SAN ONOFRE NUCLEAR GENERATING STATION
UNITS 2 AND 3

Pressurizer Safety Valve Operability and Safety Valve Discharge Piping Adequacy Report

June, 1982

Pressurizer Safety Valve Operability

and

Safety Valve Discharge Piping Adequacy

for

San Onofre Units 2 and 3

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PART A - INTRODUCTION

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PRESSURIZER SAFETY VALVE OPERABILITY AND SAFETY VALVE DISCHARGE PIPING ADEQUACY FOR SAN ONOFRE UNITS 2 AND 3

PART A - INTRODUCTION

1.0 OBJECTIVE

A preliminary evaluation supporting pressurizer safety valve operability for San Onofre Generating Station Units 2 and 3 was submitted to the Nuclear Regulatory Commission on April 1, 1982. That submittal committed to provide a final evaluation regarding both safety valves and discharge piping adequacy by July 1, 1982. The objective of the report is to provide a detailed evaluation demonstrating the operability of San Onofre Units 2 and 3 as-installed pressurizer safety valves and the adequacy of the safety valve discharge piping consistent with the July 1, 1982 commitment. The evaluation is based on applying results from the EPRI/C-E Safety and Relief Valve Test Program. Safety valve operability is discussed in Part B of this report and the adequacy of safety valve discharge piping and supports is treated in Part C.

2.0 BACKGROUND

In the aftermath of the Three Mile Island (TMI) accident, the Nuclear Regulatory Commission issued requirements that utilities operating and constructing pressurized water reactor (PWR) power plants demonstrate the operability of pressurizer safety and relief valves and the structural adequacy of the discharge piping and supports. These requirements were promulgated in NUREG-0578 (Reference 1) and NUREG 0660 (Reference 2), and further clarified in NUREG-0737 (Reference 3). At the request of utilities with PWRs, EPRI developed and implemented a generic test program for pressurizer power operated relief valves and safety valves (Reference 4). Southern California Edison Company was one of the utilities sponsoring the EPRI Valve Test Program. One phase of the test program, the testing of safety valves,

was implemented at a test facility at the Windsor, Connecticut site of Combustion Engineering, Inc., (C-E). The facility was specifically erected for the safety valve tests. The portion of the EPRI Valve Test Program performed at the C-E site is herein designated as the EPRI/C-E Safety Valve Test Program.

3.0 SUMMARY

In this report, the EPRI/C-E Safety Valve Test Program is described (including a brief description of the test facility), tests of the Dresser Model 31709NA safety valve are detailed, and a summary of the test results is provided. The San Onofre Units 2 and 3 safety valves and safety valve discharge piping installation were compared to the EPRI/C-E test results and evaluated relative to applicability to the San Onofre Units 2 and 3 system.

Demonstration of safety valve operability is based on the following:

1. The same model safety valve (Dresser 31709NA), as provided for San Onofre Units 2 and 3 was tested in the EPRI/C-E Safety Valve Test Program.

2. The identical safety valve adjusting ring settings used for the San Onofre Units 2 and 3 safety valves were tested.

3. Based on a combination of test data and analysis, the San Onofre Units 2 and 3 valve inlet piping configuration was shown to enhance the stability of valve operation relative to the EPRI/C-E test valve inlet configuration.

4. The range of valve inlet fluid conditions used in the testing either enveloped or were basically equivalent to the corresponding conditions estimated for the San Onofre Units 2 and 3 safety valves.

5. The maximum calculated bending moment at the San Onofre Units 2 and 3 valve discharge flange was significantly lower than the maximum measured value for the test valve.

6. The range of blowdowns expected for San Onofre Units 2 and 3 was based on the EPRI/C-E test backpressure vs. blowdown data. This range included a ±2% valve manufacturer's recommended tolerance and was shown to be compatible with steam fluid conditions at the valves' inlets and with stable valve operation.

The structural adequacy of the San Onofre Units 2 and 3 safety valve discharge piping installation was evaluated as follows:

1. The RELAP 4/ANSYR Code was used to generate fluid transient responses and piping dynamic forcing functions during safety valve operation for a model of an EPRI/C-E test sample.

2. The RELAP 4/ANSYR results were compared with those of a RELAP 5/MOD 1 analysis of the same EPRI/C-E test. The comparison showed that the transient responses were in agreement and that the piping dynamic forcing functions showed the same trends, with the RELAP 4/ANSYR results being more conservative. Thus, the validity of the use of the RELAP 4/ANSYR code for safety valve discharge piping analyses was established, since the validity of RELAP 5/MOD 1 had been previously demonstrated based on comparisons with EPRI/C-E test results.

3. The RELAP 4/ANSYR Code was then used to analyze a model of the San Onofre Units 2 and 3 safety valve discharge piping system to generate dynamic forcing functions during safety valve discharge. Three cases with different valve operating sequences were analyzed.

4. Using the calculated dynamic forcing functions as input, the ANSYS piping code was used to determine the resulting stress levels.

4.0 CONCLUSION

The EPRI/C-E Test Results for the Dresser 31709NA Safety Valve, in conjunction with the Part B evaluation, demonstrate the satisfactory operability of the San Onofre Units 2 and 3 safety valves.

