0.104E+03	-0.118E+03	-0.129E+03	-0.137E+03	-0.145E+03	-0.154E+03
Y	73	78	-0.166E+03	-0.182E+03	-0.206E+03	-0.235E+03	-0.265E+03	-0.289E+03
Y	79	84	-0.303E+03	-0.307E+03	-0.302E+03	-0.291E+03	-0.274E+03	-0.252E+03
Y	85	90	-0.227E+03	-0.201E+03	-0.176E+03	-0.154E+03	-0.134E+03	-0.115E+03
Y	91	96	-0.962E+02	-0.745E+02	-0.486E+02	-0.188E+02	0.585E+01	0.916E+01
Y	97	102	0.330E+02	0.536E+02	0.673E+02	0.760E+02	0.823E+02	0.115E+03
Y	103	108	0.896E+02	0.855E+02	0.104E+03	0.116E+03	0.130E+03	0.144E+03
	109	114	0.159E+03	0.174E+03	0.189E+03	0.207E+03	0.226E+03	0.245E+03
	115	120	0.258E+03	0.261E+03	0.257E+03	0.257E+03	0.258E+03	0.249E+03
	121	126	0.233E+03	0.219E+03	0.206E+03	0.193E+03	0.175E+03	0.153E+03
Y	127	132	0.126E+03	0.961E+02	0.626E+02	0.260E+02	-0.135E+02	-0.562E+02
Y	133	138	-0.102E+03	-0.151E+03	-0.201E+03	-0.278E+03	-0.251E+03	-0.379E+03
Y	139	144	-0.322E+03	-0.415E+03	-0.471E+03	-0.524E+03	-0.571E+03	-0.611E+03
Y	145	150	-0.644E+03	-0.670E+03	-0.692E+03	-0.708E+03	-0.717E+03	-0.721E+03
Y	151	156	-0.721E+03	-0.716E+03	-0.703E+03	-0.680E+03	-0.644E+03	-0.597E+03
Y	157	162	-0.548E+03	-0.498E+03	-0.451E+03	-0.416E+03	-0.393E+03	-0.376E+03
Y	163	168	-0.361E+03	-0.345E+03	-0.330E+03	-0.314E+03	-0.260E+03	-0.198E+03
Y	169	174	-0.858E+02	0.419E+02	0.136E+03	0.240E+03	0.278E+03	0.260E+03
Y	175	180	0.234E+03	0.138E+03	0.888E+01	-0.152E+03	-0.334E+03	-0.542E+03
Y	181	186	-0.786E+03	-0.107E+04	-0.137E+04	-0.171E+04	-0.212E+04	-0.264E+04
Y	187	192	-0.328E+04	-0.398E+04	-0.454E+04	-0.498E+04	-0.591E+04	-0.766E+04
Y	193	198	-0.973E+04	-0.114E+05	-0.114E+05	-0.112E+05	-0.107E+05	-0.993E+04
Y	199	204	-0.904E+04	-0.809E+04	-0.715E+04	-0.626E+04	-0.544E+04	-0.473E+04
Y	205	210	-0.411E+04	-0.359E+04	-0.317E+04	-0.285E+04	-0.264E+04	-0.253E+04
Y	211	216	-0.250E+04	-0.249E+04	-0.246E+04	-0.241E+04	-0.235E+04	-0.229E+04
Y	217	222	-0.223E+04	-0.217E+04	-0.213E+04	-0.209E+04	-0.206E+04	-0.205E+04
Y	223	228	-0.203E+04	-0.204E+04	-0.205E+04	-0.205E+04	-0.207E+04	-0.205E+04
Y	229	234	-0.204E+04	-0.201E+04	-0.197E+04	-0.194E+04	-0.186E+04	-0.183E+04
Y	235	240	-0.174E+04	-0.171E+04	-0.164E+04	-0.158E+04	-0.162E+04	-0.163E+04
Y	241	246	-0.163E+04	-0.172E+04	-0.183E+04	-0.191E+04	-0.201E+04	-0.216E+04
Y	247	252	-0.229E+04	-0.239E+04	-0.249E+04	-0.259E+04	-0.265E+04	-0.267E+04
Y	253	258	-0.266E+04	-0.264E+04	-0.258E+04	-0.248E+04	-0.237E+04	-0.223E+04
Y	259	264	-0.205E+04	-0.183E+04	-0.157E+04	-0.127E+04	-0.909E+03	-0.457E+03
Y	265	270	0.861E+02	0.700E+03	0.133E+04	0.195E+04	0.255E+04	0.310E+04
Y	271	276	0.360E+04	0.406E+04	0.448E+04	0.485E+04	0.516E+04	0.542E+04
Y	277	282	0.562E+04	0.576E+04	0.584E+04	0.585E+04	0.581E+04	0.574E+04

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Y          283  288 0.561E+04 0.546E+04 0.530E+04 0.515E+04 0.519E[illegible].53
Y          289  294 0.551E+04 0.538E+04 0.512E+04 0.488E+04 0.466E[illegible].44
Y          295  300 0.430E+04 0.416E+04 0.404E+04 0.395E+04 0.387E[illegible].38
Y          301  306 0.378E+04 0.376E+04 0.374E+04 0.374E+04 0.374E+04 0.37
Y          307  312 0.374E+04 0.374E+04 0.374E+04 0.373E+04 0.372E+04 0.37
Y          313  318 0.368E+04 0.365E+04 0.361E+04 0.357E+04 0.352E+04 0.34
Y          319  324 0.341E+04 0.334E+04 0.327E+04 0.320E+04 0.312E+04 0.30
Y          325  330 0.321E+04 0.271E+04 0.287E+04 0.279E+04 0.271E+04 0.26
Y          331  336 0.254E+04 0.245E+04 0.237E+04 0.228E+04 0.219E+04 0.21
Y          337  342 0.201E+04 0.193E+04 0.185E+04 0.176E+04 0.168E+04 0.16
Y          343  348 0.152E+04 0.144E+04 0.137E+04 0.129E+04 0.122E+04 0.11
Y          349  354 0.107E+04 0.100E+04 0.931E+03 0.852E+03 0.776E+03 0.70
Y          355  360 0.622E+03 0.547E+03 0.470E+03 0.395E+03 0.327E+03 0.26
Y          361  366 0.197E+03 0.132E+03 0.692E+02 0.101E+02-0.447E+02-0.98
Y          367  372-0.155E+03-0.208E+03-0.246E+03-0.268E+03-0.280E+03-0.29
Y          373  378-0.306E+03-0.317E+03-0.316E+03-0.304E+03-0.285E+03-0.26
Y          379  384-0.244E+03-0.221E+03-0.196E+03-0.168E+03-0.139E+03-0.10
Y          385  390-0.750E+02-0.474E+02-0.177E+02 0.253E+02 0.689E+02 0.11
Y          391  393 0.138E+03 0.166E+03 0.208E+03
TBLE       100   10   -1.
Y            1    6 0.000E+00 0.188E+02 0.257E+02-0.163E+01-0.326E+02-0.29
Y            7   12-0.188E+02-0.129E+02 0.478E+01 0.191E+02 0.160E+02 0.75
Y           13   18 0.523E+01 0.398E+01 0.397E+01 0.377E+01 0.329E+01 0.26
Y           19   24 0.206E+01 0.146E+01 0.673E+00-0.119E+01-0.134E+01-0.12
Y           25   30-0.105E+01-0.921E+00-0.853E+00-0.813E+00-0.782E+00-0.77
Y           31   36-0.809E+00-0.764E+00-0.103E+01-0.112E+01-0.110E+01-0.96
Y           37   42-0.828E+00-0.313E+00-0.255E+00-0.102E+00-0.499E-02-0.21
Y           43   48-0.557E-01-0.158E+00-0.263E+00-0.138E+00-0.191E-01-0.51
Y           49   54-0.131E+00-0.250E+00-0.354E+00-0.341E-01 0.703E+00 0.1
Y           55   60 0.147E+01 0.145E+01 0.964E+00 0.329E+00-0.328E[illegible]-0.1
Y           61   66-0.262E-01 0.183E+00 0.397E+00 0.523E+00 0.559[illegible]0.4
Y           67   72-0.201E-01-0.746E+00-0.166E+01-0.270E+01-0.375E[illegible]-0.4
Y           73   78-0.493E+01-0.473E+01-0.406E+01-0.327E+01-0.287E+01-0.3
Y           79   84-0.501E+01-0.797E+01-0.123E+02-0.184E+02-0.266E+02-0.3
Y           85   90-0.493E+02-0.608E+02-0.691E+02-0.719E+02-0.694E+02-0.6
Y           91   96-0.586E+02-0.577E+02-0.625E+02-0.711E+02-0.128E+03-0.5
Y           97  102-0.769E+02-0.638E+02-0.377E+02-0.380E+01 0.303E+02 0.7
Y          103  108 0.629E+02 0.693E+02 0.895E+02 0.957E+02 0.100E+03 0.1
Y          109  114 0.111E+03 0.115E+03 0.111E+03 0.880E+02 0.596E+02 0.5
Y          115  120 0.373E+02 0.153E+02 0.383E+01-0.723E+01-0.160E+02-0.1
Y          121  126-0.928E+01-0.689E+01-0.706E+01-0.811E+01-0.789E+01-0.5
Y          127  132-0.212E+01 0.604E+00 0.262E+01 0.362E+01 0.326E+01 0.1
Y          133  138-0.972E+00-0.436E+01-0.857E+01-0.143E+02-0.139E+02-0.2
Y          139  144-0.189E+02-0.240E+02-0.257E+02-0.267E+02-0.268E+02-0.2
Y          145  150-0.257E+02-0.251E+02-0.250E+02-0.260E+02-0.287E+02-0.3
Y          151  156-0.418E+02-0.543E+02-0.728E+02-0.985E+02-0.132E+03-0.1
Y          157  162-0.210E+03-0.238E+03-0.248E+03-0.235E+03-0.204E+03-0.1
Y          163  168-0.119E+03-0.780E+02-0.392E+02 0.445E+01 0.627E+02 0.1
Y          169  174 0.160E+03 0.121E+03 0.581E+02 0.165E+02 0.102E+02 0.2
Y          175  180 0.520E+02 0.775E+02 0.927E+02 0.922E+02 0.757E+02 0.4
Y          181  186 0.260E+02 0.991E+01-0.795E+01-0.273E+02-0.395E+02-0.4
Y          187  192-0.656E+02-0.837E+02-0.953E+02-0.981E+02-0.944E+02-0.8
Y          193  198-0.697E+02-0.582E+02-0.398E+02-0.325E+02-0.307E+02-0.3
Y          199  204-0.357E+02-0.364E+02-0.363E+02-0.361E+02-0.334E+02-0.1
Y          205  210 0.161E+02 0.526E+00-0.461E+02-0.800E+02-0.734E+02-0.2
Y          211  216 0.319E+02 0.615E+02 0.652E+02 0.515E+02 0.342E+02 0.2
Y          217  222 0.249E+02 0.108E+02-0.990E+00-0.237E+02-0.489E+02-0.6
Y          223  228-0.959E+02-0.100E+03-0.111E+03-0.116E+03-0.962E+02-0.
Y          229  234-0.930E+02-0.954E+02-0.902E+02-0.709E+02-0.895E+02-0.5
Y          235  240-0.946E+02-0.732E+02-0.108E+03-0.148E+03-0.111E+03-0.
```

```
       241   246-0.168E+03-0.192E+03-0.176E+03-0.216E+03-0.262E+03-0.251E+03
       247   252-0.281E+03-0.321E+03-0.352E+03-0.394E+03-0.408E+03-0.495E+03
Y      253   258-0.548E+03-0.582E+03-0.693E+03-0.731E+03-0.876E+03-0.102E+04
Y      259   264-0.110E+04-0.135E+04-0.163E+04-0.183E+04-0.213E+04-0.252E+04
Y      265   270-0.294E+04-0.331E+04-0.374E+04-0.425E+04-0.477E+04-0.521E+04
Y      271   276-0.556E+04-0.586E+04-0.612E+04-0.631E+04-0.641E+04-0.644E+04
Y      277   282-0.639E+04-0.626E+04-0.602E+04-0.569E+04-0.529E+04-0.485E+04
Y      283   288-0.439E+04-0.391E+04-0.340E+04-0.284E+04-0.224E+04-0.161E+04
Y      289   294-0.967E+03-0.325E+03 0.300E+03 0.892E+03 0.144E+04 0.194E+04
Y      295   300 0.239E+04 0.278E+04 0.310E+04 0.338E+04 0.359E+04 0.375E+04
Y      301   306 0.386E+04 0.393E+04 0.395E+04 0.393E+04 0.387E+04 0.379E+04
Y      307   312 0.368E+04 0.355E+04 0.341E+04 0.326E+04 0.311E+04 0.295E+04
Y      313   318 0.278E+04 0.262E+04 0.245E+04 0.229E+04 0.213E+04 0.198E+04
Y      319   324 0.183E+04 0.169E+04 0.156E+04 0.144E+04 0.133E+04 0.122E+04
Y      325   330 0.121E+04 0.101E+04 0.101E+04 0.928E+03 0.851E+03 0.780E+03
Y      331   336 0.716E+03 0.657E+03 0.604E+03 0.556E+03 0.513E+03 0.475E+03
Y      337   342 0.442E+03 0.413E+03 0.389E+03 0.369E+03 0.353E+03 0.340E+03
Y      343   348 0.330E+03 0.322E+03 0.314E+03 0.309E+03 0.304E+03 0.303E+03
Y      349   354 0.308E+03 0.309E+03 0.314E+03 0.327E+03 0.336E+03 0.347E+03
Y      355   360 0.362E+03 0.373E+03 0.384E+03 0.395E+03 0.400E+03 0.403E+03
Y      361   366 0.408E+03 0.415E+03 0.425E+03 0.434E+03 0.442E+03 0.451E+03
Y      367   372 0.464E+03 0.478E+03 0.480E+03 0.464E+03 0.437E+03 0.410E+03
Y      373   378 0.391E+03 0.377E+03 0.355E+03 0.320E+03 0.280E+03 0.240E+03
Y      379   384 0.204E+03 0.170E+03 0.138E+03 0.107E+03 0.753E+02 0.443E+02
Y      385   390 0.146E+02-0.682E+01-0.270E+02-0.579E+02-0.888E+02-0.117E+03
Y      391   393-0.133E+03-0.147E+03-0.174E+03
TBLE   110    10     -1.
Y        1     6 0.000E+00-0.423E+02-0.270E+02 0.500E+01 0.306E+02 0.130E+02
Y        7    12-0.139E+01 0.336E+01 0.492E+01 0.384E+01 0.357E+01 0.146E+01
        13    18-0.517E-01-0.271E+00-0.282E+00-0.312E+00-0.381E+00-0.381E+00
        19    24-0.241E+00-0.413E-01 0.163E+00 0.127E-01-0.747E-01-0.173E+00
Y       25    30-0.316E+00-0.494E+00-0.655E+00-0.715E+00-0.653E+00-0.545E+00
Y       31    36-0.455E+00-0.225E+00 0.162E+00 0.484E+00 0.320E+00 0.378E+00
Y       37    42 0.379E+00 0.184E+00 0.402E-01-0.497E-01 0.865E-01 0.126E+00
Y       43    48 0.202E+00 0.379E+00 0.597E+00 0.487E+00 0.614E+00 0.970E+00
Y       49    54 0.147E+01 0.105E+01 0.537E+00 0.550E+00 0.239E+00 0.741E-01
Y       55    60 0.218E+00 0.359E+00 0.780E+00 0.141E+01 0.179E+01 0.182E+01
Y       61    66 0.175E+01 0.143E+01 0.806E+00 0.453E+00 0.441E+00 0.101E+01
Y       67    72 0.492E+00-0.583E+00-0.326E+00 0.632E-01 0.156E-01-0.137E+00
Y       73    78-0.746E+00-0.177E+01-0.264E+01-0.309E+01-0.306E+01-0.254E+01
Y       79    84-0.152E+01-0.955E-01 0.690E+00 0.491E+00-0.711E+00-0.292E+01
Y       85    90-0.611E+01-0.127E+02-0.211E+02-0.293E+02-0.362E+02-0.426E+02
Y       91    96-0.443E+02-0.396E+02-0.289E+02-0.149E+02-0.709E+01-0.257E+01
Y       97   102 0.193E+01-0.108E+01-0.126E+02-0.265E+02-0.338E+02-0.400E+02
Y      103   108-0.253E+02-0.845E+01 0.197E+02 0.467E+02 0.681E+02 0.742E+02
Y      109   114 0.681E+02 0.551E+02 0.336E+02 0.149E+02-0.341E+01-0.218E+02
Y      115   120-0.815E+01 0.684E+01 0.479E+01 0.236E+01-0.303E+01-0.942E+01
Y      121   126-0.119E+02-0.115E+02-0.137E+02-0.891E+01-0.666E+01-0.454E+01
Y      127   132-0.225E+01-0.843E-01 0.145E+01 0.224E+01 0.249E+01 0.218E+01
Y      133   138 0.662E+00-0.150E+01-0.354E+01-0.641E+01-0.647E+01-0.105E+02
Y      139   144-0.895E+01-0.119E+02-0.136E+02-0.144E+02-0.148E+02-0.146E+02
Y      145   150-0.137E+02-0.123E+02-0.106E+02-0.910E+01-0.825E+01-0.835E+01
Y      151   156-0.964E+01-0.122E+02-0.163E+02-0.220E+02-0.301E+02-0.412E+02
Y      157   162-0.567E+02-0.777E+02-0.104E+03-0.132E+03-0.153E+03-0.156E+03
Y      163   168-0.135E+03-0.901E+02-0.352E+02 0.203E+02 0.628E+02 0.766E+02
Y      169   174 0.450E+02 0.198E+02 0.875E+01 0.315E+01 0.550E+00 0.326E+01
Y      175   180 0.108E+02 0.177E+02 0.213E+02 0.210E+02 0.161E+02 0.809E+01
Y      181   186-0.644E+00-0.683E+01-0.637E+01-0.392E+01-0.968E+01-0.201E+02
Y      187   192-0.252E+02-0.281E+02-0.357E+02-0.439E+02-0.466E+02-0.435E+02
Y      193   198-0.372E+02-0.374E+02-0.336E+02-0.348E+02-0.346E+02-0.323E+02
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Y          199   204-0.296E+02-0.291E+02-0.311E+02-0.685E+02-0.153[illegible]0.16
Y          205   210-0.131E+03-0.598E+02 0.144E+02 0.605E+02 0.685[illegible]0.3
Y          211   216 0.197E+02 0.190E+02 0.227E+02 0.295E+02 0.384E+02 0.4
Y          217   222 0.447E+02 0.395E+02 0.310E+02 0.204E+02 0.585E+01-0.1
Y          223   228-0.300E+02-0.473E+02-0.605E+02-0.711E+02-0.766E+02-0.7
Y          229   234-0.750E+02-0.667E+02-0.588E+02-0.540E+02-0.467E+02-0.4
Y          235   240-0.326E+02-0.331E+02-0.336E+02-0.370E+02-0.383E+02-0.3
Y          241   246-0.384E+02-0.254E+02-0.276E+02-0.285E+02-0.203E+02-0.2
Y          247   252-0.121E+02-0.180E+02-0.255E+02-0.963E+01-0.266E+02 0.9
Y          253   258 0.852E+01-0.246E+02-0.183E+02-0.865E+02-0.722E+02-0.7
Y          259   264-0.165E+03-0.143E+03-0.968E+02-0.283E+02 0.105E+03 0.6
Y          265   270-0.487E+02-0.291E+03-0.376E+03-0.394E+03-0.473E+03-0.4
Y          271   276-0.442E+03-0.536E+03-0.471E+03-0.526E+03-0.408E+03-0.4
Y          277   282-0.496E+03-0.591E+03-0.732E+03-0.910E+03-0.111E+04-0.1
Y          283   288-0.151E+04-0.168E+04-0.185E+04-0.206E+04-0.230E+04-0.2
Y          289   294-0.284E+04-0.311E+04-0.338E+04-0.361E+04-0.381E+04-0.3
Y          295   300-0.407E+04-0.414E+04-0.416E+04-0.414E+04-0.407E+04-0.3
Y          301   306-0.380E+04-0.361E+04-0.338E+04-0.309E+04-0.275E+04-0.2
Y          307   312-0.200E+04-0.162E+04-0.125E+04-0.889E+03-0.534E+03-0.1
Y          313   318 0.143E+03 0.459E+03 0.758E+03 0.104E+04 0.129E+04 0.1
Y          319   324 0.173E+04 0.192E+04 0.207E+04 0.220E+04 0.230E+04 0.2
Y          325   330 0.242E+04 0.246E+04 0.247E+04 0.248E+04 0.248E+04 0.2
Y          331   336 0.241E+04 0.236E+04 0.229E+04 0.221E+04 0.212E+04 0.2
Y          337   342 0.193E+04 0.183E+04 0.172E+04 0.161E+04 0.151E+04 0.1
Y          343   348 0.130E+04 0.121E+04 0.112E+04 0.103E+04 0.946E+03 0.8
Y          349   354 0.797E+03 0.730E+03 0.669E+03 0.613E+03 0.563E+03 0.5
Y          355   360 0.477E+03 0.442E+03 0.411E+03 0.384E+03 0.359E+03 0.
Y          361   366 0.315E+03 0.293E+03 0.270E+03 0.246E+03 0.224E+03 0.
Y          367   372 0.187E+03 0.172E+03 0.160E+03 0.152E+03 0.149E+03 0.
Y          373   378 0.144E+03 0.136E+03 0.125E+03 0.117E+03 0.11[illegible] 0.
Y          379   384 0.980E+02 0.884E+02 0.778E+02 0.676E+02 0.58[illegible] 0.
Y          385   390 0.446E+02 0.403E+02 0.378E+02 0.376E+02 0.407[illegible]2 0.
Y          391   393 0.537E+02 0.609E+02 0.690E+02
IN               801184.1        184.1       184.1
IN               80285.4         85.4        85.4
IN               80391.1         91.1        91.1
IN               80470.2         70.2        70.2
IN                 24164.        164.        164.
IN               805684.0        684.0       684.0
IN               22877.          77.         77.
IN               80616.2         16.2        16.2
IN               84125.7         25.7        25.7
IN               842250.         250.        250.
IN               843111.8        111.8       111.8
IN               807256.2        256.2       256.2
IN               85211.4         11.4        11.4
IN               853250.         250.        250.
IN                 3577.         77.         77.
IN               808684.0        684.0       684.0
IN               138164.         164.        164.
IN               80970.2         70.2        70.2
IN               81091.1         91.1        91.1
IN               81185.4         85.4        85.4
IN               812184.1        184.1       184.1
IN                 5240.5        40.5        40.5
IN                 53111.4       111.4       111.4
IN               844454.         454.        454.
IN                 55111.4       111.4       111.4
IN                 5668.9        68.9        68.9
IN               815249.8        249.8       249.8
```

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IN            816352.4     352.4     352.4
              817364.5     364.5     364.5
              850354.4     354.4     354.4
IN            818354.4     354.4     354.4
IN            851384.8     384.8     384.8
IN            161202.5     202.5     202.5
IN             62202.5     202.5     202.5
IN            820404.      404.      404.
IN            821439.4     439.4     439.4
IN            265236.9     236.9     236.9
IN            266145.8     145.8     145.8
IN             66145.8     145.8     145.8
IN              6791.1      91.1      91.1
IN              7110.8      10.8      10.8
IN               725.9       5.9       5.9
IN              1735.9       5.9       5.9
IN              1744.3       4.3       4.3
IN             82622.9      22.9      22.9
IN            827480.0     480.0     480.0
IN            828527.0     527.0     527.0
IN               855.7       5.7       5.7
IN              8620.       20.       20.
IN             83047.2      47.2      47.2
IN              9022.9      22.9      22.9
IN              9140.0      40.0      40.0
IN            832527.0     527.0     527.0
IN            833480.0     480.0     480.0
IN              1043.        3.        3.
IN              1057.2       7.2       7.2
IN              1067.2       7.2       7.2
                1074.5       4.5       4.5
           10  806.4772               .8778
           20  841-.2840              .9588
FF         30  843-.9588             -.2840
FF         40  807.4772               .8788
FF         50  852.9588               .2840
FF         60   52-.8788              .4772
FF         70   55-.4772             -.8788
FF         80  161          -1.
FF         90  265-.9252              .3795
FF        100   66-.9951              .0993
FF        110   67 .0702    -.7071    .7036
SK        236  237-.8526    -.2425    .4629    -.2131    .9701    .1157
SP RC-H40 236  237130000.
SK         56   57.4772               .8788              1.
SP RC-H37  56   57160000.
SP        559  560          230000.
SK        851   61.9252              -.3795              1.
SP RC-H39 851   61160000.
SK         62   63.174      -.8886    .4243    -.3372   -.4586    -.8222
SP RC-H38  62   63171000.
EN
EX         NEW FILE
NF          12     31.
EN
EX         NEW FILE SRSS  DBE AND 2 SRV NFEQ2F
NE           1     20.      22.       24.                          31.
OU           1     31.
OU           2     31.
OU           3     31.
```

```
EN
EX          EQ SUMMARY R31 EQ 12 WITH TWO SAV
EQ              11        10.
EQ              12        10.          31.
EN
```