The results of the analysis of the San Onofre Units 2 and 3 discharge piping and supports, discussed in Part C of this report, demonstrate that the installation is structurally adequate.

5.0 REFERENCES

1. NUREG-0578, TMI-2 Lessons Learned Task Force Status Report and Short Term Recommendations, Nuclear Regulatory Commission, July 1979.

2. NUREG-0660, Nuclear Regulatory Commission Action Plan Developed as a Result of the TMI-2 Accident, May 1980.

3. NUREG-0737, Clarification of TMI Action Plan Requirements, Nuclear Regulatory Commission, November 1980.

4. Program Plan for the Performance Testing of PWR Safety and Relief Valves, Revision 1, July 1, 1980, by Electric Power Research Institute, Nuclear Power Division.

PART B - SAFETY VALVE OPERABILITY

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PART B - SAFETY VALVE OPERABILITY

1.0 PURPOSE

The purpose of this section of the report is to demonstrate the operability of the San Onofre Units 2 and 3 pressurizer safety valves based on test results from the EPRI/CE Safety Valve Test Program.

2.0 GENERAL APPROACH

A general review of the as-installed San Onofre Units 2 and 3 pressurizer safety valves, including the geometry of the inlet and discharge piping, was conducted. The valve model and type were identified and compared with the valves tested in the EPRI/CE test program to determine that one of the test valves was representative of the San Onofre Units 2 and 3 valves. The fluid conditions under which the representative valve design was tested were reviewed to ensure that the test fluid conditions were representative of the conditions prescribed in the San Onofre Units 2 and 3 FSAR as well as conditions resulting from Extended High Pressure Injection and Cold Overpressurization events. The San Onofre Units 2 and 3 safety valve inlet and discharge piping arrangement was compared to the arrangement of the test valve piping arrangement. The test data were evaluated and their applicability to the San Onofre Units 2 and 3 project was assessed. Based on this assessment, conclusions regarding San Onofre Units 2 and 3 safety valve operability were developed.

3.0 EPRI/CE SAFETY VALVE TEST PROGRAM

3.1 Test Facility Description

3.1.1 Introduction

The test facility for the EPRI/C-E PWR Safety Valve Test Program is located at C-E's Kreisinger Development Laboratory in Windsor, Connecticut. Reference 1 provides a detailed description of the facility. A summary description is provided below.

3.1.2 Test Loop Layout

The layout of the test loop is shown in Figures 3.1 and 3.2. The valve inlet piping configuration was varied, depending upon the specific valve being tested. The valve inlet piping configuration shown (the short vertical inlet) is the configuration used for testing the Dresser Model 31709NA safety valve. A loop seal inlet configuration could be installed for use in other tests. This test loop is capable of steam, water and transition (steam-to-water) flow tests. Tank 1 (500 ft^3) serves as a surge vessel where liquid and/or steam inventory can simulate the thermal-hydraulic conditions in a PWR pressurizer. Tank 2 (1150 ft^3) serves as the driver vessel through expansion or evaporation of its contained fluid. A recirculation pump and heaters are provided for each tank to maintain thermodynamic conditions in the tanks. Additional flow capacity is available by supplementing accumulator capacity with that of the test facility boiler rated at 150,000 lb/hr. This steam flow can be used either directly, or as a driving head, to push water through the test valve. Valve SW-3 permits variation of the backpressure up to 1000 psig during testing. A line containing a rupture disc is provided to prevent overpressurization of the discharge piping should the leak check isolation valve, SW-2, be inadvertently left closed during a test.

3.1.3 Piping Supports

The test loop piping supports were designed to limit the peak dynamic response amplification to 110% of the hydraulic forcing

function peak value, so that extremely rigid dynamic support structures were designed for the test valve stand and test valve discharge piping. The test valve stand (Figure 3.3) allows most of the shear and moment at the test valve inlet flange to be transmitted through a pair of linkage assemblies. In addition to the test valve stand, discharge pipes supports were provided at the second discharge elbow, midway between the second and third discharge elbows, and at the third discharge elbow. Figures 3.4 and 3.5 show the structural support at the second and third discharge elbows, respectively. At the second discharge elbow, the pipe is restrained vertically and horizontally using hydraulic snubbers. In the course of the test program, the hydraulic snubbers were replaced by solid members to facilitate interpretation of the pipe response data. The support structure midway between the second and third discharge elbows includes hydraulic snubbers and the support restricts out-of-plane vibration of this relatively long section of pipe. The support at the third elbow allows free in-plane horizontal motion but is rigid vertically.

3.1.4 Instrumentation

The test instrumentation provided in the valve test facility is listed in Tables 3.1 and 3.2. The test instrumentation provided the basic data for assessing valve operability and determining valve and piping reaction forces. Necessary process instrumentation was also provided to aid in loop operation and in monitoring equipment performance. The location of the test instrumentation in the test loop is shown on Figures 3.6, 3.7 and 3.8. A detailed description of the test loop instrumentation is provided in Reference 1 .

3.2 Testing Procedure

The general procedure for valve testing was to raise the pressure at a prescribed rate to lift the valve, starting from a valve inlet pressure below the valve opening setpoint.

The installed instrumentation recorded the valve behavior as it lifted, discharged, and closed. For each valve tested, runs were made with different valve adjusting ring settings, pressure ramp rates, backpressures, and inlet fluid conditions. The inlet fluid conditions tested were steam, water, and steam-to-water transition. The detailed procedure varied, depending upon the inlet fluid conditions being tested.

A valve leakage test was run prior and subsequent to each valve lift test. Safety valve opening set points were checked frequently throughout the test.

3.2.1 Steam Tests with High Pressure Ramp Rate

Tanks 1 and 2 were filled with steam and isolated from each other. Tank 1 pressure was about 2300 psia while Tank 2 was at about 2950 psia. Valve lift was initiated by opening the isolation valve between the tanks.

3.2.2 Steam Tests with Low Pressure Ramp Rate

Tank 1 was isolated from Tank 2 and filled with steam at about 2300 psia. Steam from the boiler was fed to Tank 1 to raise pressure at the desired low ramp rate to lift the valve.

3.2.3 Water Tests

Tank 1 was filled and Tank 2 partially filled with water at the required test temperature. With the isolation valve between the tanks open, steam from the boiler was supplied to Tank 2 to raise the pressure to lift the safety valve on water.

3.2.4 Steam - Water Transition Tests

Tanks 1 and 2 were partially filled with saturated water at 2300 psia. The isolation valve between the tanks was in the

open position. Boiler steam was fed to Tank 2 to raise the pressure to lift the safety valve on steam. Safety valve lift resulted in the flow of water from Tank 2 to Tank 1. Eventually, Tank 1 filled with water and the safety valve inlet fluid changed from steam to water.

3.3 Dresser Safety Valve Model 31709NA Tests

3.3.1 Introduction

Since Dresser safety valves are provided in a number of PWRs, two different models (Dresser Models 31709NA and 31739A) were included in the EPRI/C-E Safety Valve Test Program. The tests on Model 31709NA are particularly relevant to San Onofre Units 2 and 3 since this particular model is provided on San Onofre Units 2 and 3.

3.3.2 Valve Description

The Dresser Model 31709NA safety valve is a direct-acting spring-loaded valve, with an enclosed bonnet and a balanced bellows to minimize the effect of the superimposed back pressure. The valve is provided with valve adjusting rings, described in the next section, which allow adjustments in valve performance characteristics. Valve parameters are listed in Table 3.3 and an illustration of the valve is provided in Figure 3.9.

3.3.3 Valve Adjusting Ring Description

The valve is equipped with three adjusting rings; lower, middle, and upper (Figure 3.10). The flow distribution and the static and dynamic pressures in the valve, and thus, valve performance characteristics, can be changed by adjustment of these rings. The position of the lower adjusting rings defines the huddle chamber and the size of the secondary orifice. The appropriate lower ring setting serves to eliminate valve simmer and causes

the valve to pop open quickly at the popping pressure. The lower ring also provides a cushioning effect to preclude seat damage when the valve closes. The middle ring setting, in conjunction with that of the lower ring, affects the amount of valve lift achieved as well as the closing pressure. The upper ring provides a capability for adjustment to assure valve lift and capacity are obtained even at high back pressure.

The positions of the adjusting rings are locked by means of adjusting ring pins. These pins are threaded into the valve body. The pins engage notches which are cut into the rings. To adjust a ring, the corresponding ring pin is removed and a screwdriver is used to turn the rings. The detailed procedure for valve ring adjustment is described in Reference 2.

3.3.4 Inlet Piping Arrangement

Information on the inlet piping arrangement used in the tests of the Dresser Model 31739NA safety valve is provided in Figure 3.11 and Table 3.4.

3.3.5 Test Conditions

The basis for the selection of the test conditions for the EPRI/C-E safety valve tests is described in Reference 3.

3.3.5.1 Fluid Conditions

The Model 31709NA safety valve was tested under various fluid conditions as follows:

Fluid Condition	Test Numbers
Steam	603, 606, 611, 614, 615, 618, 620, 1305
Steam-to-Water Transition	623, 628
Subcooled Water (429°F - 589°F)	625, 630, 1308, 1311

A detailed tabulation of the test fluid conditions is included in Table 3.5. Table 3.5 is a test summary obtained from Reference 4. However, it should be noted that only steam conditions are applicable to the San Onofre Units 2 and 3 valves, as described in Section 5.4.

3.3.5.2 Valve Adjusting Ring Settings

Analysis of the results of a preliminary valve test led to the conclusion that increased valve blowdown was associated with improved valve behavior. The testing of the Dresser 31709NA safety valve was performed using valve adjusting ring settings which resulted in blowdowns somewhat greater than 5%. The various adjusting ring settings used for the Dresser Model 31709NA valve tests are included in Table 3.5.

3.3.5.3 Test Backpressure

Since the backpressure developed at the safety valve outlet is considered a primary parameter affecting valve performance, safety valves were tested over a range of backpressures expected at PWR plants.

The Dresser 31709NA safety valves was tested at backpressures ranging between 174 psia and 530 psia. Refer to Table 3.5 for the detailed data.

3.3.6 Test Results

3.3.6.1 Introduction

The results of the Dresser Model 31709NA valve tests are summarized in Table 3.5. The percent blowdown listed in the table was calculated based on the design setpoint pressure of 2500 psig. Alternatively, the percent blowdown calculation could have been based on the actual valve opening pressure. Fourteen tests were performed using the short inlet pipe configuration (Figure 3.11). Each of the tests was performed with the valve

adjusting ring positions established by Dresser based on previous EPRI/C-E test experience obtained on the smaller Dresser 31739A safety valve. Test results are summarized in the following sections.