APPENDIX I

RELAP5/FORCE CALCULATED THERMAL/HYDRAULIC LOADS FOR KEWAUNEE S/RV DISCHARGE PIPING

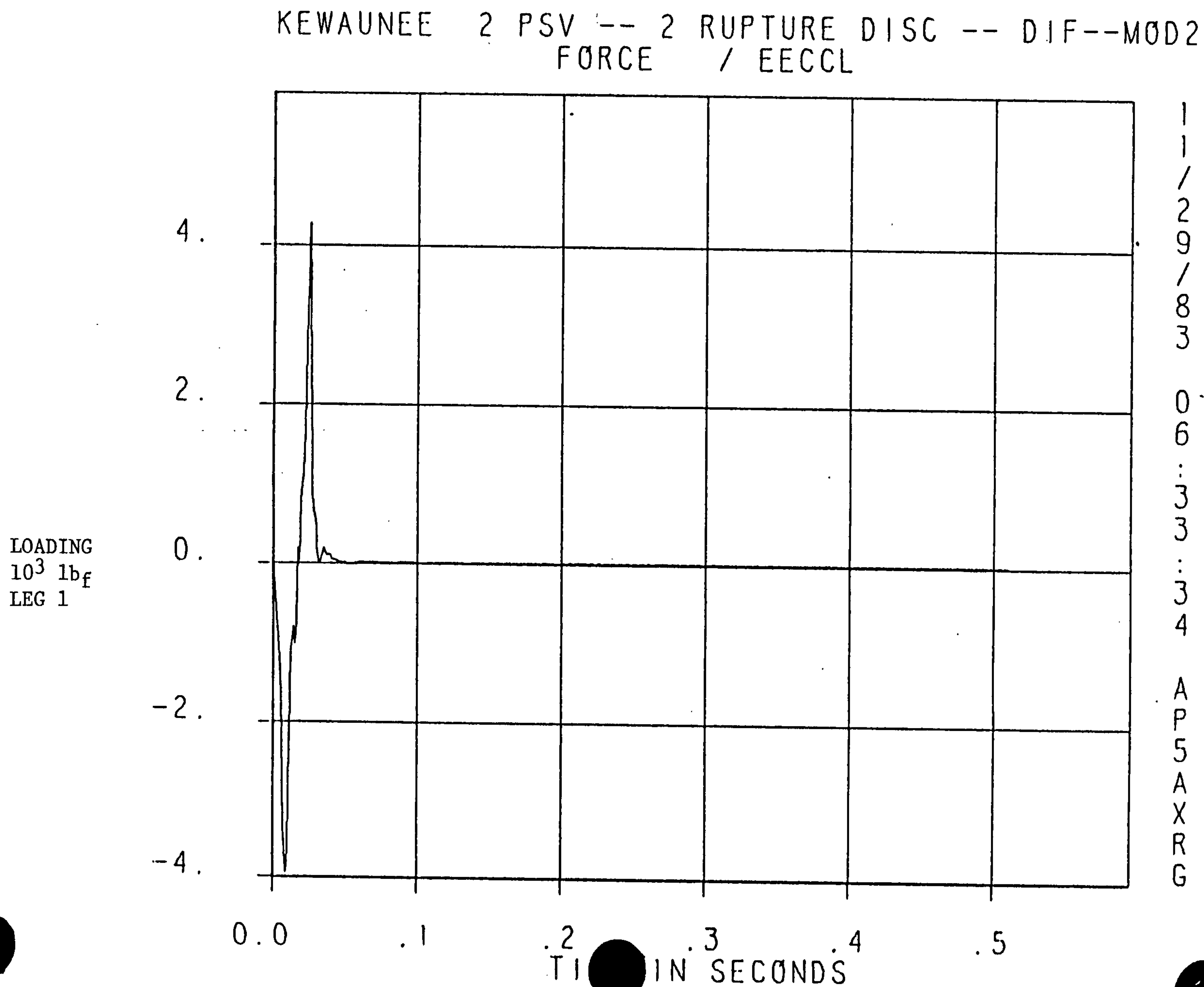
APPENDIX I
RELAP5/FORCE CALCULATED THERMAL/HYDRAULIC LOADS FOR KEWAUNEE S/RV DISCHARGE PIPING

All results in this section are for the piping configuration with two rupture discs at the discharge of safety valves PR-3A and PR-3B, one orifice plate with a 0.137 sq ft open flow area located beyond the first 10-inch discharge elbow, the 10-inch piping run replacing the 6-inch piping run between the two safety valves, and one additional restraint on the vertical 10-inch piping run.

LIST OF TRANSIENT LOADS

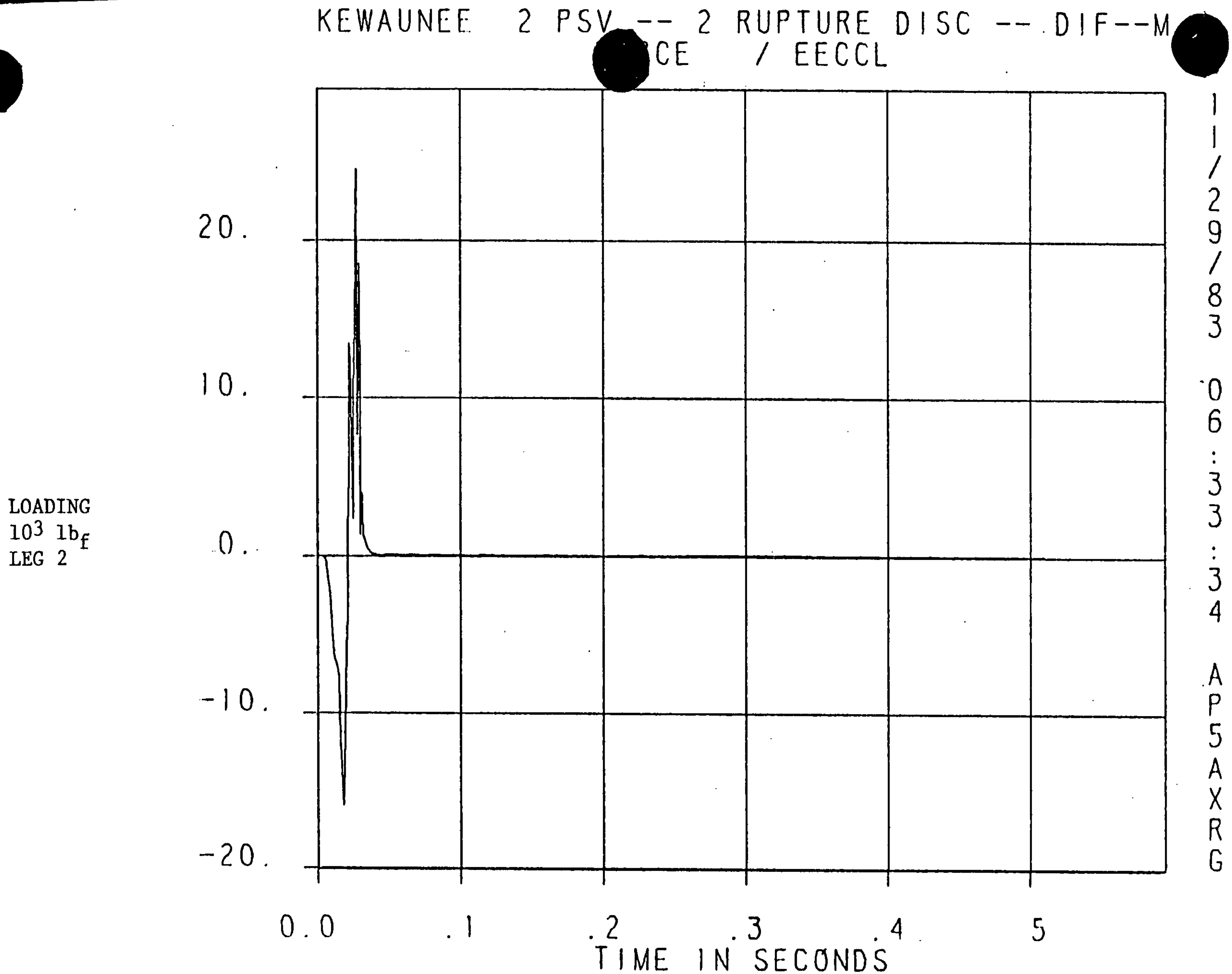
*Table 5-12 on page 5-39 defines legs.

LIST OF TRANSIENT LOADS (Continued)

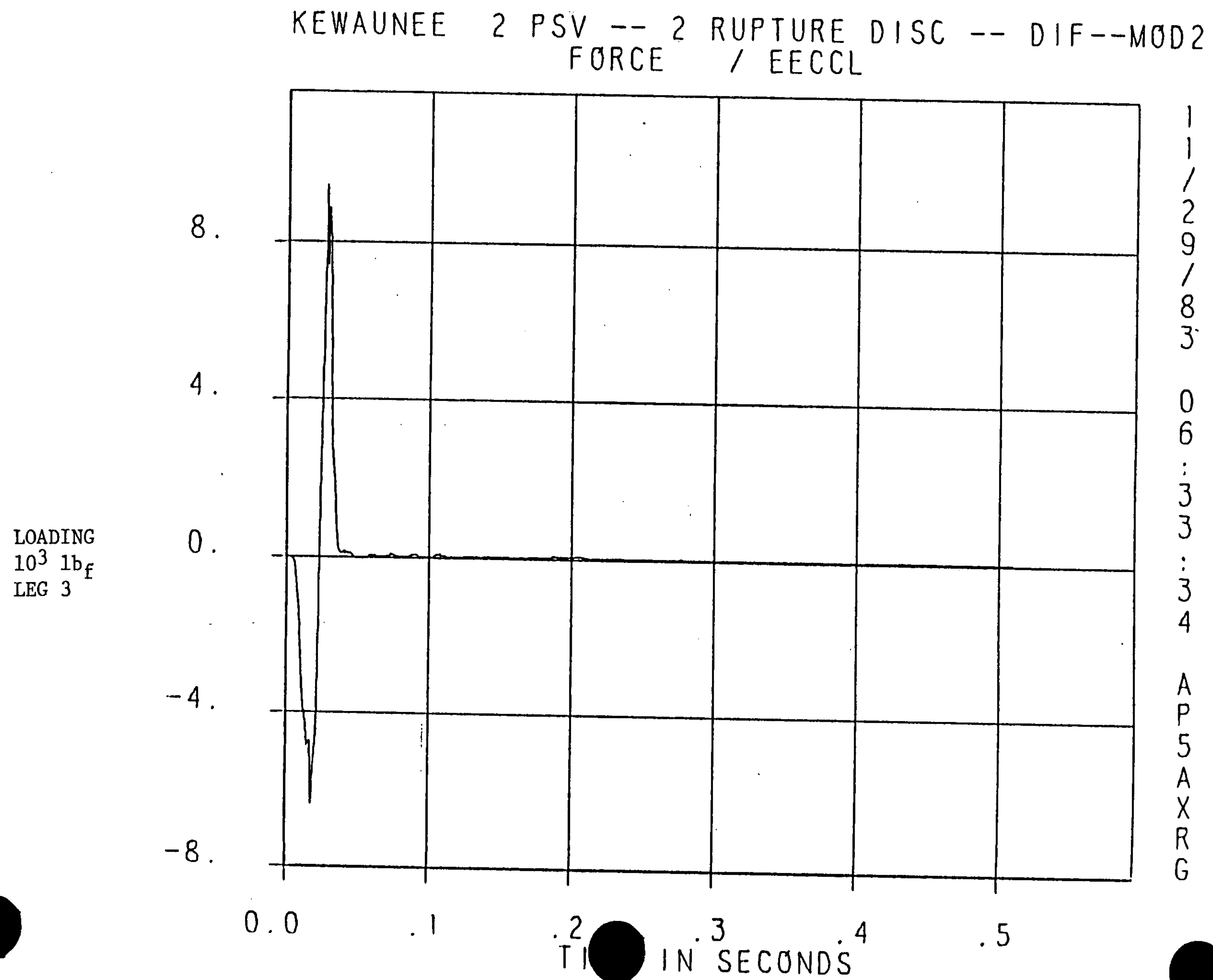


T/H LOADING FOR 2 PSV ACTUATION ON PIPING LEG 1

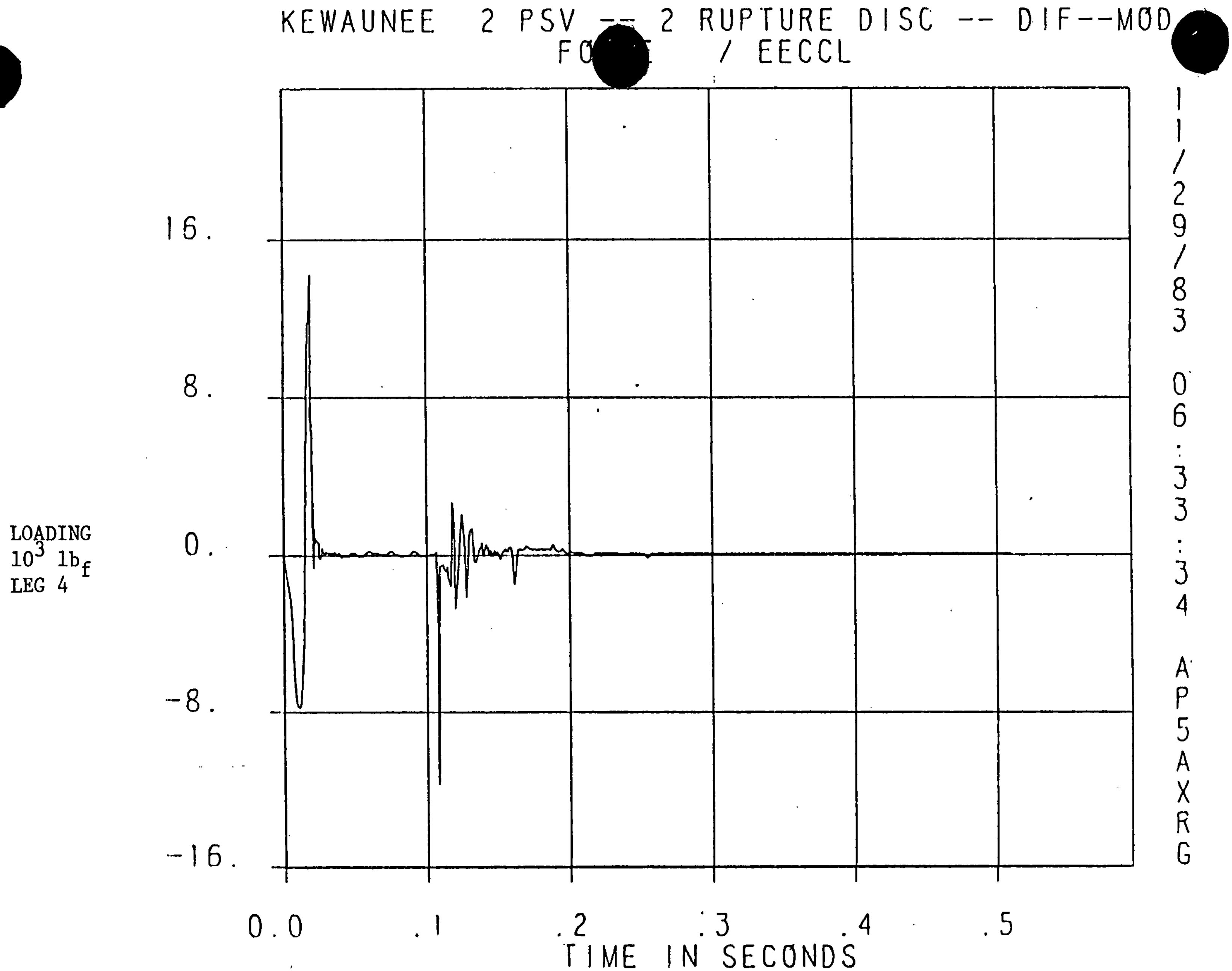
FIGURE I-1



T/H LOADING FOR 2 PSV ACTUATION ON PIPING LEG 2
FIGURE I-2

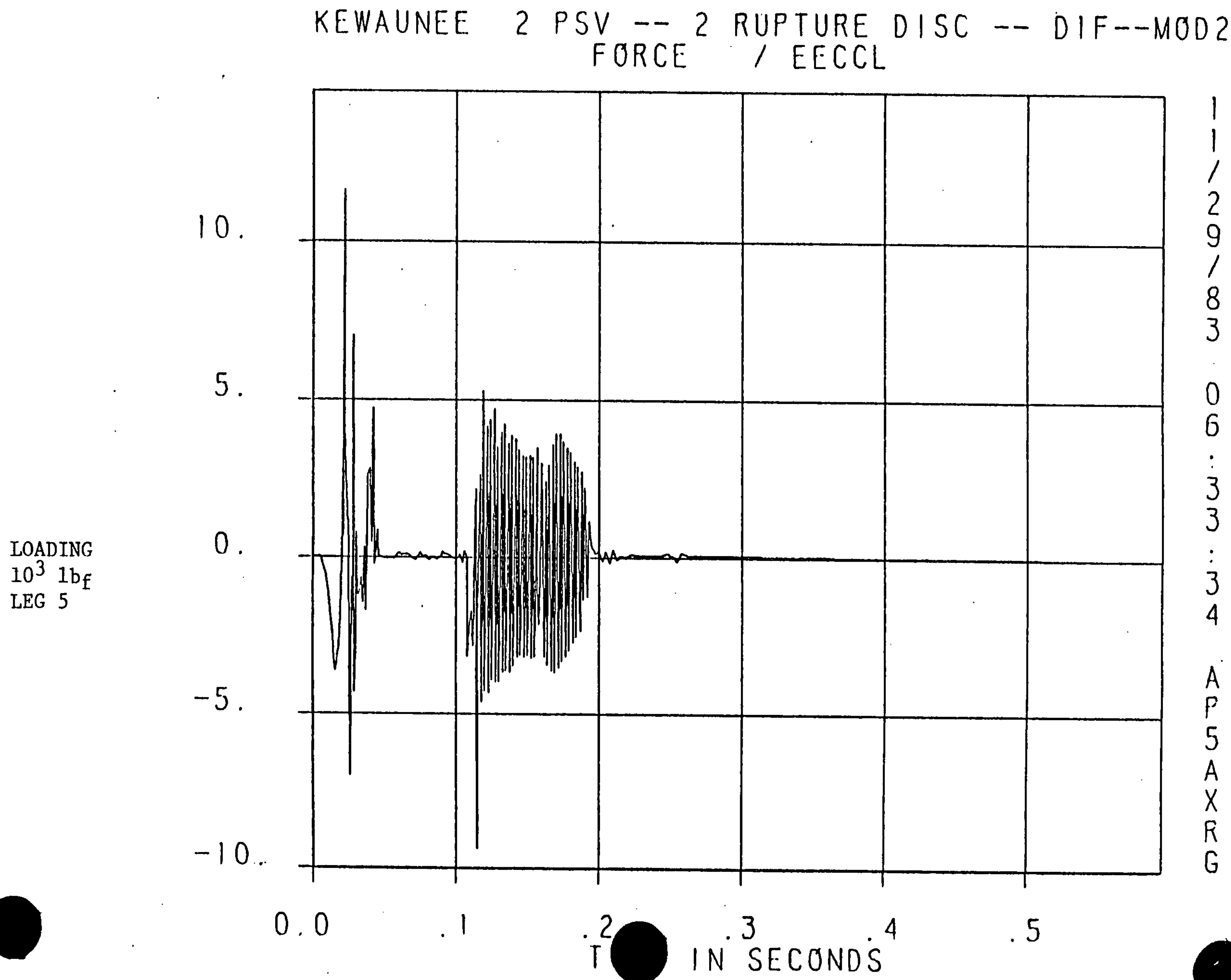


T/H LOADING FOR 2 PSV ACTUATION ON PIPING LEG 3
FIGURE I-3



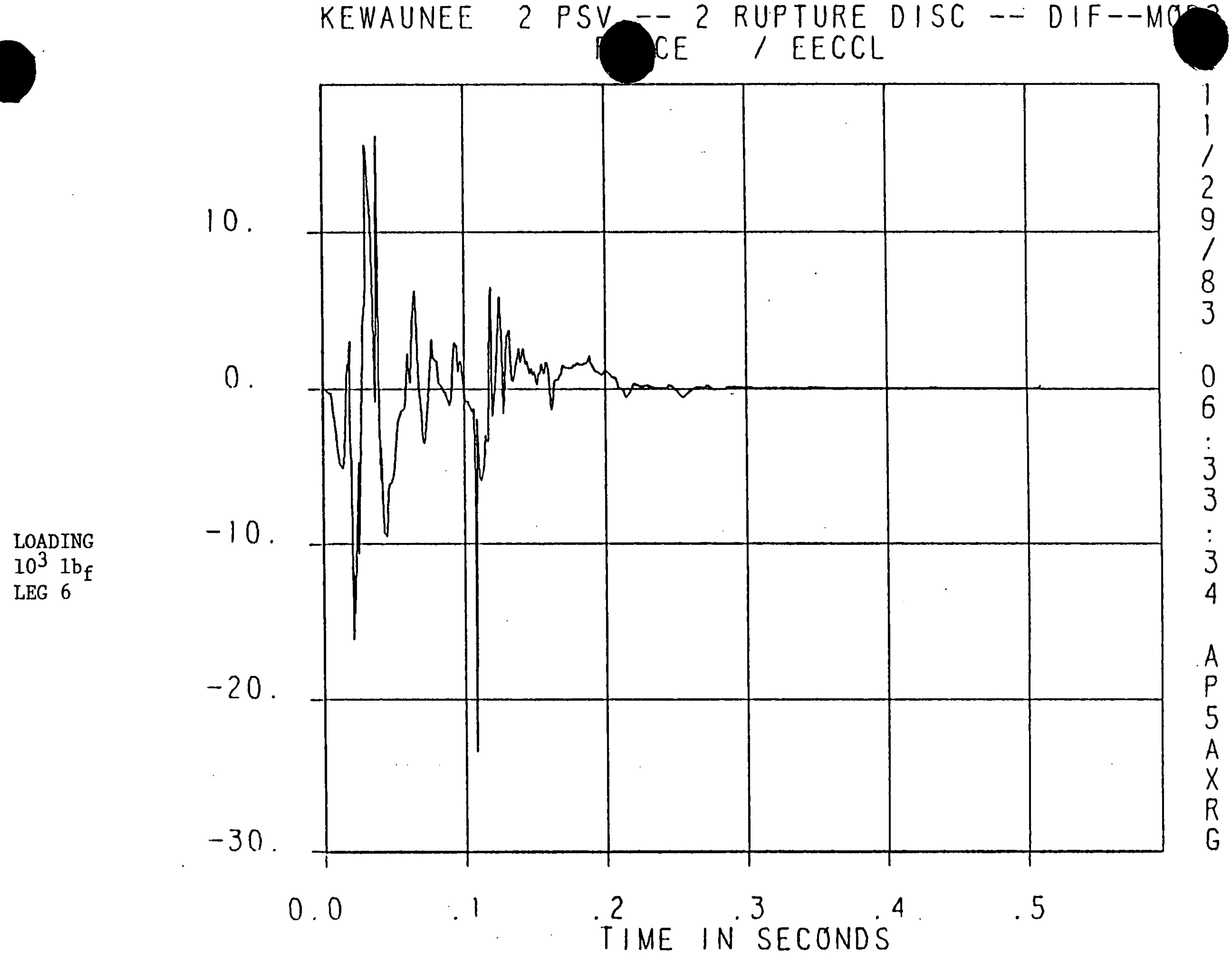
T/H LOADING FOR 2 PSV ACTUATION ON PIPING LEG 4