3.3.6.2 Steam Tests

A total of eight steam tests was performed with high and low ramp rates, varying back pressures from 174 to 530 psia and three different middle ring positions. Neither the valve upper or lower ring position was changed during these tests. For all of these tests, the valve opened within ±3% of the valve design set pressure and exhibited stable performance. In tests where the inlet pressure accumulated to 6% above the valve design set pressure, the valve achieved rated lift. Valve blowdown varied, depending on the position of the middle ring and the back pressure. Generally, the valve blowdown decreased as the back pressure increased and as the middle ring was adjusted to higher test positions. Blowdown ranged from a maximum of 14.2% (at low backpressures) to a minimum of 7.5% (at high backpressures).

3.3.6.3 Transition Tests

Two steam-to-water transition tests with an intermediate back pressure (approximately 400 psia) were performed using the highest and lowest middle ring positions of the steam tests. For both tests, the valve opened within ±3% of the valve design set pressure and exhibited stable performance. The valve blowdown ranged from 17.0% to 18.5%.

3.3.6.4 Water Tests

Four water tests were performed with an intermediate back pressure at nominal water temperatures of 650, 550 and 400°F.

During the two 650°F water tests performed, which used the highest and lowest middle ring positions of the steam tests, the valve opened at system pressures of 2393 to 2412 psia and exhibited stable performance. Valve blowdowns ranged from 16.3 to 22.6%.

The two subsequent water tests (550°F and 400°F) were performed using the highest middle ring position. For both tests, the valve opened at a system pressure within ±3% of the valve design set pressure. During the 550°F water test, the valve opened, showed stable behavior, and closed with 4.0% blowdown.

During the 400°F water test, the valve opened at 2558 psia and exhibited five partial lift cycles over a period of three seconds. The valve then opened fully and chattered. Three seconds later in the transient, the valve stopped chattering without manual actuation and then closed. After the transient, a steam leakage test was attempted. The valve partially opened at which point the leak test was terminated.

3.3.6.5 Valve Inspection Results

The valve was disassembled and inspected five times in the course of the test series. Even though the following observations were detected upon inspection, the valve operations were not impaired. Excessive post-test leakage was the reason for the inspection in two cases, both after high pressurization rate steam tests. In the first case, at the beginning of the series, the leakage was due to an elongation of the bellows nose which eliminated the clearance between the valve disc and disc holder. According to the manufacturer it was a normal occurrence for a new bellows. The thickness of the disc holder was reduced to reestablish the clearance. In the second case, light scratches were found across the seals. In the third case, also after a high pressurization rate steam test, the thrust bearing and adapter were found to be galled. The apparent

reason for the galling was that the outer surface of the spacer was allowed to come in contact with the inner surface of the adapter. The thrust bearing adapter was remachined. The lower lip of the disc holder was also machined to reestablish the gap between the disc and disc holder.

After the 650°F water test, the valve condition was found to be acceptable. In all the cases, the seat surfaces were lapped prior the valve reassembly. After the 400°F test, galled guiding surfaces and several damaged internal parts were found; the bellows assembly was ruptured, the seating area of the disc was collapsed, the disc holder was fused inside the guide and the bushing seating surface had deformed.

3.3.6.6 Valve Discharge Flange Bending Moments

During the valve testing program, the induced bending moments at the valve discharge flange during valve opening and closing were measured. These measurements were used to evaluate the effect of discharge piping on value operability (see Section 5.6). The maximum bending moment measured during the steam tests of the Dresser 31709NA safety valve was 200,200 inch-lbs. For the water and steam-water transition tests, the maximum bending moment measured was 473,200 inch-lbs. The test results (see Table 3.5) indicated that these loadings did not impair the operability of the valve.

3.3.7 Discussion of Test Results

3.3.7.1 Valve Adjusting Ring Settings

In a preliminary valve test in which a long inlet pipe was used, unstable valve operation (chattering) was noted. The measured valve opening time (16 milliseconds) was considerably shorter than expected (40 to 60 milliseconds) by the valve manufacturer, and a sharp drop in valve inlet pressure occurred

as the valve opened. Factors which were considered as contributing to the valve instability were the long length of the inlet piping, the rapid valve opening time, and a valve ring adjustment to provide a relatively short blowdown (i.e., less than 5%). To avoid the instability problem, all further tests were performed using the shortest practical inlet line and valve ring adjustments to produce increased blowdown.

Table 3.5 includes the different ring settings used in the tests. The shorter inlet piping minimized the drop in valve inlet pressure as the valve opened while the valve ring adjustment for increased blowdown served to de-sensitize the valve response to a drop in valve inlet pressure. However, excessive safety valve blowdown in the plant may result in a transition from steam flow to water flow through the valves. Since the safety valves, inlet piping, discharge piping and supports are designed for steam discharge only, the magnitude of the blowdown must be bounded to maintain the original design fluid condition at the valve inlet. Therefore, one of the objectives of the valve testing was to determine optimum valve ring adjustments which provided stable valve operation without excessive blowdown.

3.3.7.2 Blowdown vs. Backpressure

The EPRI tests of the Dresser 31709NA safety valves showed that blowdown increased with decreasing builtup backpressure. The data for the steam tests for different ring settings is plotted in Figure 3.12 . Figure 3.13 is an analogous plot of test results for the smaller Dresser 31739A valve, which shows a similar backpressure - blowdown relationship. It can be concluded that (at least in the range tested) the blowdown decreases as the middle adjusting ring is raised to a higher position, provided the other adjustment rings remain fixed.

3.3.7.3 Water and Steam-Water Tests

Since the San Onofre Units 2 and 3 safety valves are not expected to be exposed to water or steam-water transition conditions, the test data for these conditions are not evaluated in this report.

Instrumentation List
EPRI Safety/Relief Valve Test Project

INSTR.	DAS CHAN.	DESCRIPTION	CLASSIFICATION	RANGE	MAX FREQUENCY (Hz)
PDT 01	01	Differential Pressure Drum 1 Inlet to Drum 2 Inlet	Test	0-1500 psid	20
PDT 02	02	Differential Pressure Drum 1 to Upstream of Test Valve	Test	0-100 psid	20
PDT 03	03	Differential Pressure Test Valve Discharge to 2nd Discharge Elbow	Test	0-150 psid	20
PDT 04	04	Differential Pressure 2nd Discharge Elbow to Upstream of SW-2	Test	0-100 psid	20
PDT 05	05	Differential Pressure Across Back Pressure Valves(SW-3 & SW-2)	Test	0-1000 psid	20
PDT 06	06	Differential Pressure Downstream SW-3 to Atmosphere	Test	0-300 psid	20
PDT 07	07	Differential Pressure Discharge Pipe Exit Nozzle to Atmosphere	Test	0-100 psid	200
PT 08	08	Pressure Valve Exit	Test	0-1500 psia	20
PT 09	09	Pressure First Horizontal Run Discharge Pipe	Test	0-1500 psia	200
PT 10	10	Pressure Vertical Discharge Run (inlet 2nd elbow)	Test	0-1500 psia	200
PT 11	11	Pressure Upstream of SW-2	Test	0-1500 psia	200
PT 12	12	Pressure Test Valve Inlet	Test	0-3500 psis	500
TE 13	13	Surface Temperature Test Valve (TC-1)	Test	0-800 F	2
TE 14	14	Surface Temperature Test Valve (TC-2)	Test	0-800 F	2
TE 15	15	Surface Temperature Test Valve (TC-3)	Test	0-800 F	2
TE 16	16	Surface Temperature Test Valve (TC-4)	Test	0-800 F	2
ZE 17	17	Position Test Valve Stem (LVDT-1)	Test	0-4 inches (± 2 inch)	200
ZE 18	18	Position Test Valve Stem (LVDT-2)	Test	0-4 inches (± 2 inch)	200
TE 19	19	Temperature Test Valve Inlet (TC-1)	Test	0-800 F	2
TE 20	20	Temperature Test Valve Inlet (TC-2) (loop seal only)	Test	0-800 F	2
XE 21	21	Acceleration Test Valve X-Axis	Test	0-10g	200
XE 22	22	Acceleration Test Valve Y-Axis	Test	0-10g	200
XE 23	23	Acceleration Test Valve Z-Axis	Test	0-10g	200
FT 24	24	Flow Venturi Diff. Press. (1)	Test	0-40 psid	20
FT 25	25	Flow Venturi Diff. Press. (2)	Test	0-40 psid	20
PT 26	26	Pressure Flow Venturi	Test	0-3500 psis	20
TE 27	27	Temperature Flow Venturi (TC)	Test	0-800 F	2
WE 28	28	Load (± X-Axis) into Support Test Valve Inlet Flange (upper)	Test	± 25 kips, ± 100 kips	200
WE 29	29	Load (± X-Axis) into Support Test Valve Inlet Flange (lower)	Test	± 25 kips, ± 100 kips	200
WE 30	30	Load (± X-Axis) at End of 1st Vertical Run Discharge Pipe	Test	± 25 kips, ± 100 kips	200
WE 31	31	Load (± X-Axis) at End of 1st Vertical Run Discharge Pipe	Test	± 25 kips, ± 100 kips	200
WE 32	32	Load (± Y-Axis) at End of 1st Vertical Run Discharge Pipe	Test	± 25 kips, ± 100 kips	200
WE 33	33	Load (± Y-Axis) at End of 1st Vertical Run Discharge Pipe	Test	± 25 kips, ± 100 kips	200
WE 34	34	Load (± Y-Axis) into Support at Exterior Elbow	Test	± 25 kips, ± 100 kips	200
WE 35	35	Load (± Y-Axis) into Support at Exterior Elbow	Test	± 25 kips, ± 100 kips	200
ZE 36	36	Position (Displacement) (± Y-Axis) Test Valve	Test	± 5 inches	200
ZE 37	37	Position (Displacement) (± X-Axis) 2nd Discharge Elbow	Test	± 5 inches	200
ZE 38	38	Position (Displacement) (± Y-Axis) 2nd Discharge Elbow	Test	± 5 inches	200