FIGURE I-4



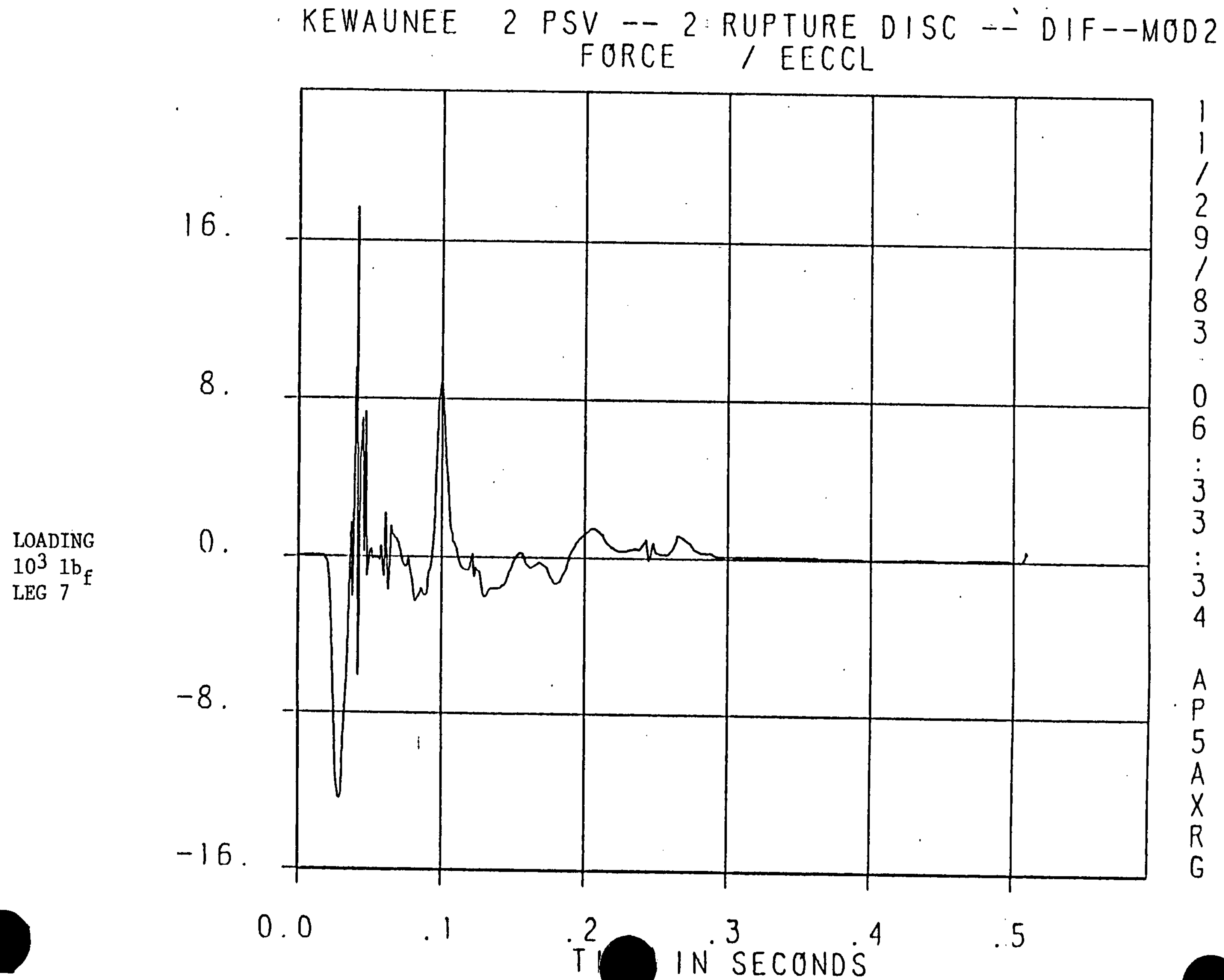
T/H LOADING FOR 2 PSV ACTUATION ON PIPING LEG 5

FIGURE I-5



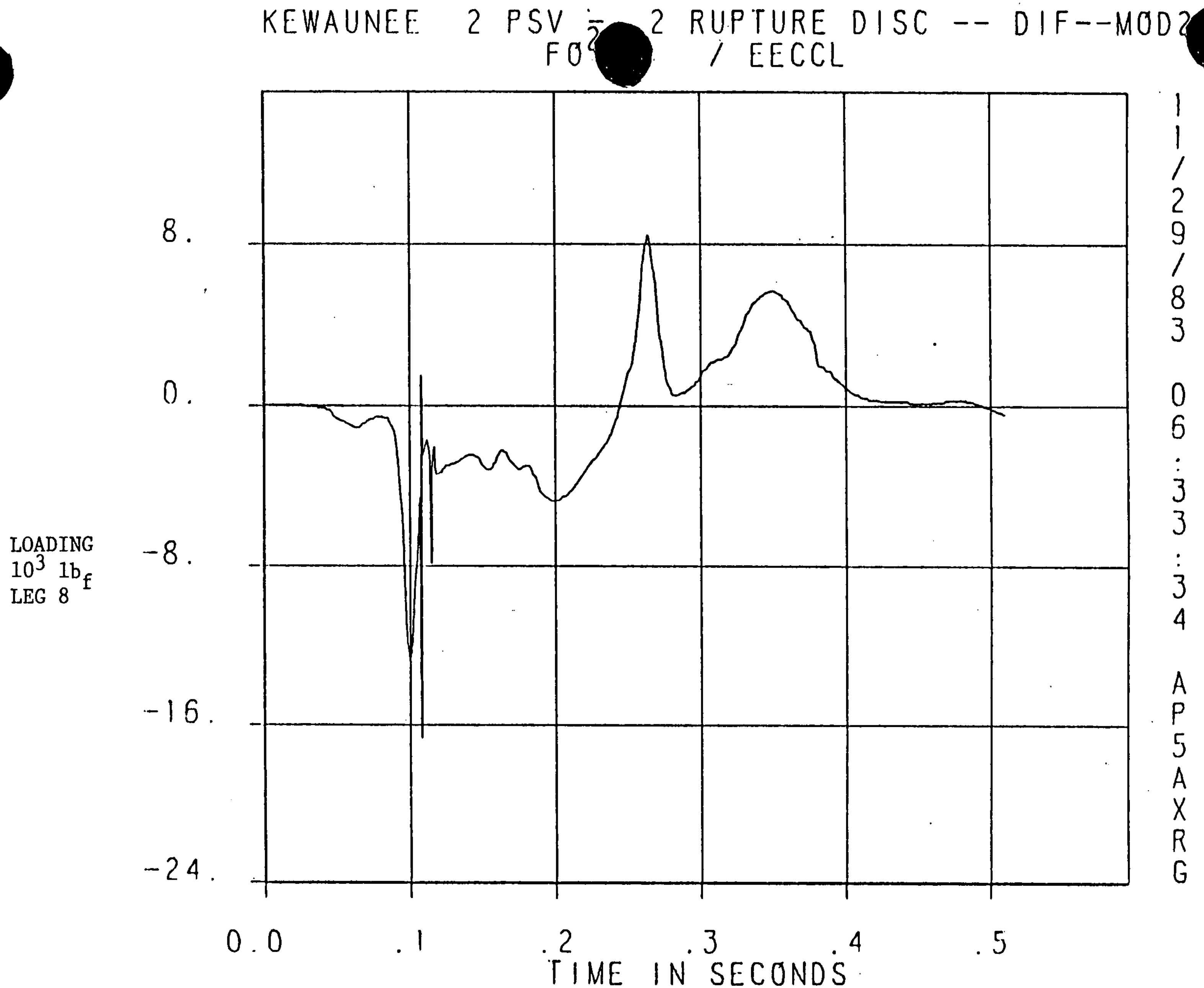
T/H LOADING FOR 2 PSV ACTUATION ON PIPING LEG 6