Table 3.1

Instrumentation List
EPRI Safety/Relief Valve Test Project

INSTR.	DAS CHAN.	DESCRIPTION	CLASSIFICATION	RANGE	MAX FREQUENCY (Hz)
ZE 39	39	Position (Displacement) (± X-Axis) External Discharge Elbow	Test	± 5 inches	200
TE 40	40	Temperature Test Valve Outlet Fluid (TC-1)	Test	0-800 F	2
TE 41	41	Temperature Test Valve Outlet Fluid (TC-2)	Test	0-800 F	2
TE 42	42	Temperature Downstream of Back Pressure Valve (SW-3) (TC)	Test	0-800 F	2
TE 43	43	Temperature Inlet to 2nd Discharge Elbow (TC)	Test	0-800 F	2
TE 44	44	Temperature Between SW-2 and SW-3 (TC)	Test	0-800 F	2
TE 45	45	Temperature Exit Nozzle Fuid (TC)	Test	0-800 F	2
TE 46	46	Temperature Inside Pipe Wall 1st Horizontal Run Discharge Pipe (TC)	Test	0-800 F	2
TE 47	47	Temperature Inside Pipe Wall Vertical Run Discharge Pipe (TC)	Test	0-800 F	2
TE 48	48	Temperature Inside Pipe Wall 2nd Horizontal Run Dischare Pipe (TC)	Test	0-800 F	2
LT 49	49	Level DP, Drum 1 (Rosemount)	Test	0-17 psid	20
LT 50	50	Level DP, Drum 2 (Rosemount)	Test	0-17 psid	20
ZE 51	51	Position W-6 Stem (LVDT)	Test	0-4 inches (± 2 inches)	200
PT 52	52	Pressure Drum #1	Test	0-3500 psis	20
TE 53	53	Temperature Drum #1 Fluid (TC-1)	Test	0-800 F	2
TE 54	54	Temperature Drum #1 Fluid (TC-2)	Test	0-800 F	2
TE 55	55	Temperature Drum #1 Fluid (TC-3)	Test	0-800 F	2
TE 56	56	Temperature Drum #1 Fluid (TC-4)	Test	0-800 F	2
LT 57	57	Differential Pressure Drum #1 Level (Radial Taps)	Test	0-15 psid	20
LT 58	58	Differential Pressure Drum #1 Level (Pipe Taps)	Test	0-15 psid	20
PT 59	59	Pressure Drum #2	Test	0-3500 psis	20
TE 60	60	Temperature Drum #2 Fluid (TC-1)	Test	0-800 F	2
TE 61	61	Temperature Drum #2 Fluid (TC-2)	Test	0-800 F	2
TE 62	62	Temperature Drum #2 Fluid (TC-3)	Test	0-800 F	2
TE 63	63	Temperature Drum #2 Fluid (TC-4)	Test	0-800 F	2
TE 64	64	Temperature Drum #2 Fluid (TC-5)	Test	0-800 F	2
TE 65	65	Temperature Drum #2 Fluid (TC-6)	Test	0-800 F	2
LT 66	66	Differential Pressure Drum #2 Level (Radial Taps)	Test	0-15 psid	20
LT 67	67	Differential Pressure Drum #2 Level (Pipe Taps)	Test	0-15 psid	20
SE 68	68	Strain Tank 2 Support Skirt (±y, 0°)	Test	0-500 micro inch/inch	2
SE 69	69	Strain Tank 2 Support Skirt (±y, 180°)	Test	0-500 micro inch/inch	2
SE 70	70	Strain, Discharge Downcomer (Axial) #1	Test	0-500 micro inch/inch	200
SE 71	71	Strain, Discharge Downcomer (Hoop) #1	Test	0-500 micro inch/inch	200
SE 72	72	Strain Discharge Downcomer (45°) #1	Test	0-500 micro inch/inch	200
SE 73	73	Strain, Discharge Downcomer (Axial) #2	Test	0-500 micro inch/inch	200
SE 74	74	Strain, Discharge Downcomer (Hoop) #2	Test	0-500 micro inch/inch	200

Table 3.1 (cont'd)

Instrumentation List
EPRI Safety/Relief Valve Test Project

INSTR.	DAS CHAN.	DESCRIPTION	CLASSIFICATION	RANGE	MAX FREQUENCY (Hz)
SE 75	75	Strain,	Test	0-500 micro inch/inch	200
TE 76	76	Thermocouple, Ambient Temperature	Test	0-800°F	2
TE 77	77	Temperature Tank 1 (RTD)	Test	0-800°F	0.1
TE 78	78	Thermocouple, (Strain Gage) Disch. Downcomer #1	Test	0-800 F	2
TE 79	79	Thermocouple, (Strain Gage) Disch. Downcomer #2	Test	0-800 F	2
ZE 84	84	Position (Displacement) + X-Axis Vertical Discharge Run Pipe (LVDT)	Test	± 3 inches	200
SE 85	85	Strain Upstream TV (Axial) #1	Test	0-500 micro inch/inch	200
SE 86	86	Strain Upstream TV (Hoop) #1	Test	0-500 micro inch/inch	200
SE 87	87	Strain Upstream TV (Axial) #2	Test	0-500 micro inch/inch	200
SE 88	88	Strain Upstream TV (Hoop) #2	Test	0-500 micro inch/inch	200
TE 89	89	Thermocouple Upstream TV Strain Gage #1	Test	0-800 F	2
TE 90	90	Thermocouple, Upstream TV Strain Gage #2	Test	0-800 F	2
TE 91	91	Thermocouple, Upstream TV Discharge Strain Gage #1	Test	0-800 F	2
TE 92	92	Thermocouple, Upstream TV Discharge Strain Gage #2	Test	0-800 F	2
ZE 93	93	Position (Displacement) (± X-Axis) 1st Discharge Elbow	Test	± 3 inches	200
ZE 94	94	Position (Displacement) (∓ Y-Axis) 1st Discharge Elbow	Test	∓ 3 inches	200
ZE 95	95	Position (Displacement) (∓ Y-Axis) Lower Horizontal Pipe Run (Midpoint)	Test	∓ 3 inches	200
SE 96	96	Strain Tank 1 Support Skirt (±y, 0°)	Test	0-500 micro inch/inch	200 Hz
SE 97	97	Strain Tank 1 Support Skirt (∓y, 180°)	Test	0-500 micro inch/inch	200 Hz
SE 98	98	Strain Tank 1 Support Skirt (∓y, 90°)	Test	0-500 micro inch/inch	200 Hz
SE 99	99	Strain Tank 1 Support Skirt (∓y, 270°)	Test	0-500 micro inch/inch	200 Hz
PT 100	100	Test Valve Preloader Cylinder #1 Pressure	Test	0-10,000 psig	200 Hz
SE 100	100	Strain, TV Discharge (Axial) #1	Test	0-500 micro inch/inch	200 Hz
PT 101	101	Upstream Pressure	Upstream Spoolpiece	0-3500 psis	200
TE 102	102	Upstream Temperature (TC)	Upstream Spoolpiece	0-800F	20
TE 103	103	Upstream Temperature (RTD)	Upstream Spoolpiece	0-800F	
DET 104	104	Upstream Density (γ-D Beam A-1) (Single Beam Densitometer)	Upstream Spoolpiece	0-62.4 lbm/ft³	200

Table 3.1 (cont'd)

Instrumentation List
EPRI Safety/Relief Valve Test Project

INSTR.	DAS CHAN.	DESCRIPTION	CLASSIFICATION	RANGE	MAX FREQUENCY (Hz)
TE 214	140	Temperature Drum #2 Recirc. Flow Orifice (TC)	Process Instrument	0-800 F	
FT 215	141	Differential Pressure Drum #2 Recirc. Flow Orifice	Process Instrument	0-20psid	
PT 216	142	Roof Vent Pressure	Process Instrument	0-3500 psis	
PT 217	143	Boiler Drum Pressure	Process Instrument	0-3500 psis	
TE 218	144	Boiler Drum Fluid Temperature (TC)	Process Instrument	0-800 F	
LT 219	145	Differential Pressure Boiler Drum Level	Process Instrument	0-3.2 psid	
JT 220	146	Wattmeter Drum #1 Heaters	Process Instrument	0-60 kw	
JT 221	147	Wattmeter Drum #2 Zone 1 Heaters	Process Instrument	0-60 kw	
JT 222	148	Wattmeter Drum #2 Zone 2 Heaters	Process Instrument	0-60 kw	
PT 301	N/A	Roof Steam Vent Pressure	Control Loop Instr.	0-3500 psig	
PDT 302	N/A	Feedwater to Loop Differential Pressure	Control Loop Instr.	0-300 psid	
TE 303	N/A	Circ. Pump 1 Cooling Water TC	Control Loop Instr.		
TE 304	N/A	Circ. Pump 2 Cooling Water TC	Control Loop Instr.		
TE 305	N/A	Rupture Disk D.S. Piping TC	Alarm Only		

Total Test Instruments	107	500 Hz-1,	200 Hz- 48	20 Hz-19,
Total Spoolpiece Instruments	20		200 Hz- 9	20 Hz-10,
Total Process Instruments	22			
Total Instruments on DAS	149			

Note: 0^{o} for Tank Support Skirt Strain Gages is the direction of the discharge pipe.

Note: Hydraulic PRELOAD Cylinder Pressures PT 100,105,106,111,112,110,126,149 are not installed initially, and channels are assigned to other sensors for PT 100,105,106,110,112,112 (100,110,111,112 are strain gages; 105,106 are assigned to other pressure as indicated on the Instrument List)

Table 3.1 (cont'd)