FIGURE I-6

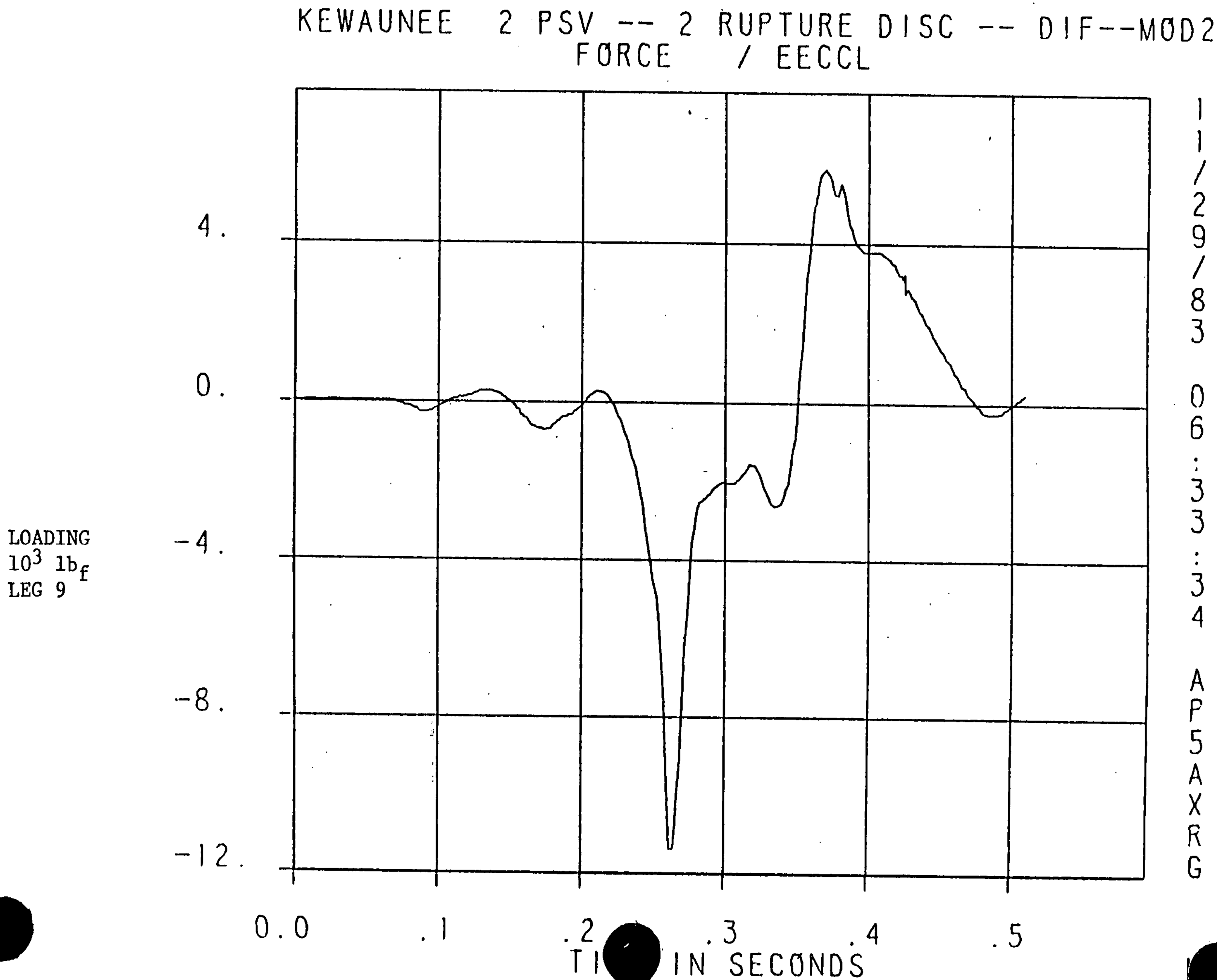


T/H LOADING FOR 2 PSV ACTUATION ON PIPING LEG 7

FIGURE I-7

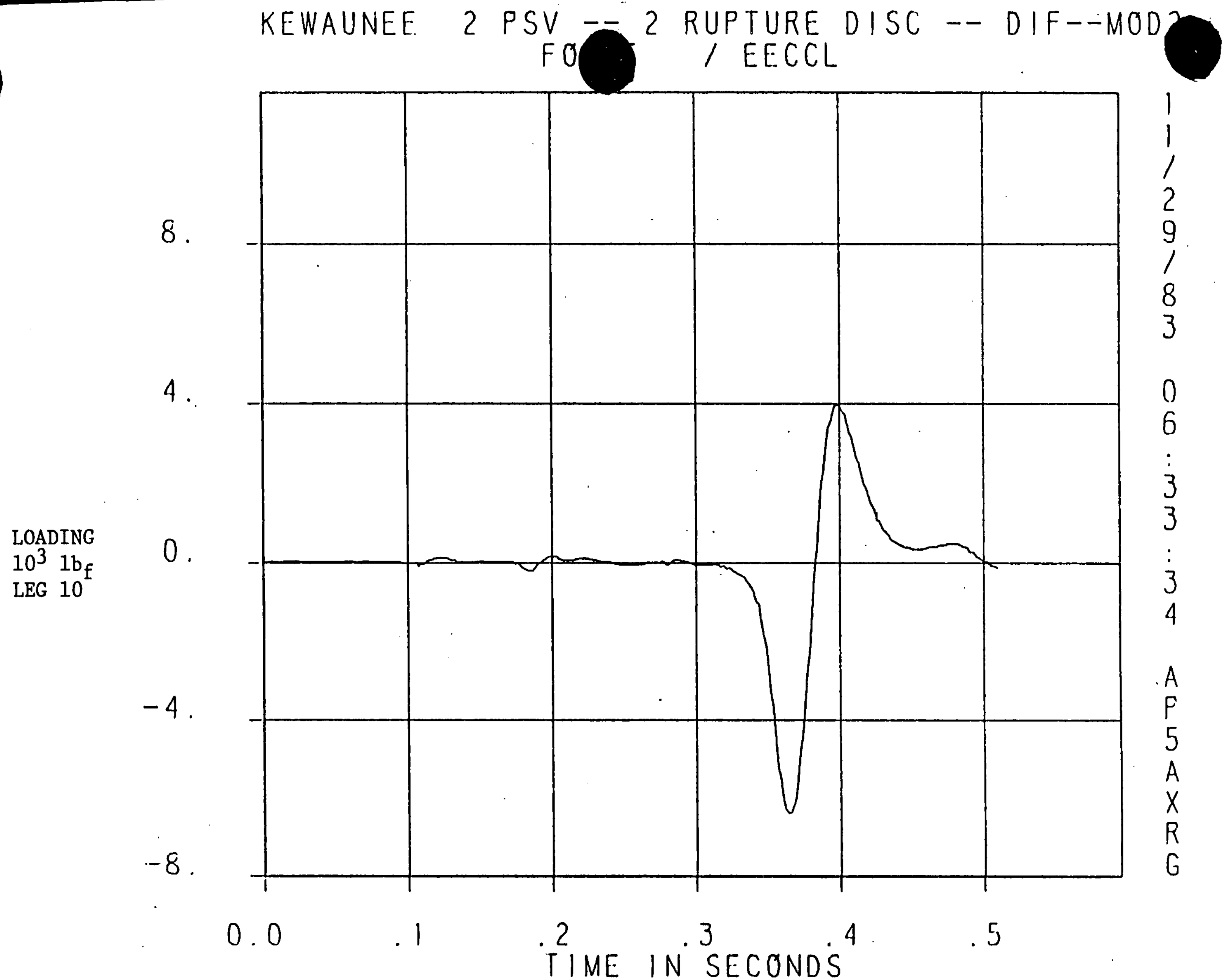


T/H LOADING FOR 2 PSV ACTUATION ON PIPING LEG 8
FIGURE I-8

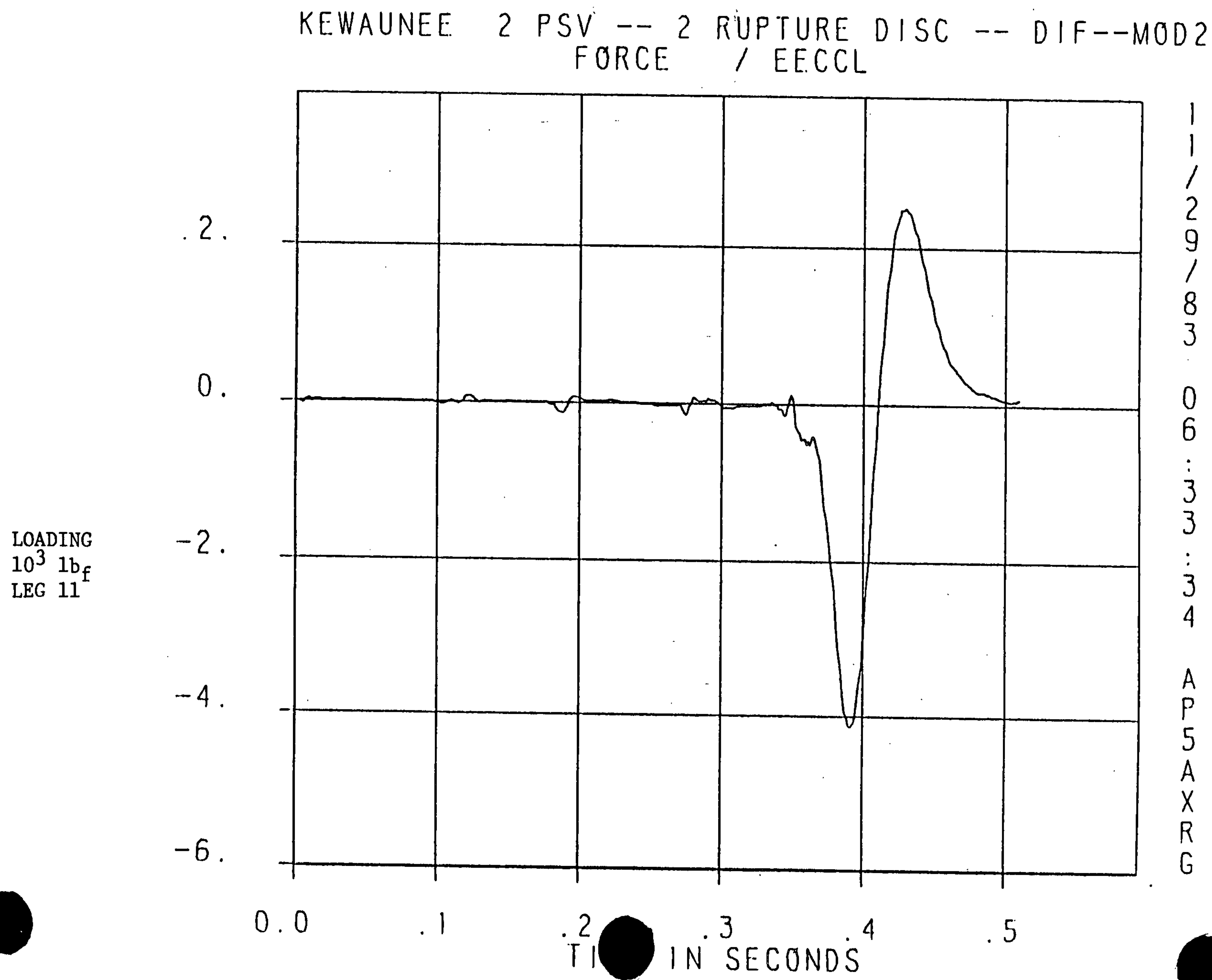


T/H LOADING FOR 2 PSV ACTUATION ON PIPING LEG 9

FIGURE I-9

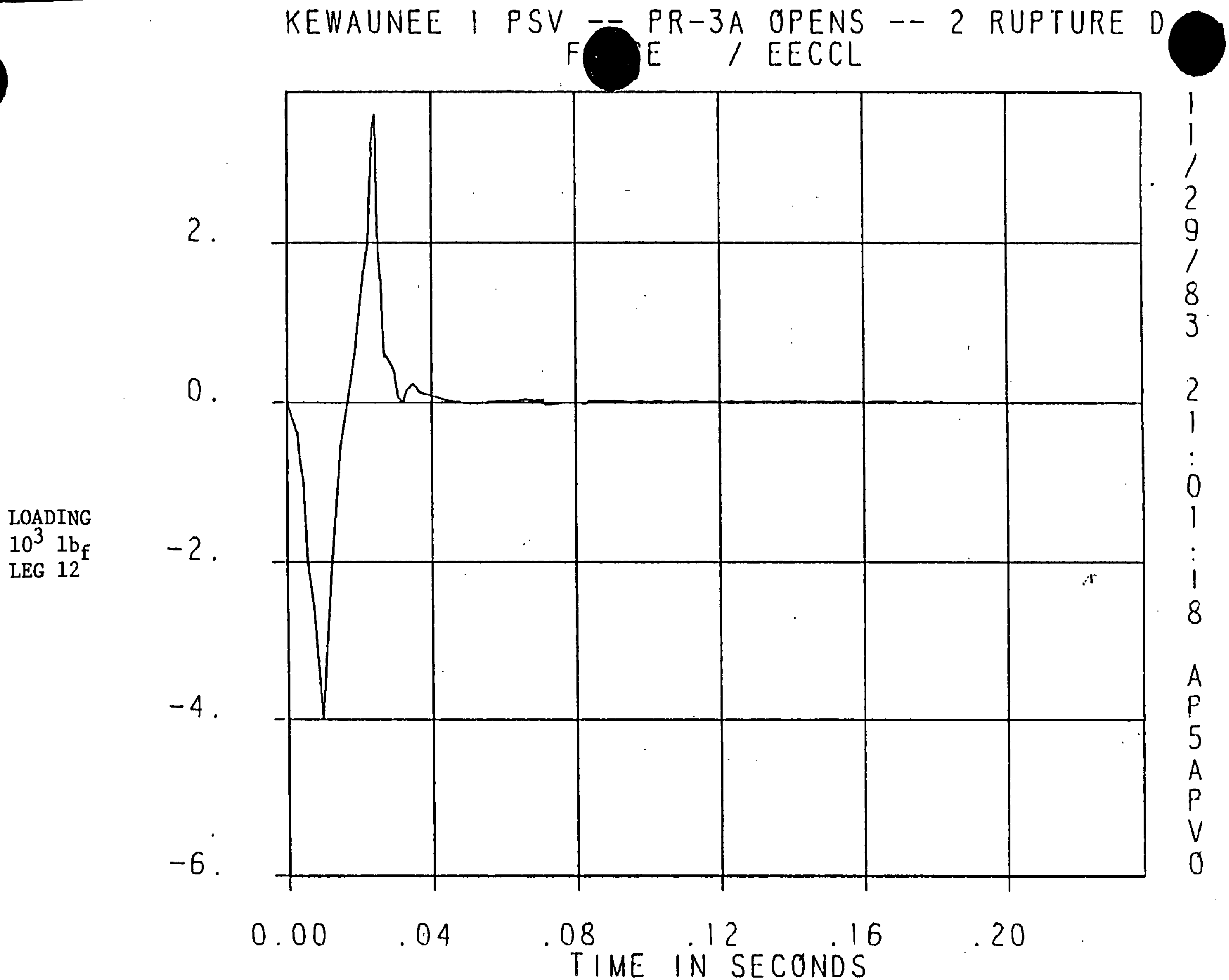


T/H LOADING FOR 2 PSV ACTUATION ON PIPING LEG 10
FIGURE I-10

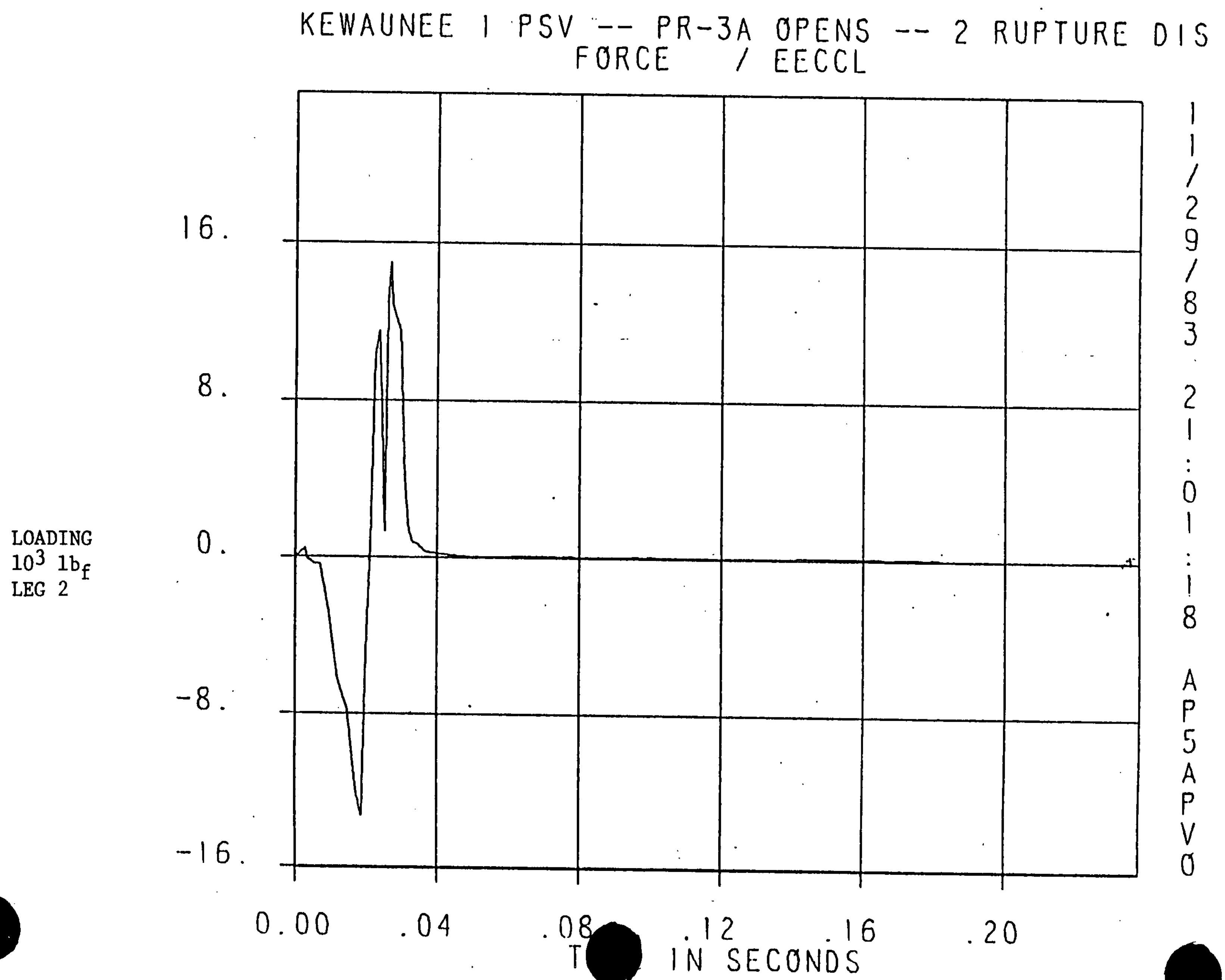


T/H LOADING FOR 2 PSV ACTUATION ON PIPING LEG 11

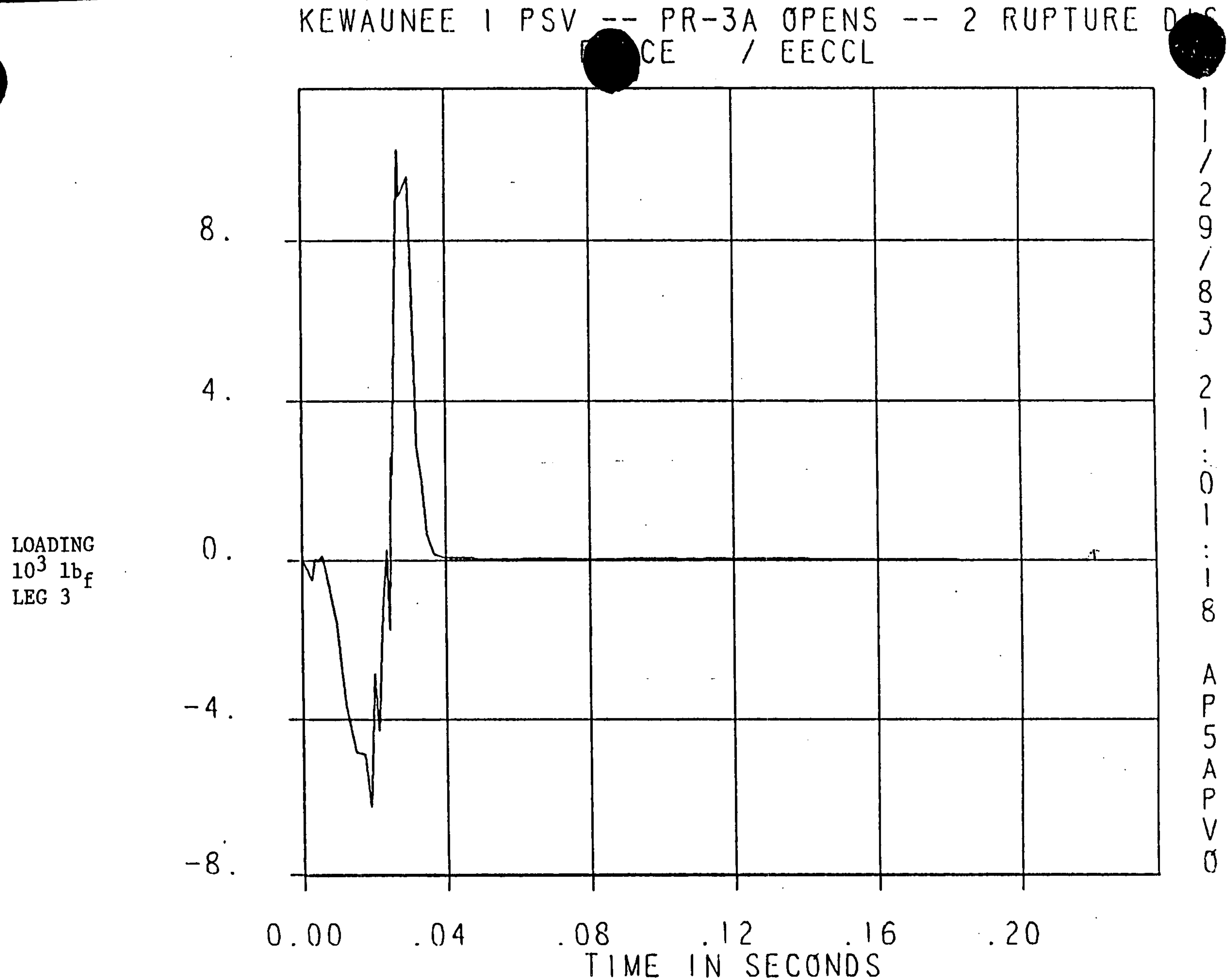
FIGURE I-11



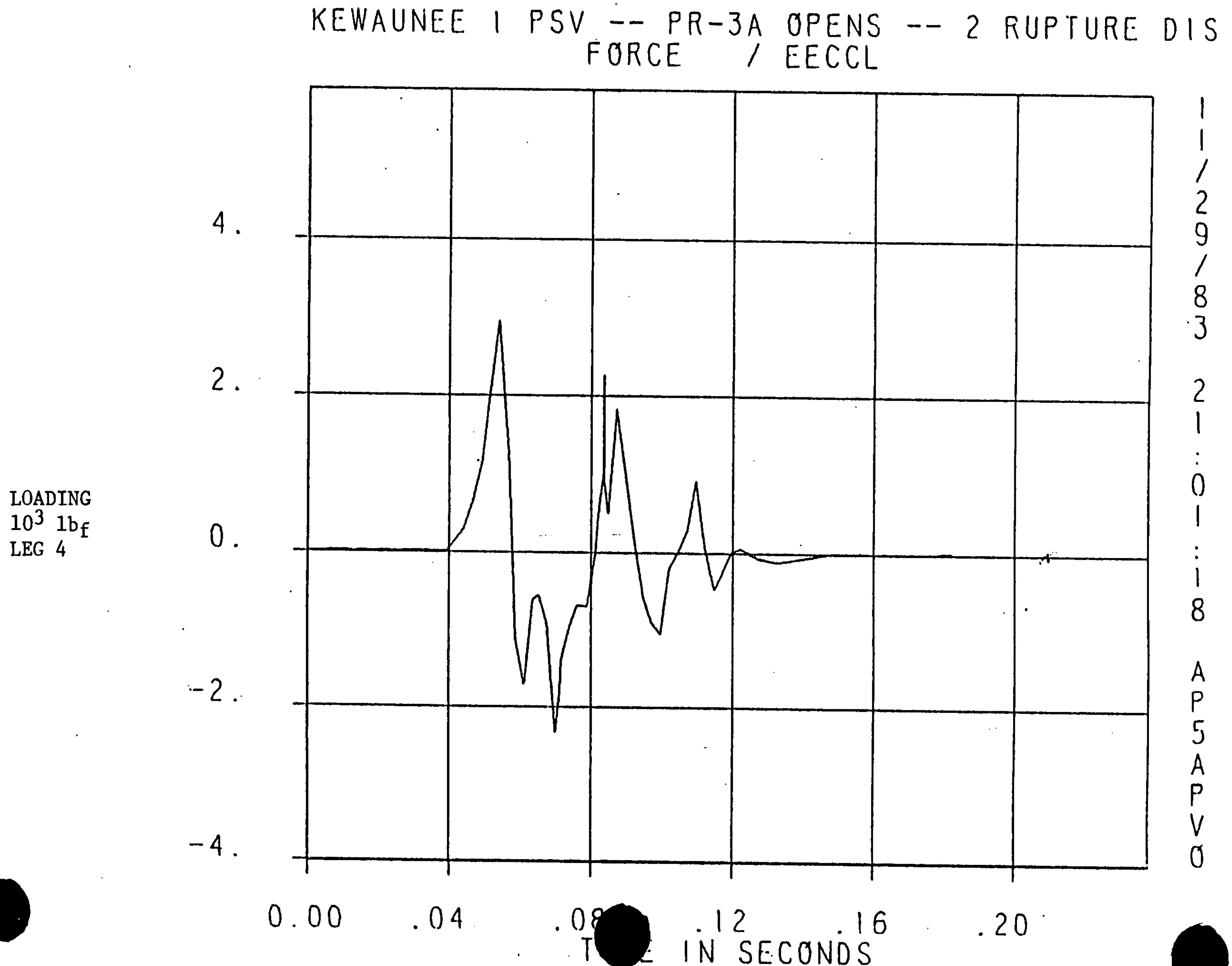
T/H LOADING FOR PSV PR-3A ACTUATION ON PIPING LEG 1
FIGURE I-12



T/H LOADING FOR PSV PR-3A ACTUATION ON PIPING LEG 2
FIGURE I-13

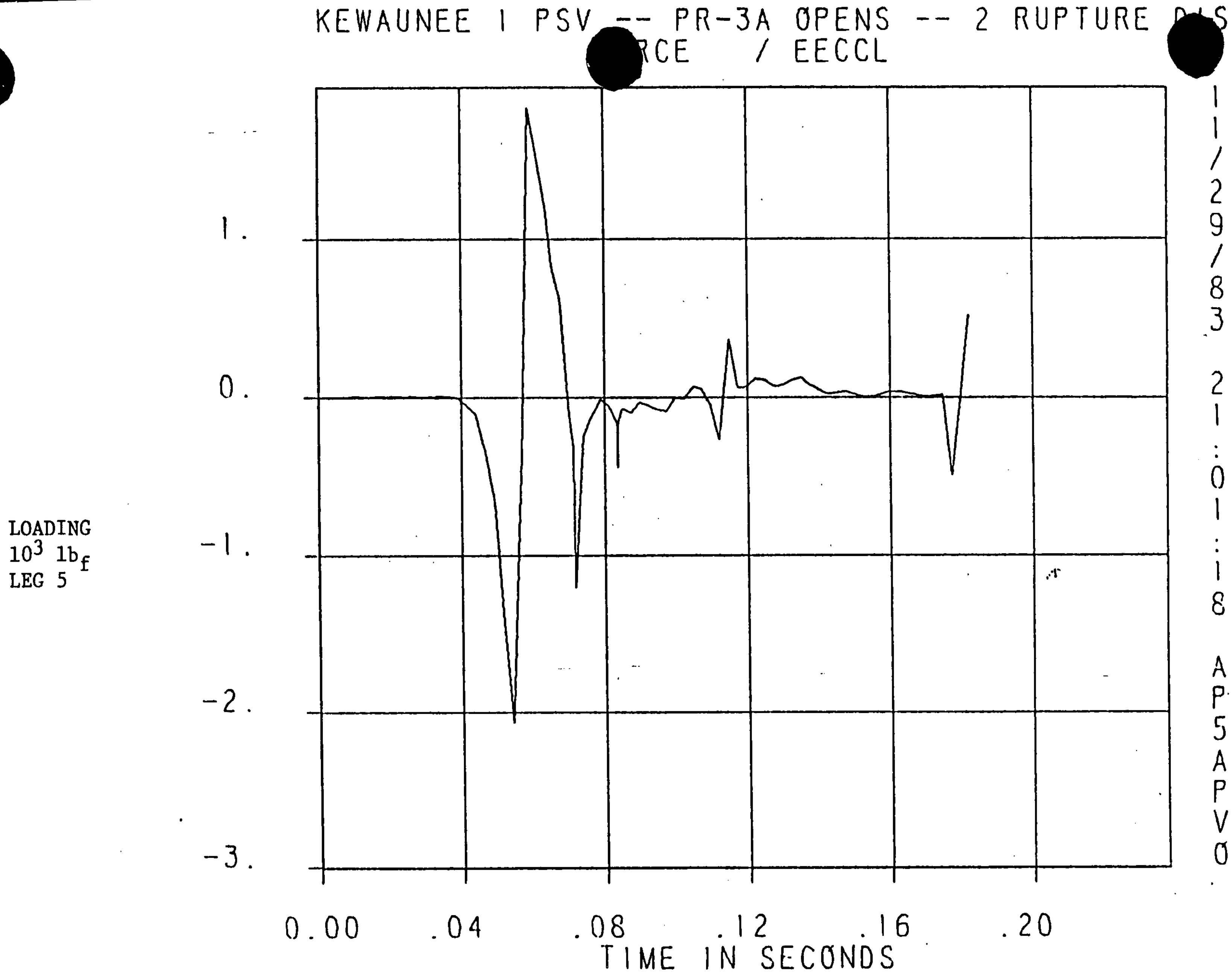


T/H LOADING FOR PSV PR-3A ACTUATION ON PIPING LEG 3
FIGURE I-14

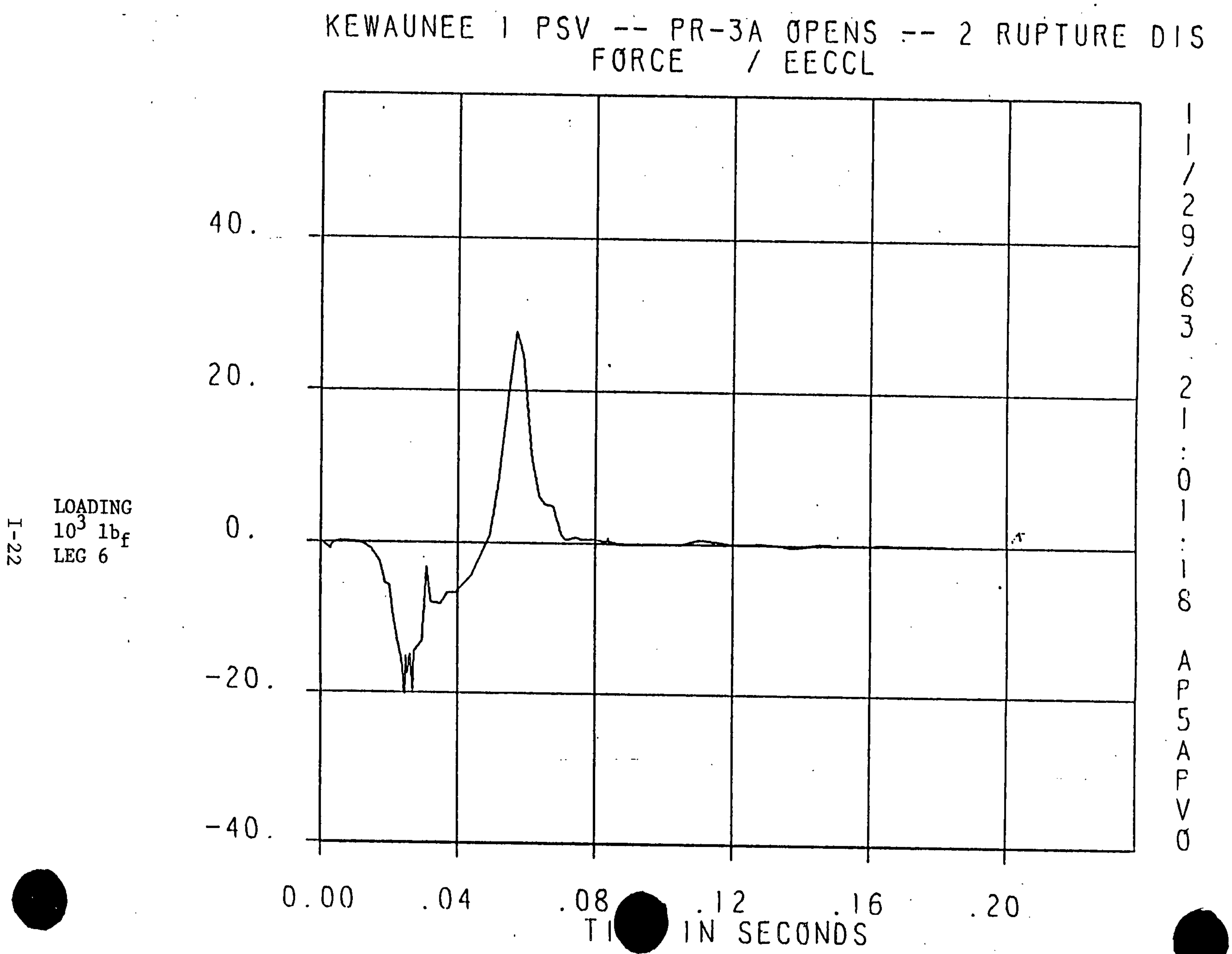


T/H LOADING FOR PSV PR-3A ACTUATION ON PIPING LEG 4

FIGURE I-15

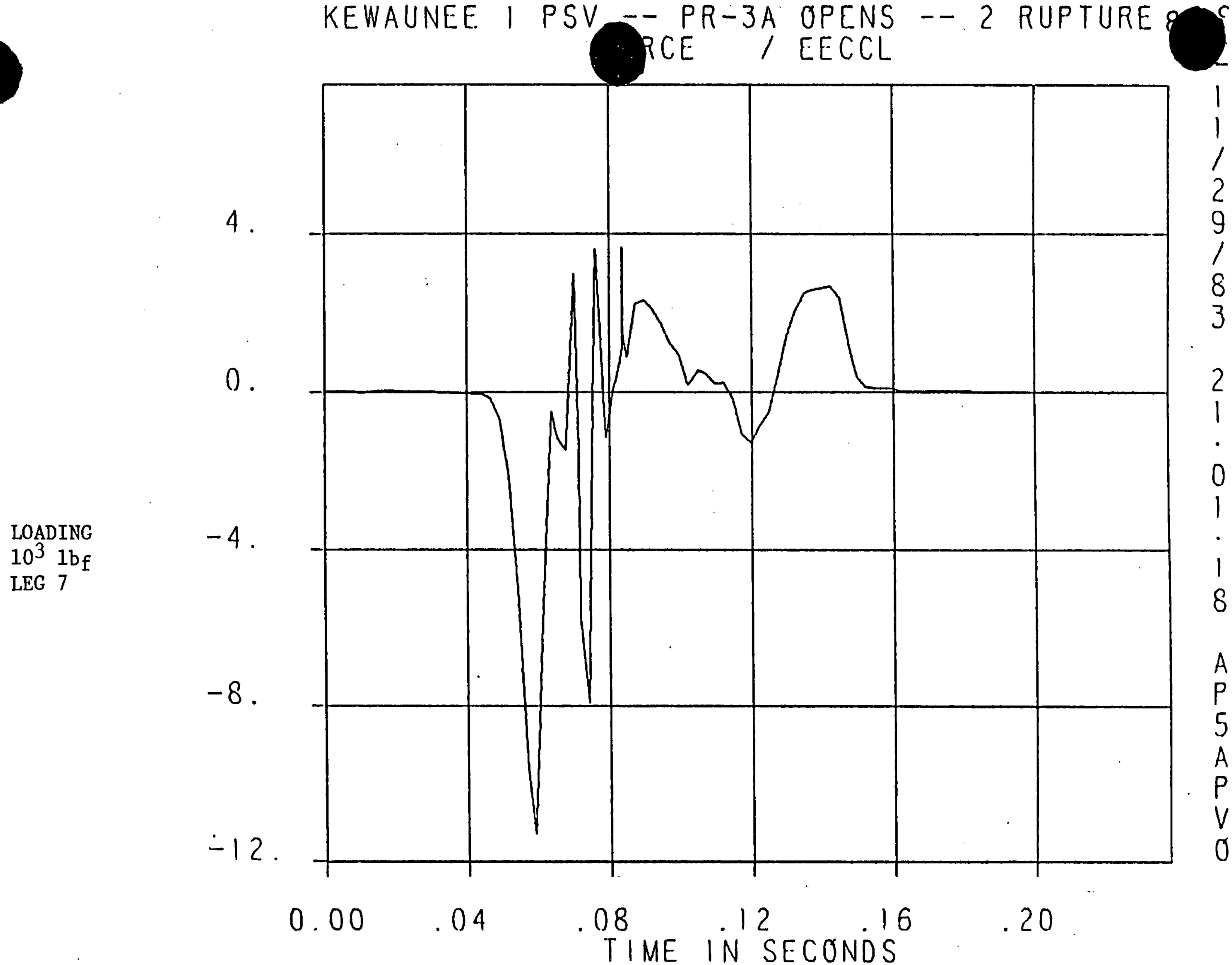


T/H LOADING FOR PSV PR-3A ACTUATION ON PIPING LEG 5
FIGURE I-16

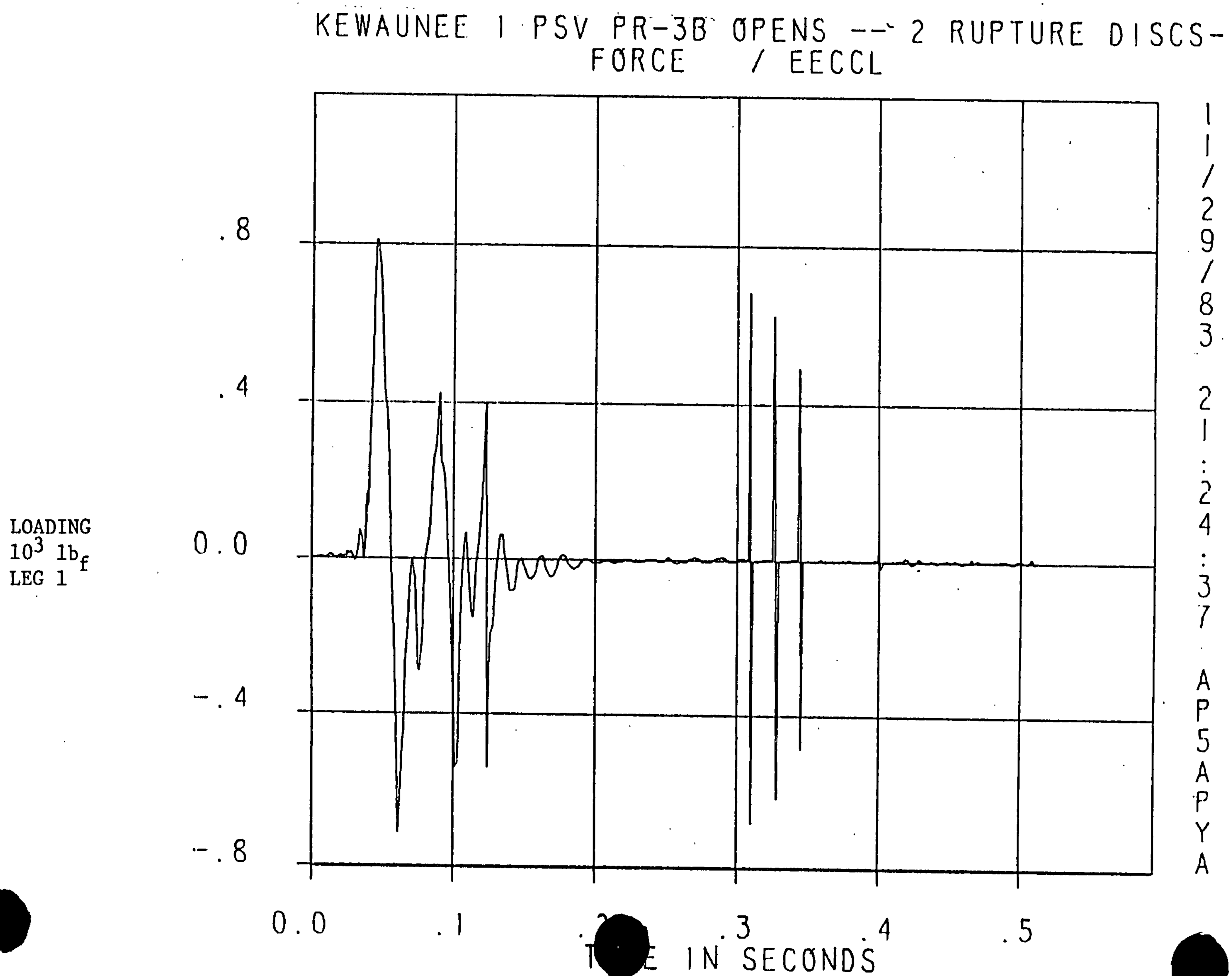


T/H LOADING FOR PSV PR-3A ACTUATION ON PIPING LEG 6

FIGURE I-17

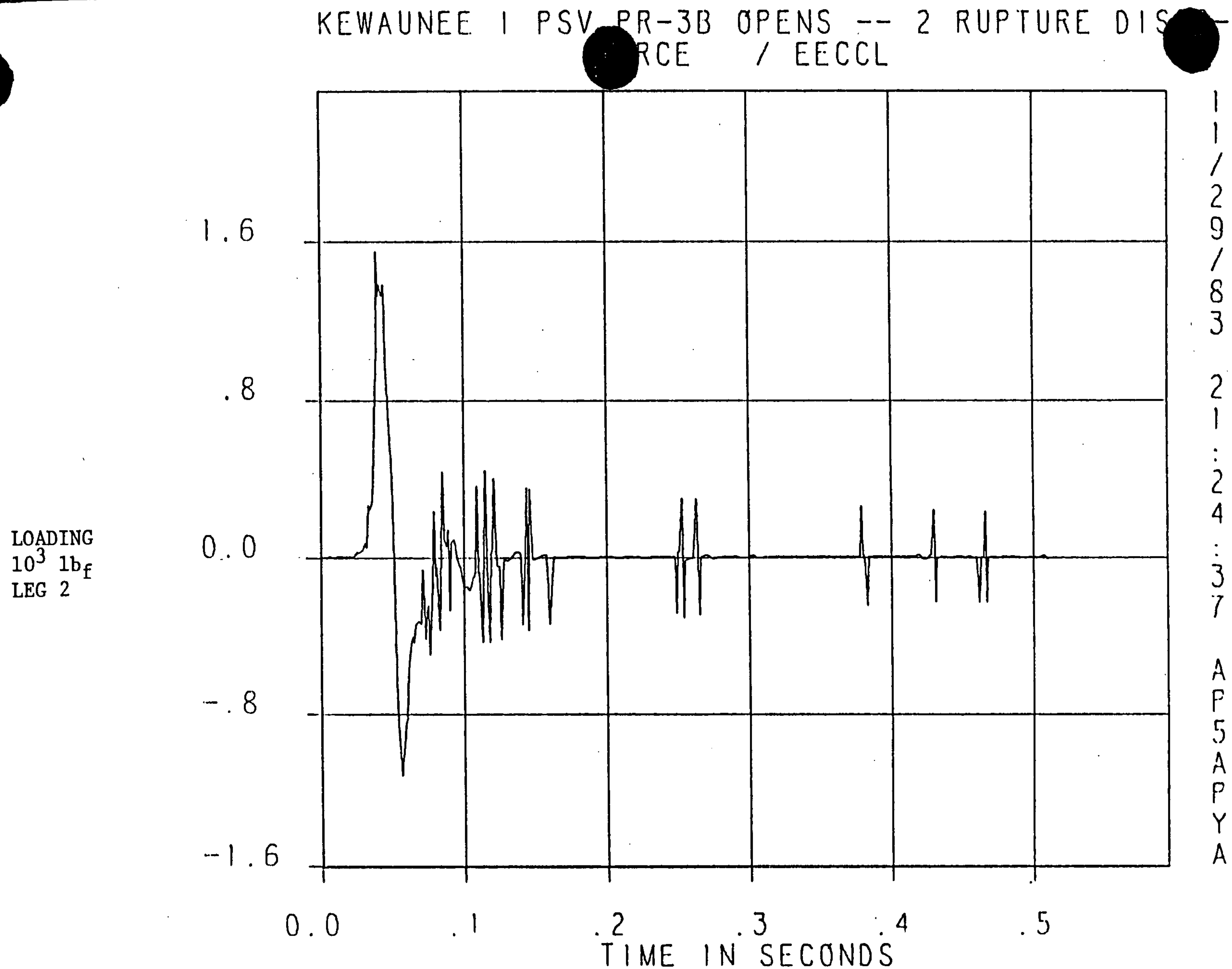


T/H LOADING FOR PSV PR-3A ACTUATION ON PIPING LEG 7
FIGURE I-18

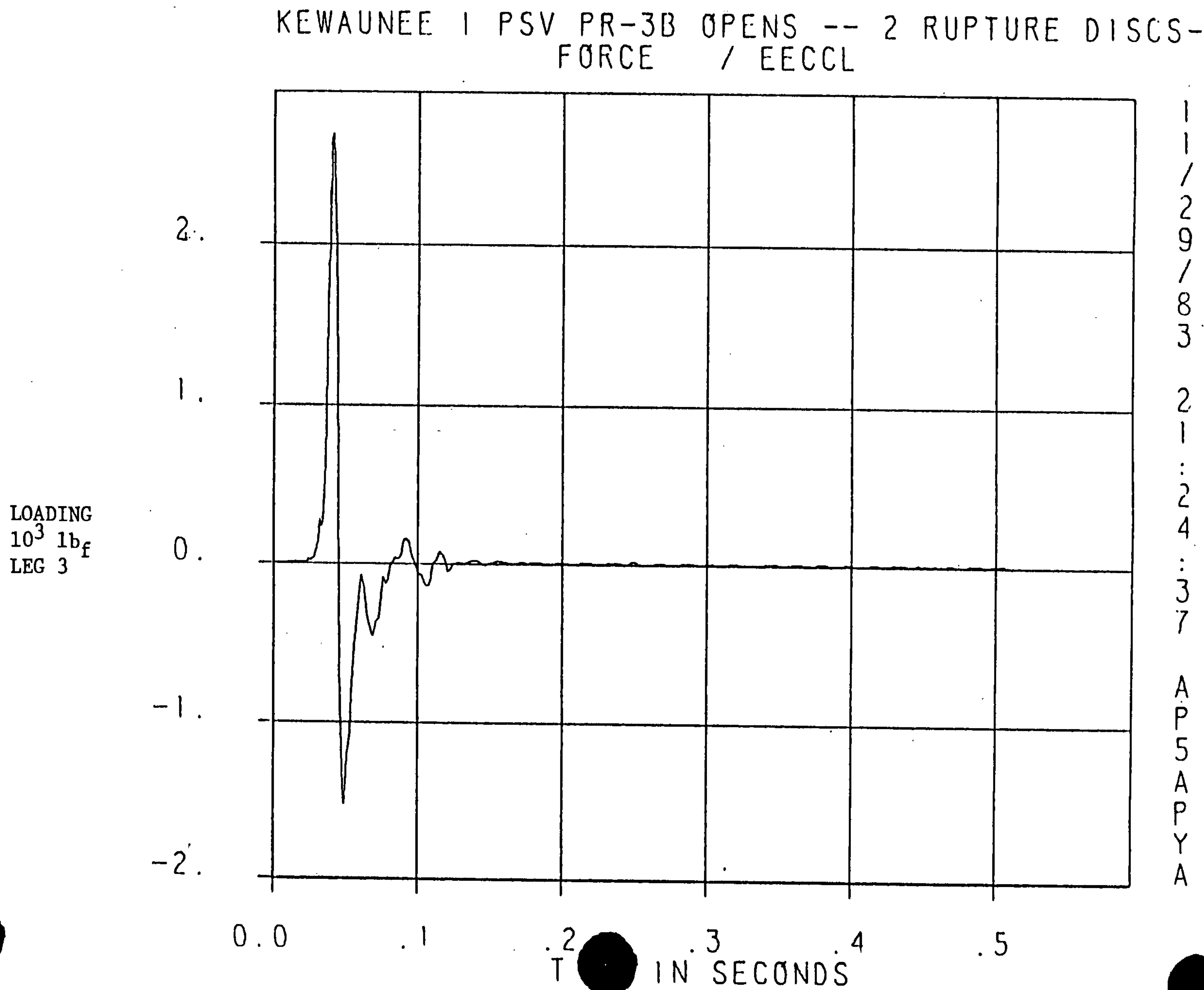


T/H LOADING FOR PSV PR-3B ACTUATION ON PIPING LEG 1

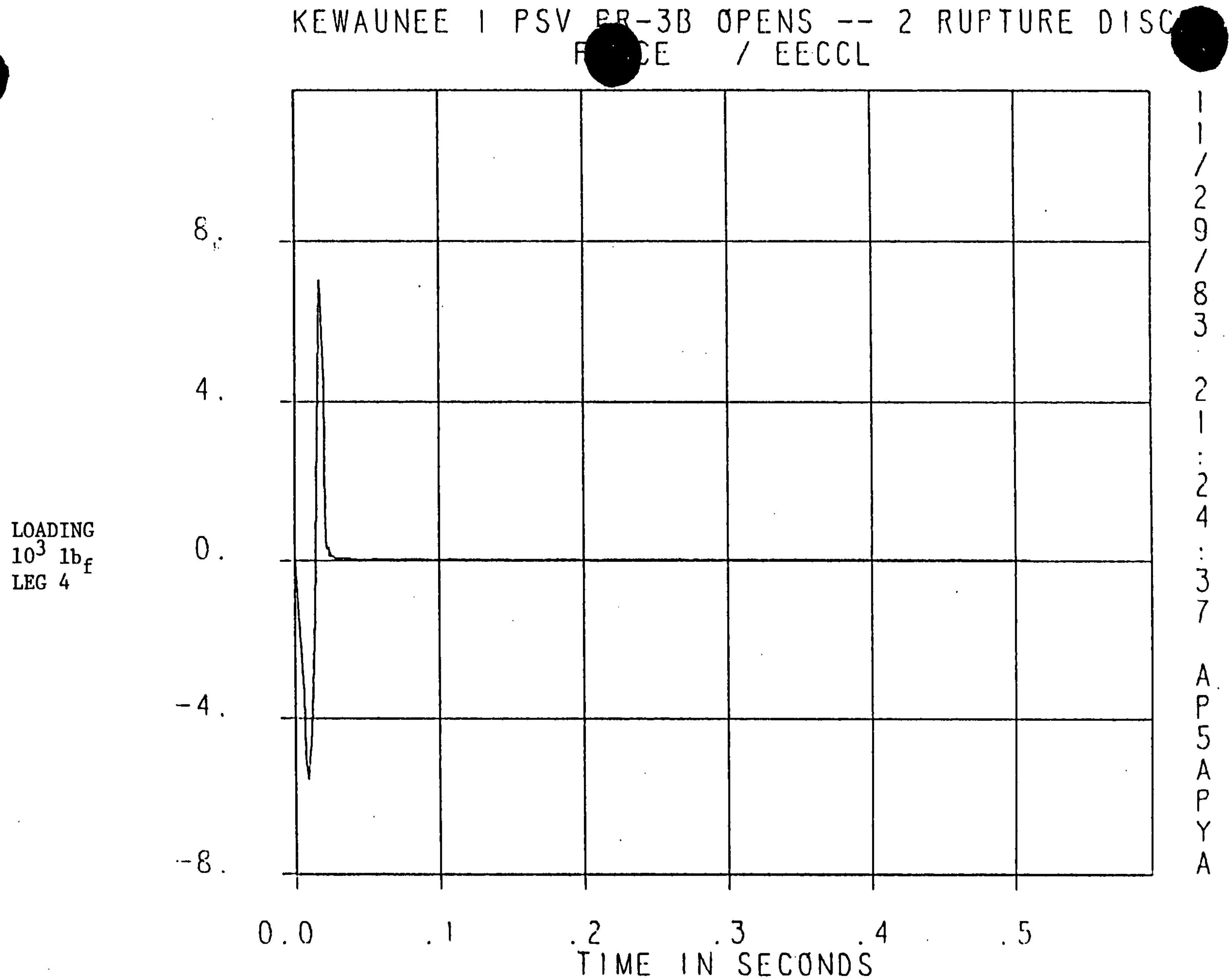
FIGURE I-19



T/H LOADING FOR PSV PR-3B ACTUATION ON PIPING LEG 2
FIGURE I-20

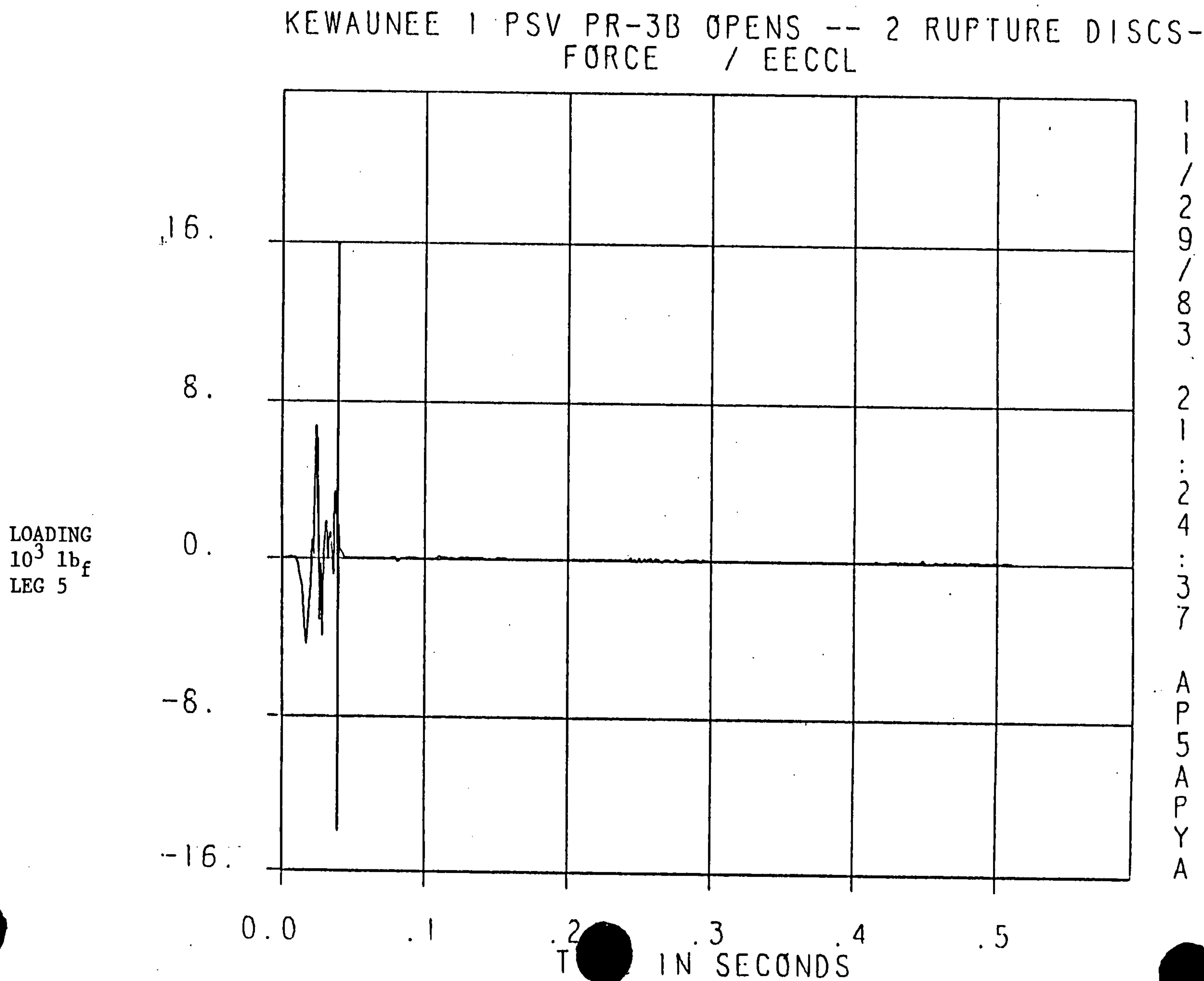


T/H LOADING FOR PSV PR-3B ACTUATION ON PIPING LEG 3
FIGURE I-21



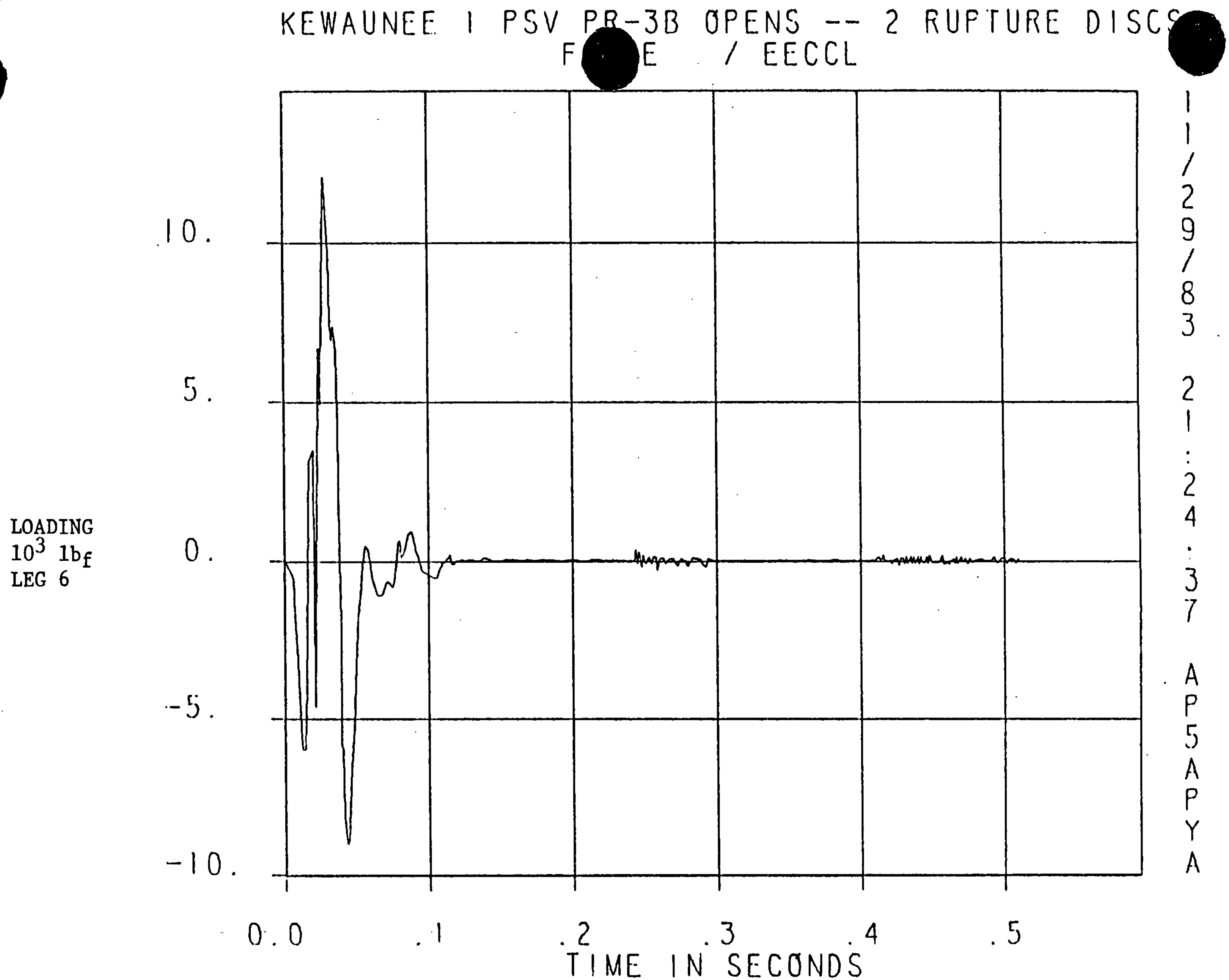
T/H LOADING FOR PSV PR-3B ACTUATION ON PIPING LEG 4

FIGURE I-22



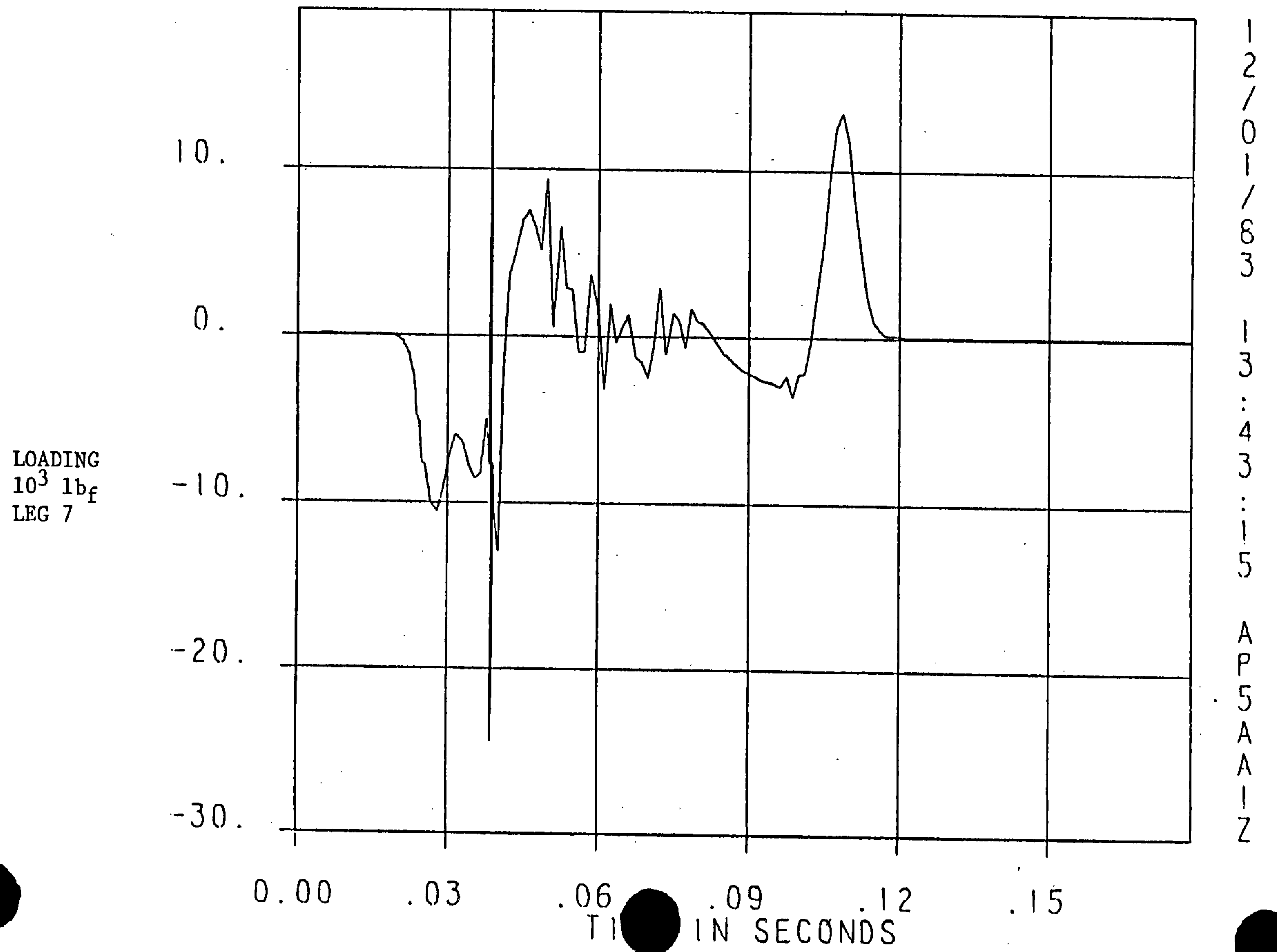
T/H LOADING FOR PSV PR-3B ACTUATION ON PIPING LEG 5

FIGURE I-23



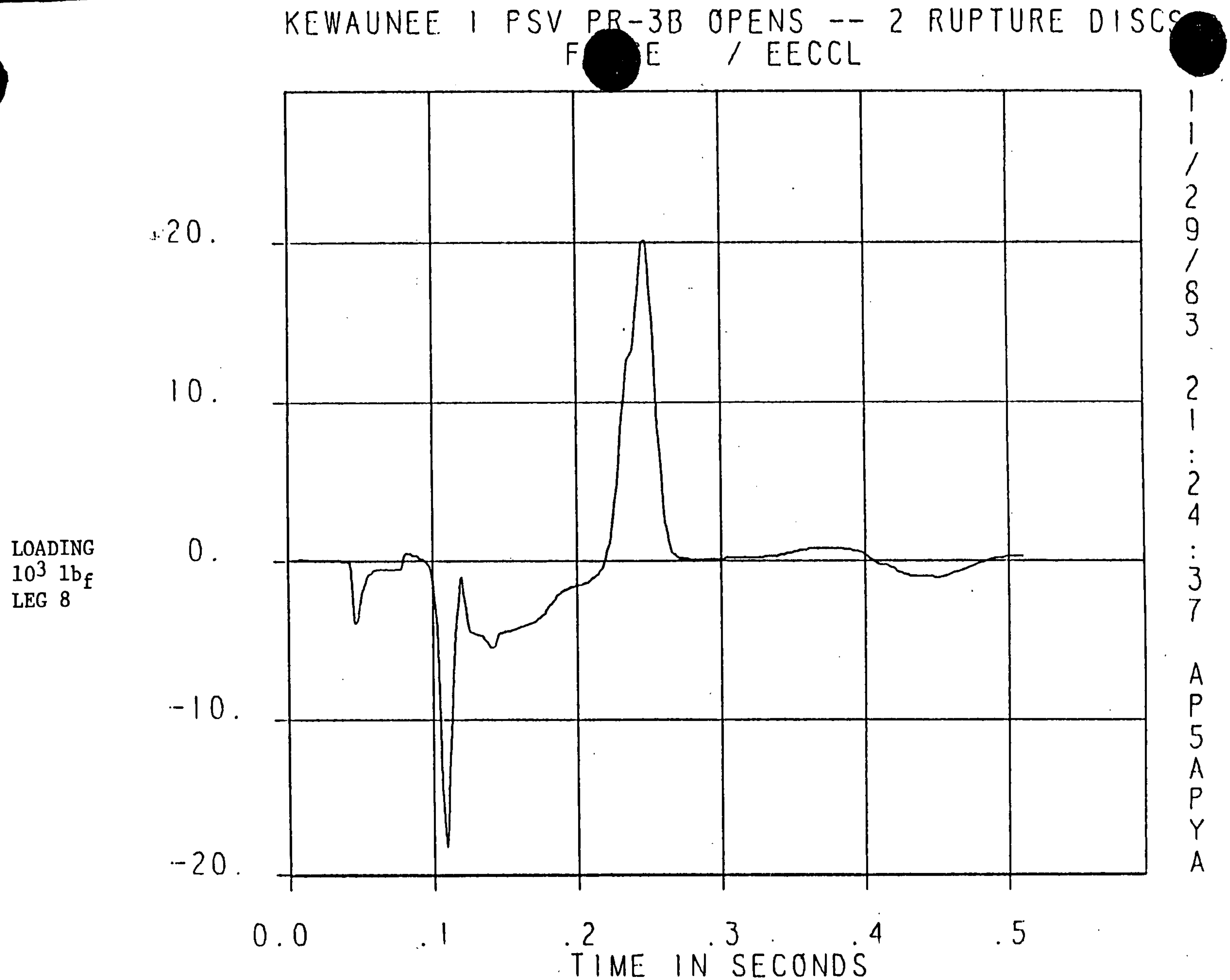
T/H LOADING FOR PSV PR-3B ACTUATION ON PIPING LEG 6
FIGURE I-24

KEWAUNEE 1 PSV PR-3B OPENS -- 2 RUPTURE DISCS-
FORCE / EECCL

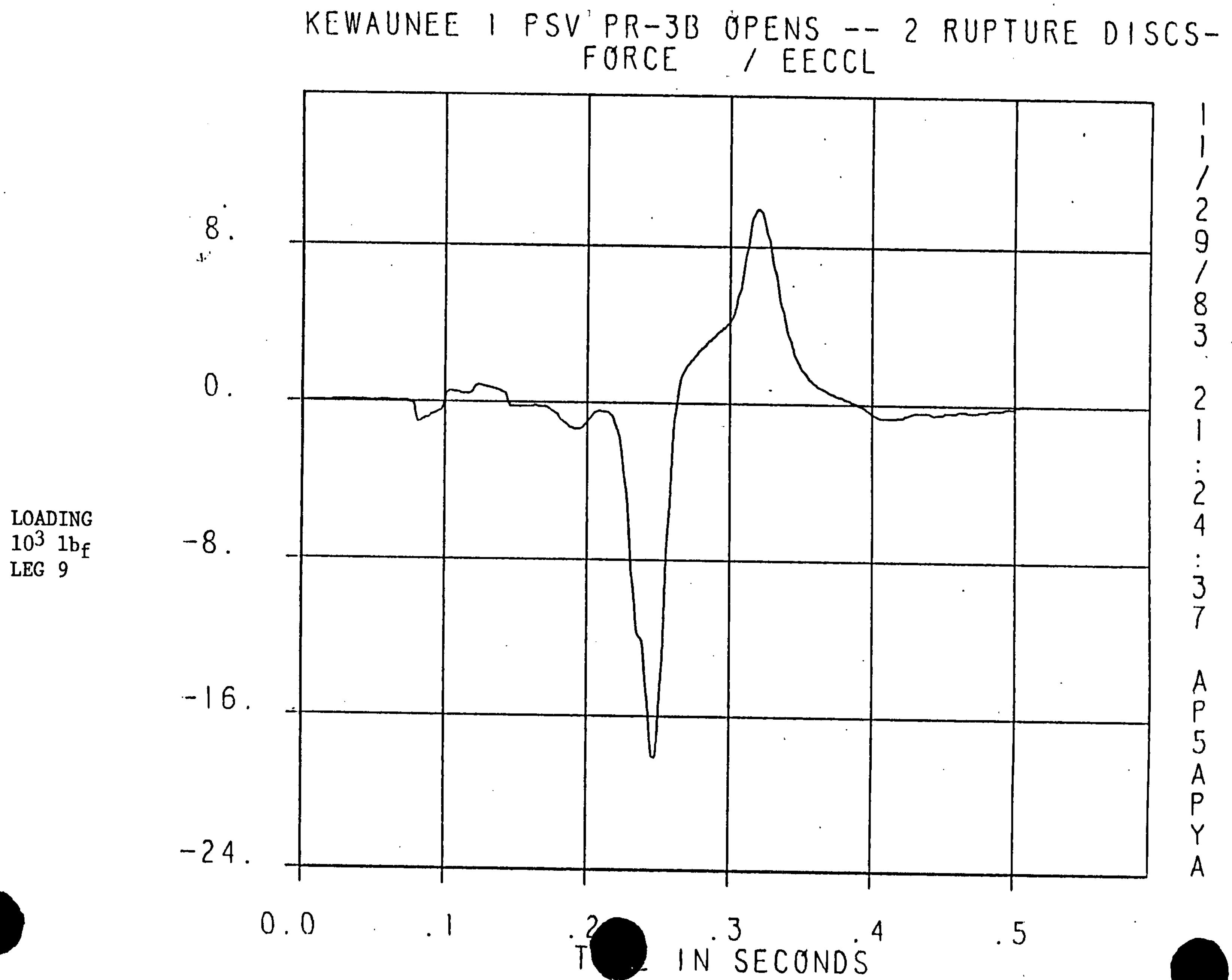


T/H LOADING FOR PSV PR-3B ACTUATION ON PIPING LEG 7

FIGURE I-25

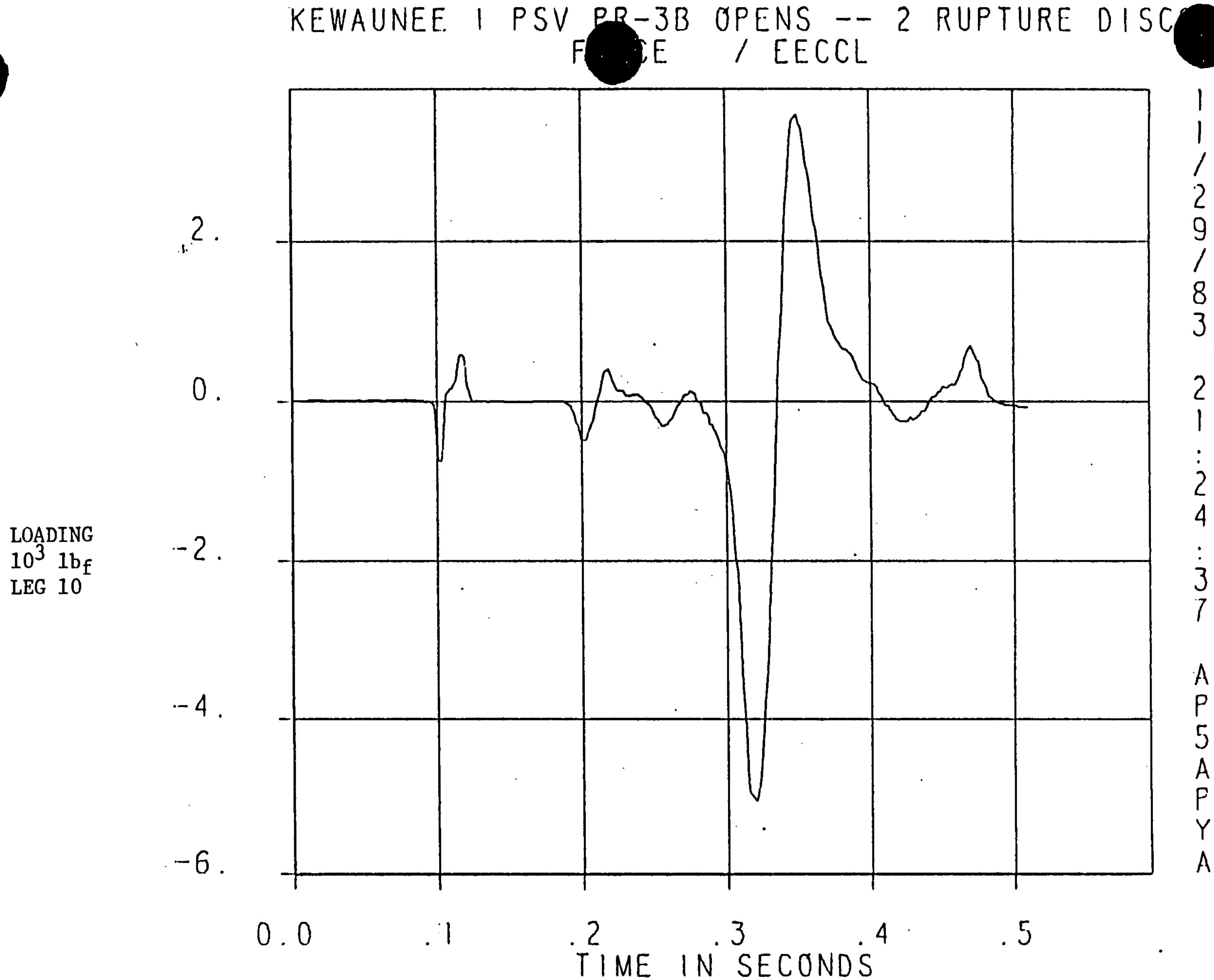


T/H LOADING FOR PSV PR-3B ACTUATION ON PIPING LEG 8
FIGURE I-26



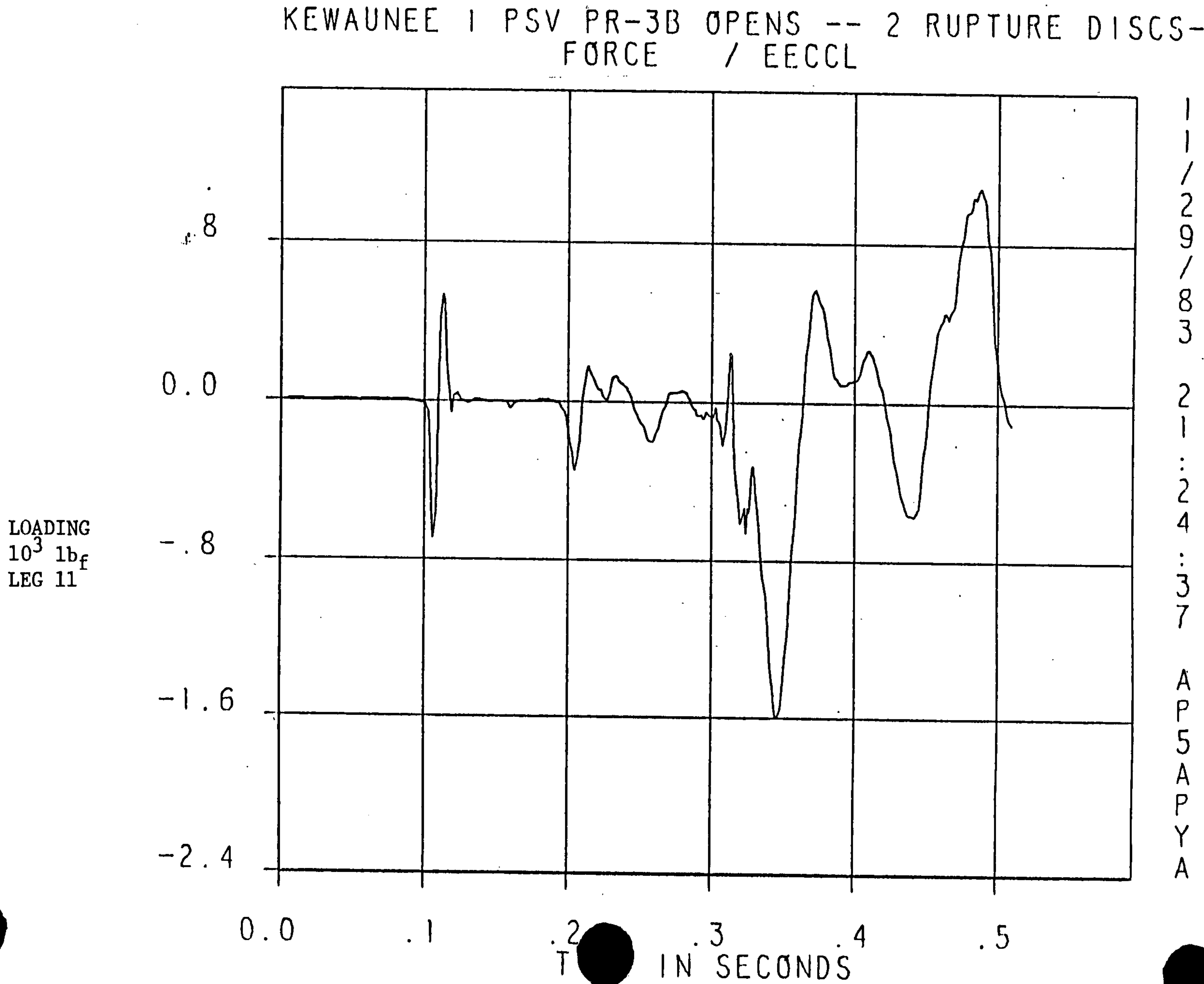
T/H LOADING FOR PSV PR-3B ACTUATION ON PIPING LEG 9

FIGURE I-27



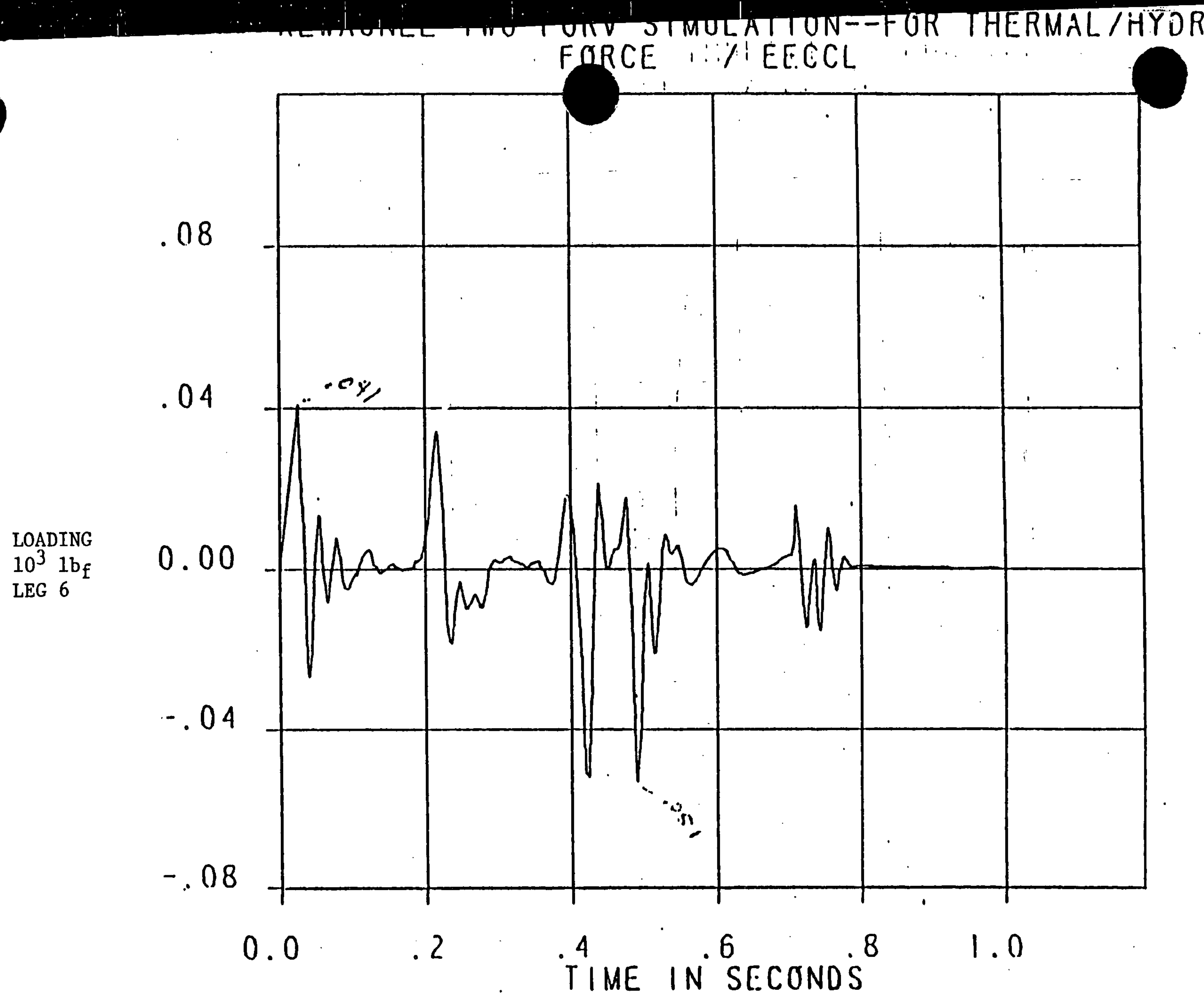
T/H LOADING FOR PSV PR-3B ACTUATION ON PIPING LEG 10

FIGURE I-28

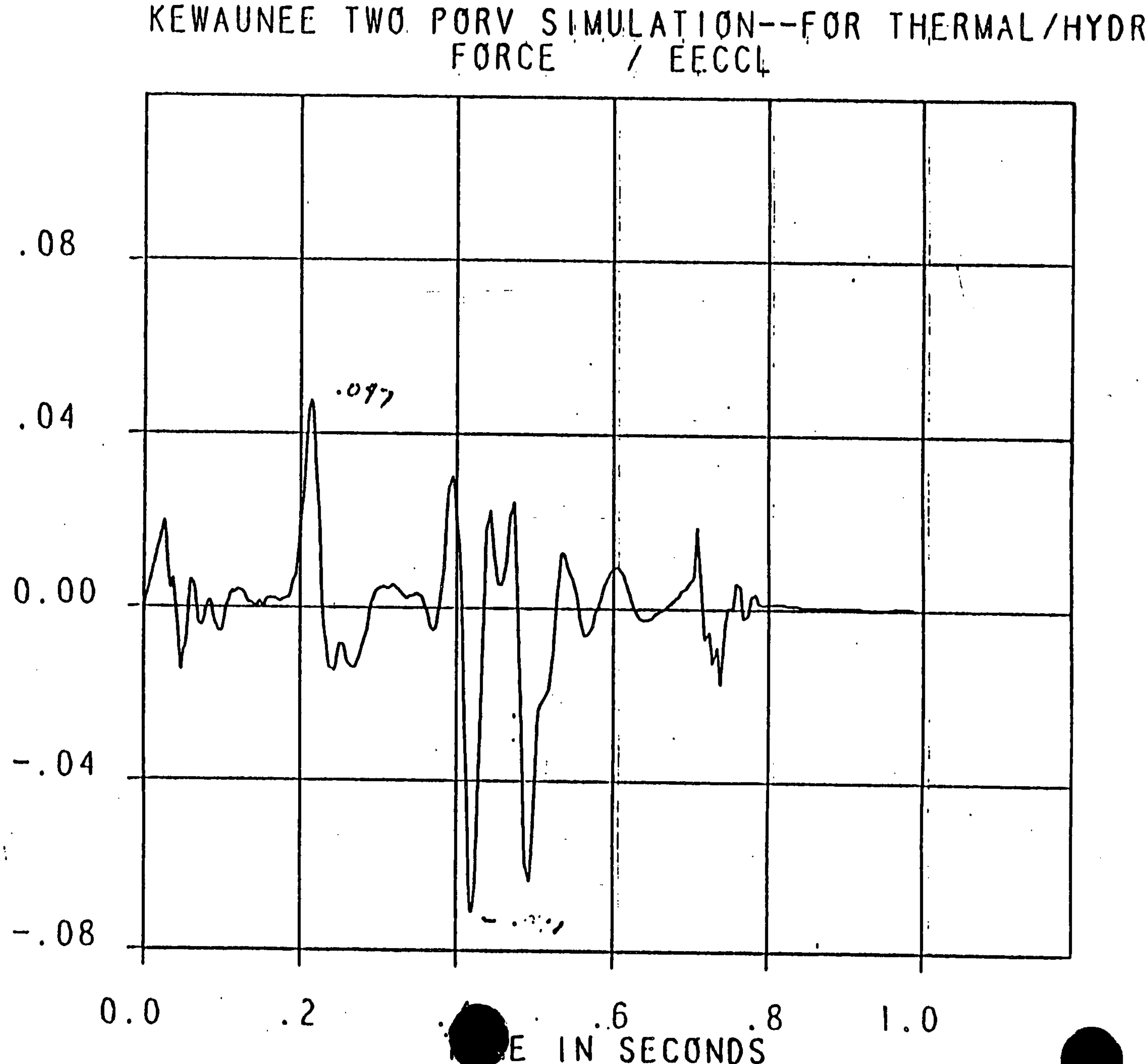


T/H LOADING FOR PSV PR-3B ACTUATION ON PIPING LEG 11

FIGURE I-29

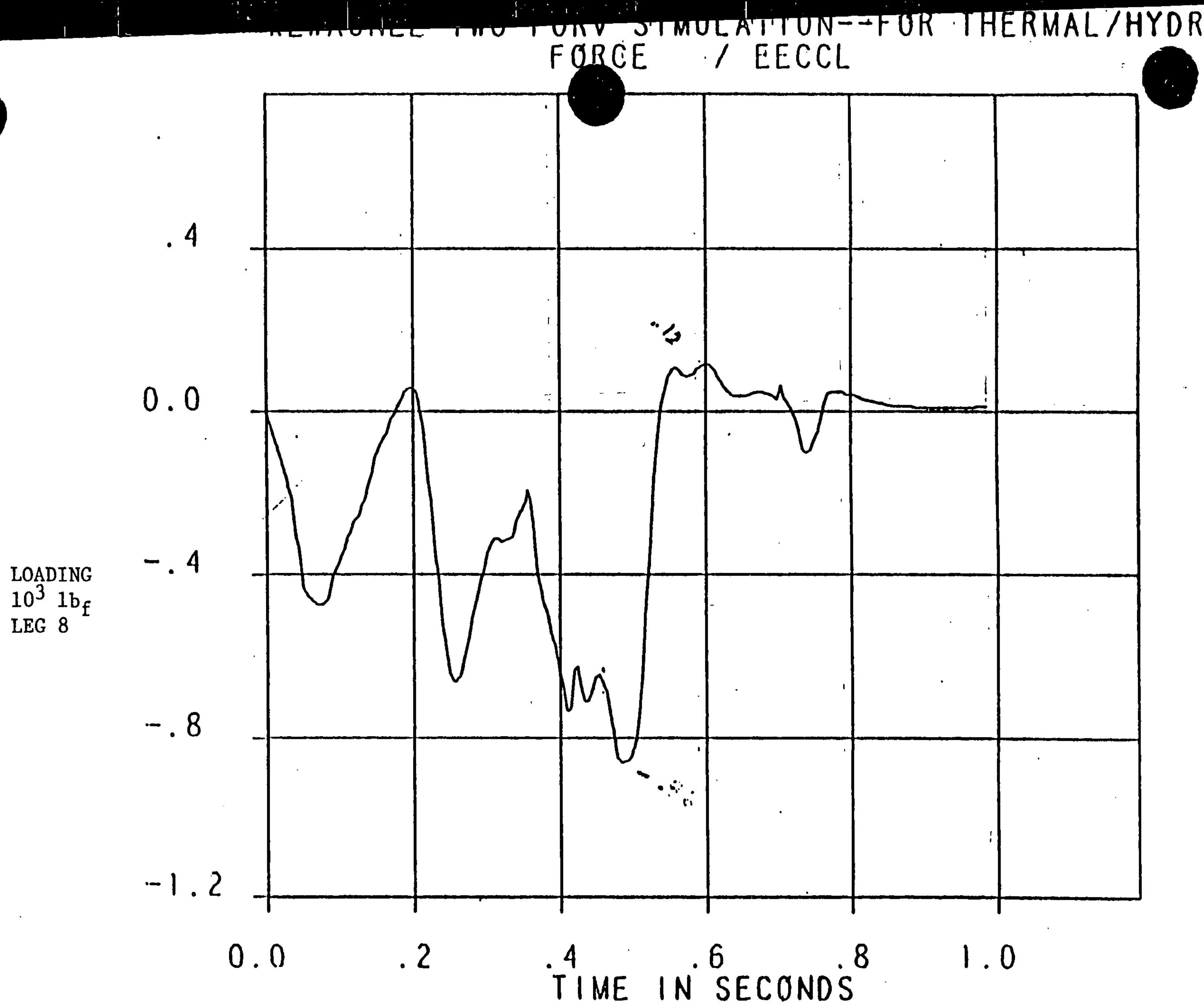


T/H LOADING FOR DOUBLE PORV ACTUATION ON PIPING LEG 6
FIGURE I-30

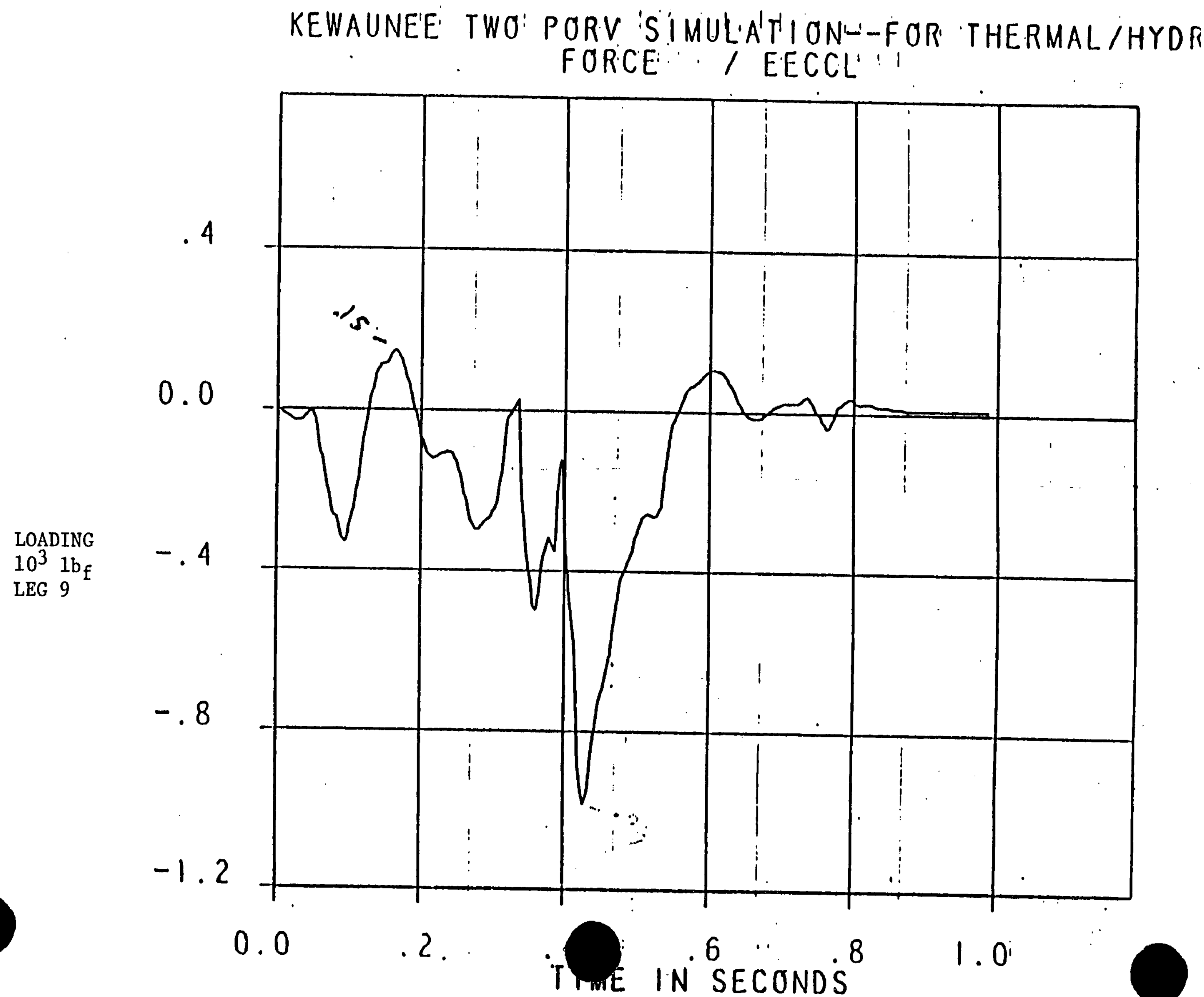


T/H LOADING FOR DOUBLE PORV ACTUATION ON PIPING LEG 7

FIGURE I-31

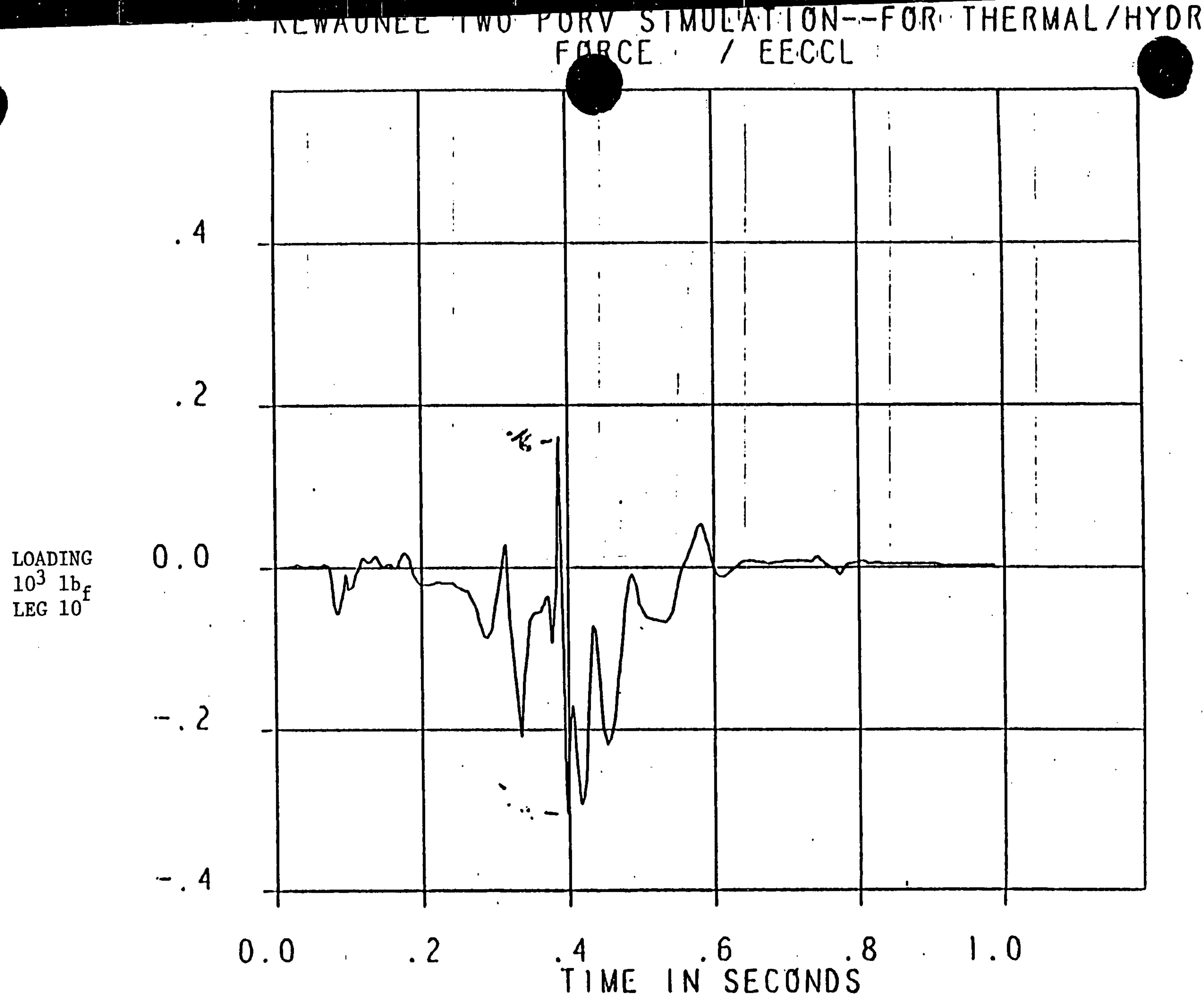


T/H LOADING FOR DOUBLE PORV ACTUATION ON PIPING LEG 8
FIGURE I-32



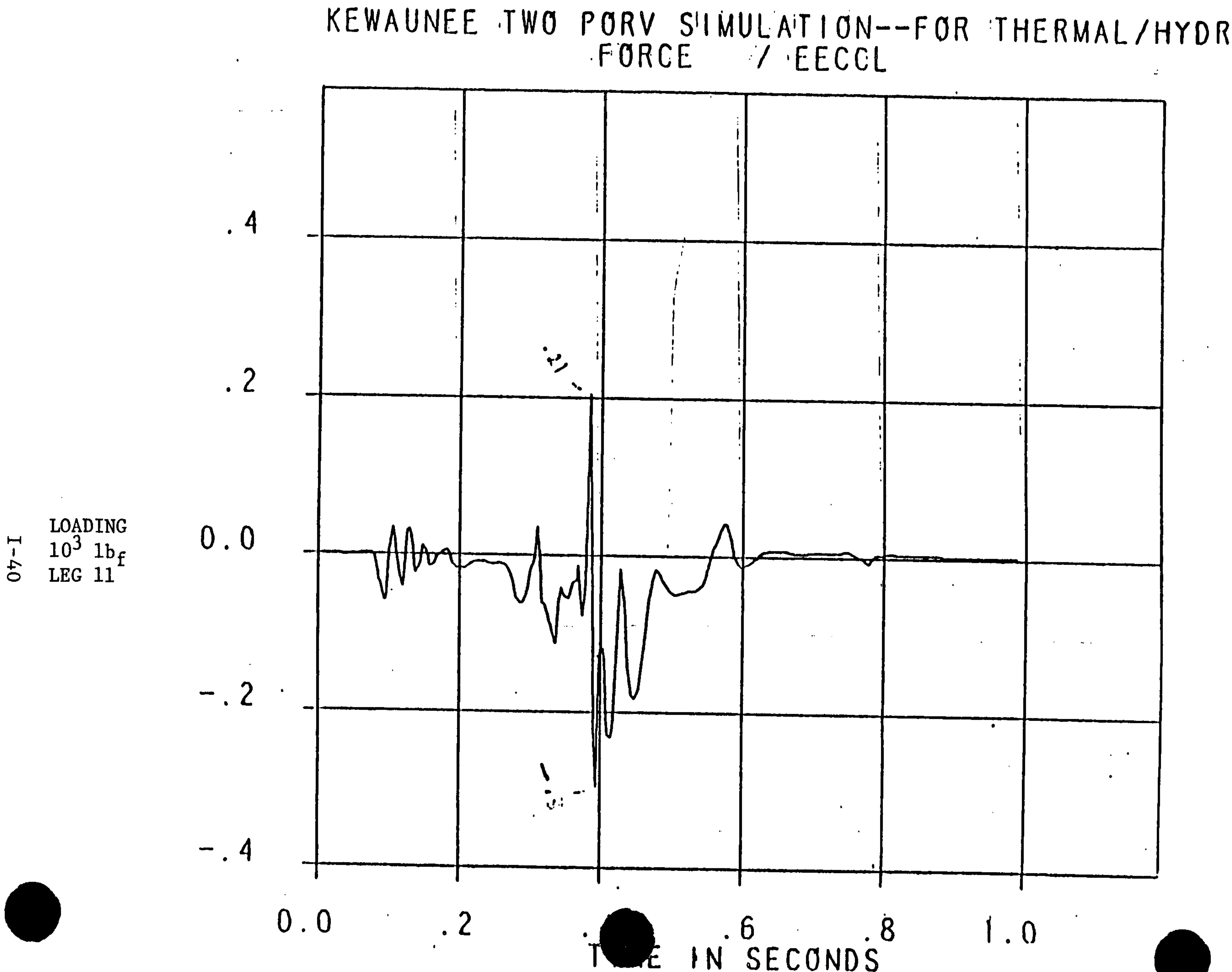
T/H LOADING FOR DOUBLE PORV ACTUATION ON PIPING LEG 9

FIGURE I-33



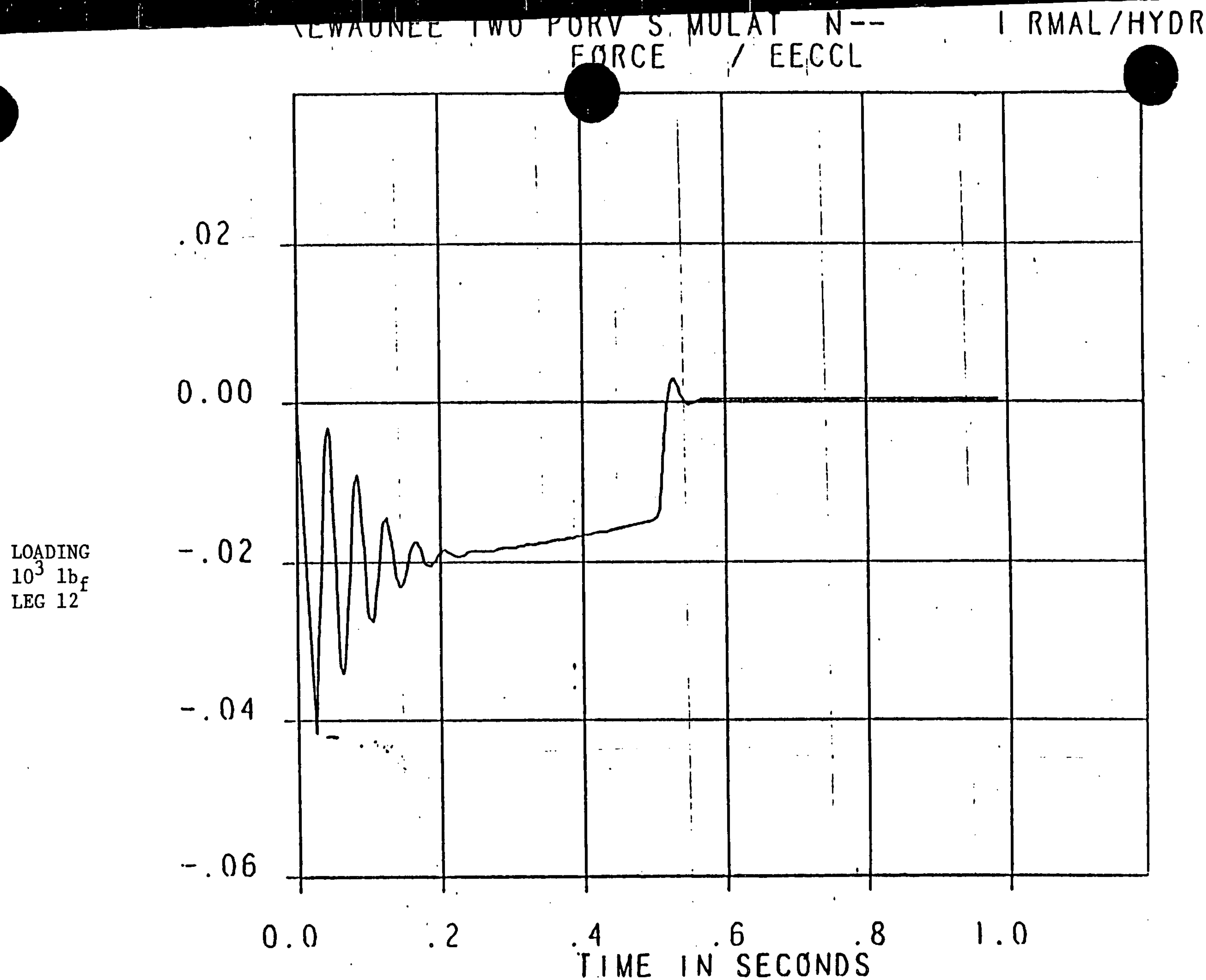
T/H LOADING FOR DOUBLE PORV ACTUATION ON PIPING LEG 10

FIGURE I-34



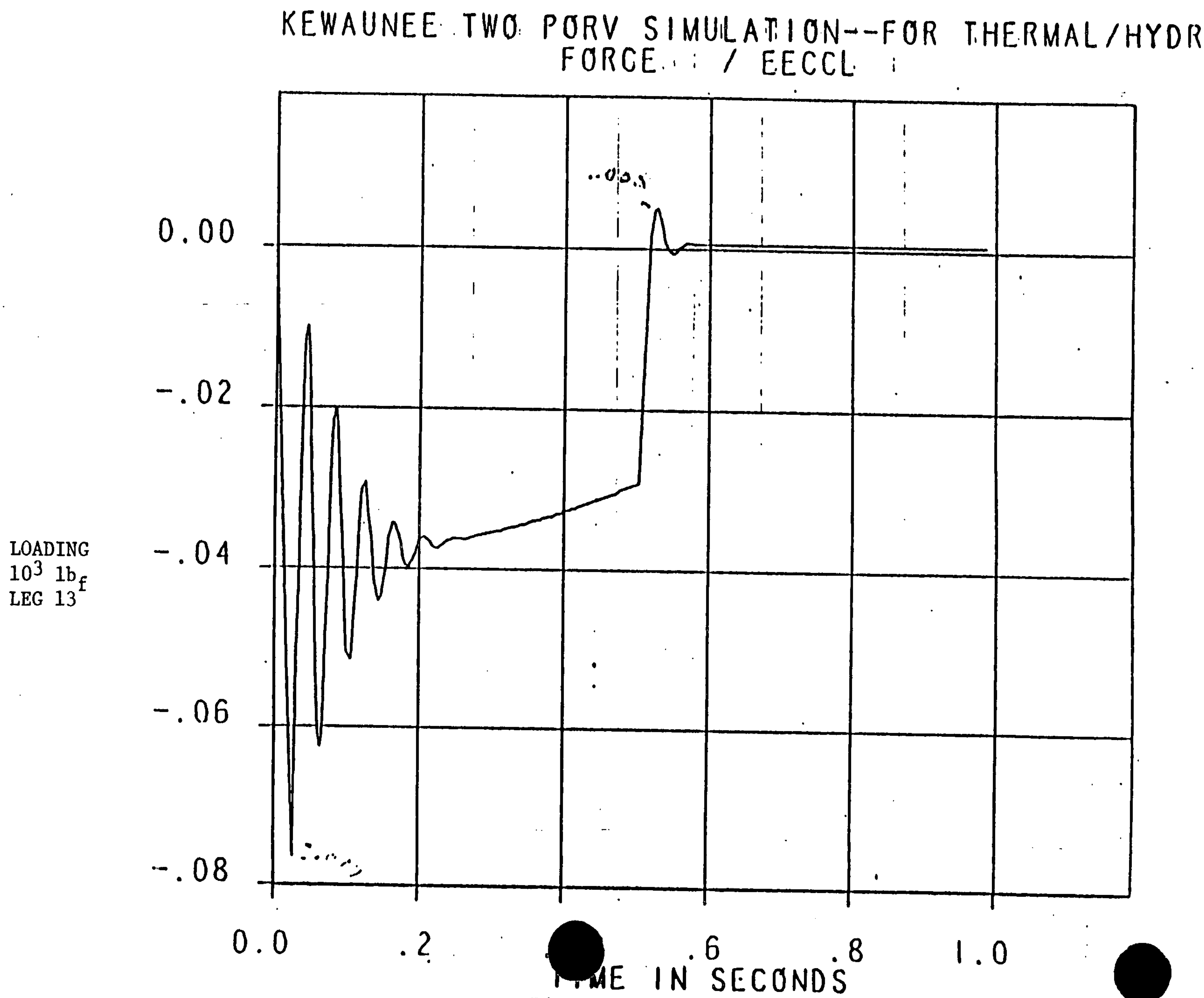
T/H LOADING FOR DOUBLE PORV ACTUATION ON PIPING LEG 11

FIGURE I-35



T/H LOADING FOR DOUBLE PORV ACTUATION ON PIPING LEG 12

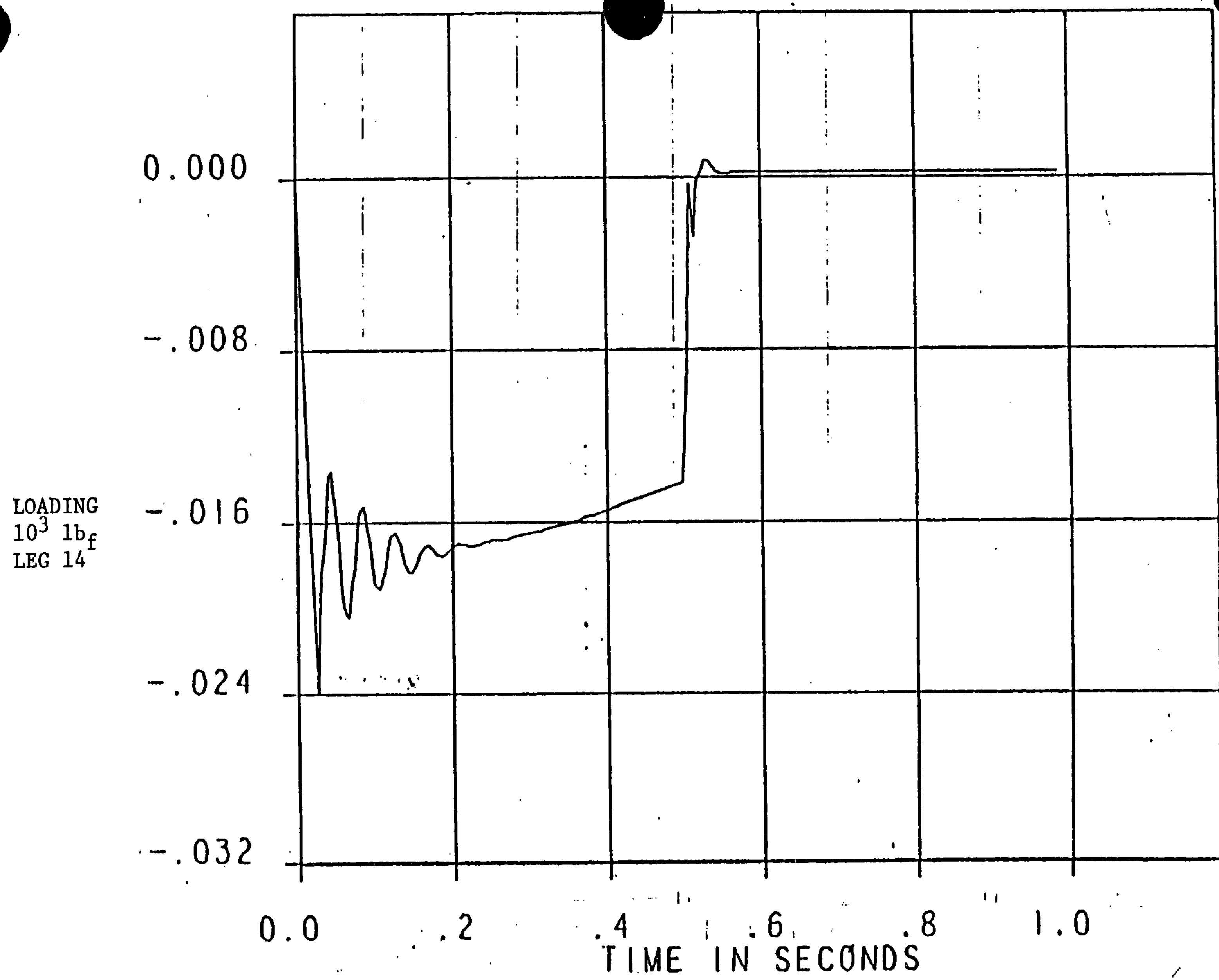
FIGURE I-36



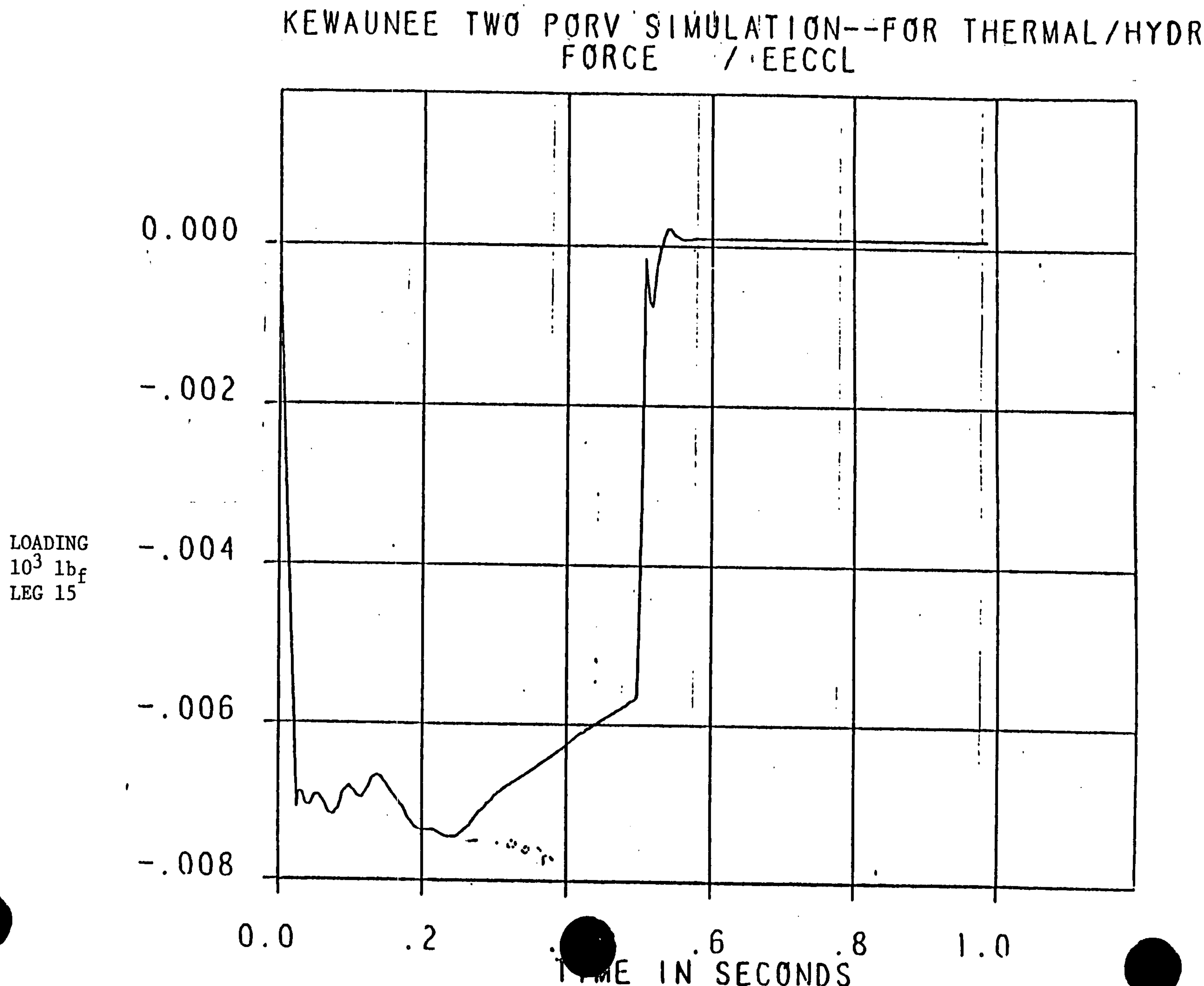
T/H LOADING FOR DOUBLE PORV ACTUATION ON PIPING LEG 13

FIGURE I-37

KEWAUNEE TWO PORV SIMULATION--FOR THERMAL/HYDR
FORCE / EECCL

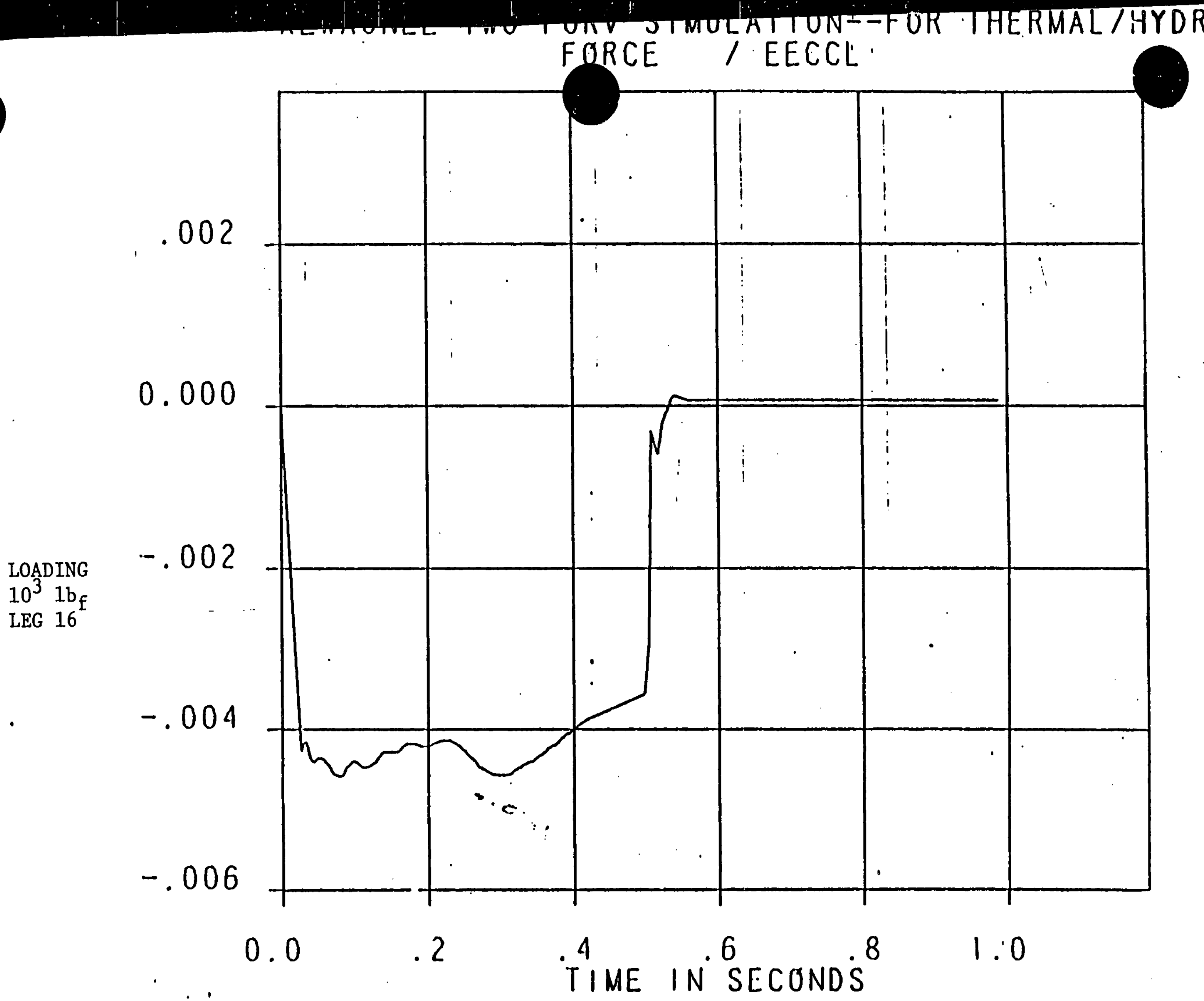


T/H LOADING FOR DOUBLE PORV ACTUATION ON PIPING LEG 14
FIGURE I-38



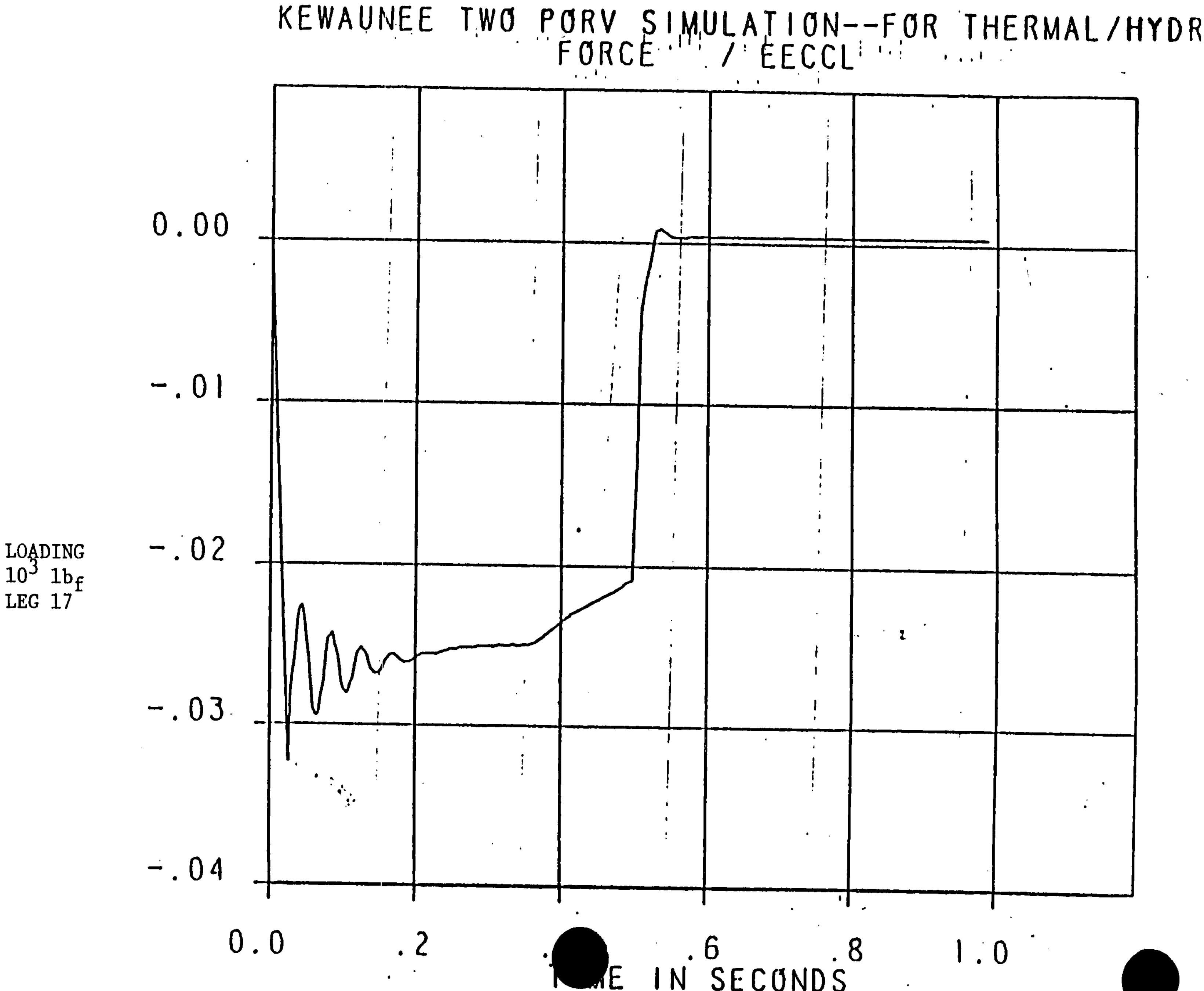
T/H LOADING FOR DOUBLE PORV ACTUATION ON PIPING LEG 15

FIGURE I-39

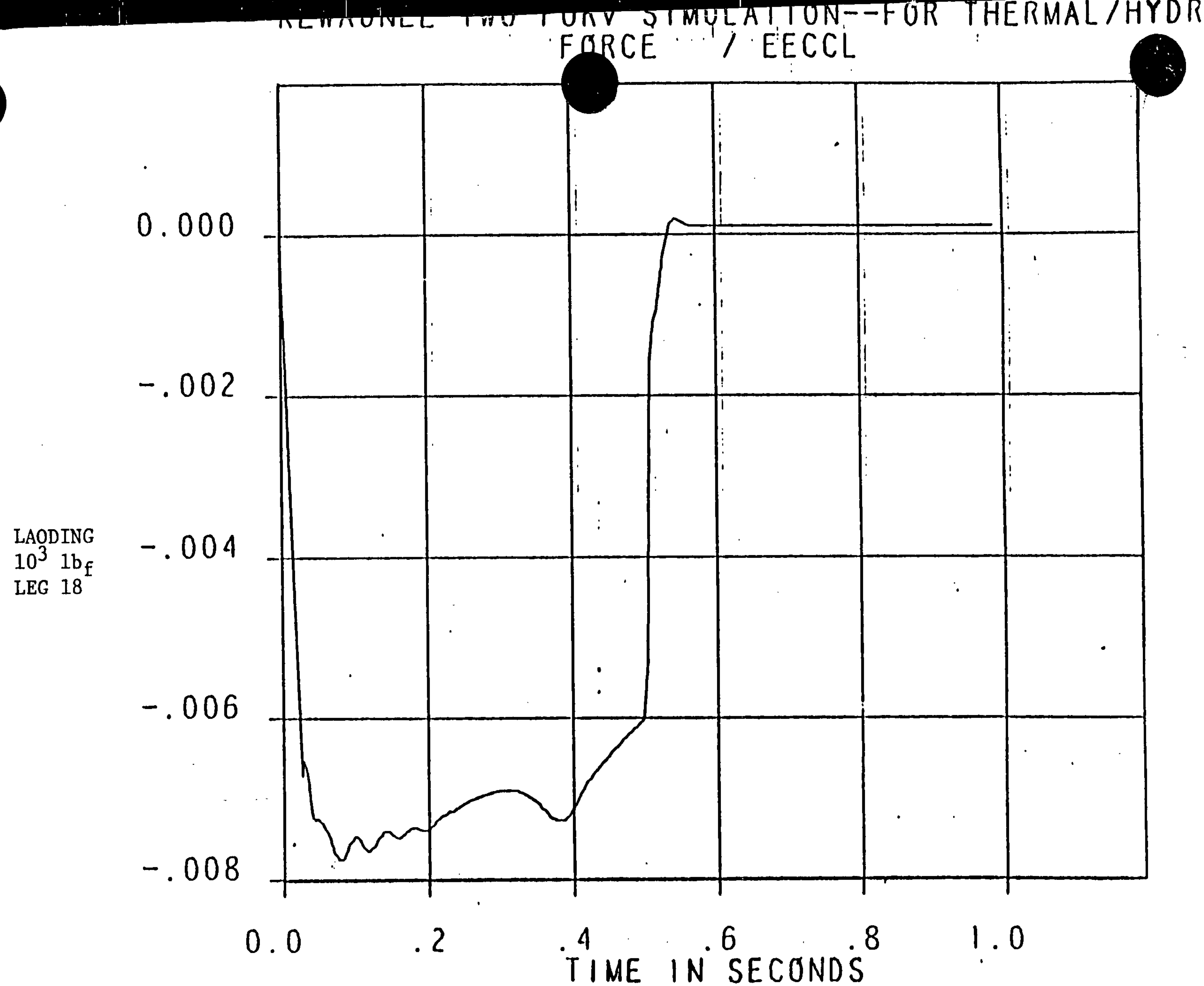


T/H LOADING FOR DOUBLE PORV ACTUATION ON PIPING LEG 16

FIGURE I-40

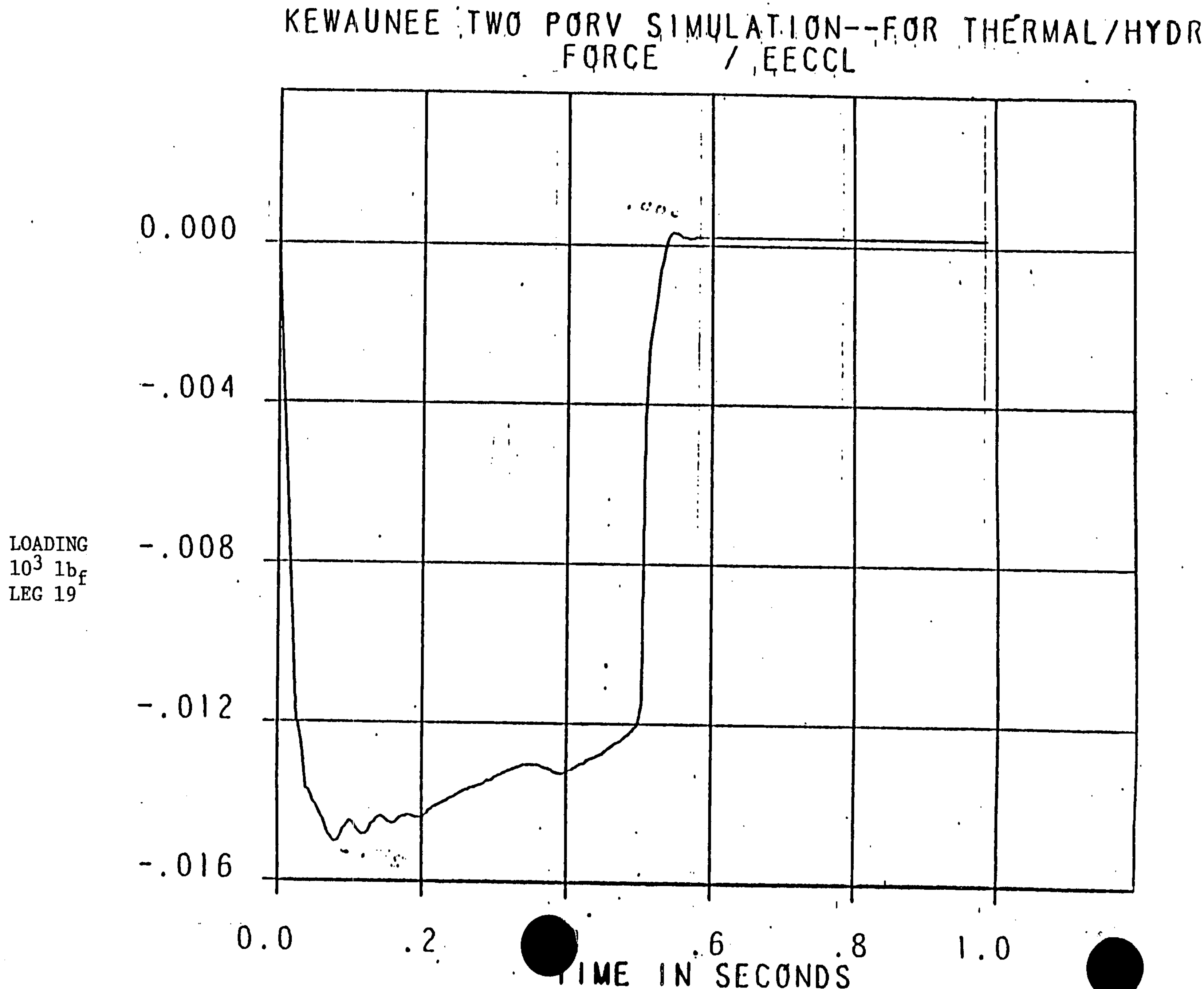


T/H LOADING FOR DOUBLE PORV ACTUATION ON PIPING LEG 17



T/H LOADING FOR DOUBLE PORV ACTUATION ON PIPING LEG 18

FIGURE I-42



T/H LOADING FOR DOUBLE PORV ACTUATION ON PIPING LEG 19