Instrumentation List
EPRI Safety/Relief Valve Test Project

INSTR.	DAS CHAN.	DESCRIPTION	CLASSIFICATION	RANGE	MAX. FREQUENCY (Hz)
PT 105	105	Test Valve Preloader Cylinder #2 Pressure (Used as Inlet Flange Pres.)	Test	0-10,000psig (0-3500 psis)	200
PT 106	106	Test Valve Preloader Cylinder #2 Pressure (Used as TV Bowl Pressure)	Test	0-10,000psig (0-1000 psis)	200
FE 107	107	Upstream Fluid Velocity (Full Flow Turbine Meter)	Upstream Spoolpiece	0-200 ft/sec	20
FE 108	108	Upstream Fluid Velocity Turbine Meter Probe 1	Upstream Spoolpiece	0-200 ft/sec	20
FE 109	109	Upstream Fluid Velocity Turbine Meter Probe 2	Upstream Spoolpiece	0-200 ft/sec	20
PT 110	110	Test Valve Preloader Cylinder #4 Pressure	Test	0-10,000 psig	200
SE 110	110	Strain, TV Discharge (Hoop) #1	Test	0-500 micro inch/inch	200
PT 111	111	Test Valve Preloader Cylinder #5 Pressure	Test	0-10,000 psig	200
PT 112	112	Test Valve Preloader Cylinder #6 Pressure	Test	0-10,000 psig	200
FE 113	113	Upstream Momentum Flux Drag Disc 1	Upstream Spoolpiece	0-200,000 lb/ft-sec^2	200
TE 114	114	Upstream Temperature Drag Disc 1 (TC)	Upstream Spoolpiece	0-800 F	20
FE 115	115	Upstream Momentum Flux Drag Disc 2	Upstream Spoolpiece	0-200,000 lb/ft-sec^2	200
TE 116	116	Upstream Temperature Drag Disc 2 (TC)	Upstream Spoolpiece	0-800 F	20
DET 117	117	Downstream Density (ρ-D Beam A-2)	Downstream Spoolpiece	0-62.4 lbm/ft^3	200
DET 118	118	Downstream Density (ρ-D Beam B-2)	Downstream Spoolpiece	0-62.4 lbm/ft^3	200
DET 119	119	Downstream Density (ρ-D Beam C-2)	Downstream Spoolpiece	0-62.4 lbm/ft^3	200
FE 120	120	Downstream Fluid Velocity Turbine Meter Probe 3	Downstream Spoolpiece	0-200 ft/sec	20
FE 121	121	Downstream Fluid Velocity Turbine Meter Prote 4	Downstream Spoolpiece	0-200 ft/sec	20
FE 122	122	Downstream Momentum Flux Drag Disc 3	Downstream Spoolpiece	0-200,000 lb/ft-sec^2	200
TE 123	123	Downstream Temperature Drag Disc 3 (TC)	Downstream Spoolpiece	0-800 F	20
FE 124	124	Downstream Momentum Flux Drag Disc 4	Downstream Spoolpiece	0-200,000 lb/ft-sec^2	200
TE 125	125	Downstream Temperature Drag Disc 4 (TC)	Downstream Spoolpiece	0-800 F	20
PT 126	126	Test Valve Preloader Cylinder #7 Pressure	Test	0-10,000 psig	200
SE 126	126	Strain, TV Discharge (Axial) #2	Test	0-500 micro inch/inch	200
PT 149	149	Test Valve Preloader Cylinder #7 Pressure	Test	0-10,000 psig	200
SE 149	149	Strain, TV Discharge (Hoop) #2	Test	0-500 micro inch/inch	200
PT 201	127	Pressure Stream Flow Orifice	Process Instrument	0-3500 psis	
TE 202	128	Temperature Steam Flow Orifice (TC)	Process Instrument	0-800 F	
TE 203	129	Temperature Steam Flow Orifice (RTD)	Process Instrument	0-800 F	
FT 204	130	Differential Pressure Steam Flow Orifice (High)	Process Instrument	0-25 psid	
FT 205	131	Differential Pressure Steam Flow Orifice (Low)	Process Instrument	0-3.2 psid	
TE 206	132	Temperature Drum #1 Inside Wall (TC)	Process Instrument	0-800 F	
TE 207	133	Temperature Drum #1 Outside Wall (TC)	Process Instrument	0-800 F	
TE 208	134	Temperature Drum #2 Inside Wall (TC)	Process Instrument	0-800 F	
TE 209	135	Temperature Drum #2 Outside Wall (TC)	Process Instrument	0-800 F	
PT 210	136	Pressure Drum #1 Recirc. Flow Orifice	Process Instrument	0-3500 psis	
TE 211	137	Temperature Drum #1 Recirc. Flow Orifice (TC)	Process Instrument	0-800 F	
FT 212	138	Differential Pressure Drum #1 Recirc. Flow Orifice	Process Instrument	0-20 psid	
PT 213	139	Pressure Drum #2 Recirc. Flow Orifice	Process Instrument	0-3500 psis	

Table 3.1 (cont'd)

Table 3.2

SUMMARY OF INSTRUMENTATION CHARACTERISTICS

(Test and Spoolpiece Instruments)

Parameter Measured	Type Transducer	Manufacturer/ Model No.	Type Signal Conditioner	Manufacturer Model No.	System Accuracy % Full Scale	System Freq. Response	Full Scale Range (s)
Pressure	Strain Gage Diaphram	BLH Electronics Model DHF	Strain Gage Amplifier	Bell & Howell 1-183	±0.27%	>1 KHz	0-3500 psis
	Strain Gage Diaphram	Sensotec Z-Series	Strain Gage Amplifier	Bell & Howell 1-183	±0.27%	>1 KHz	0-1500 psia
	Strain Gage Diaphram	Sensotec TJE Series	Strain Gage Amplifier	Bell & Howell 1-183	±0.14%	>1 KHz	0-10,000 psi
Differential	Variable Reluctance Magnetic Diaphram	Validyne DP 22	Carrier Demodulator	Validyne CD-19	±0.5%	300 Hz	±40 psid thru ±1500 psid
		Validyne DP 303	Carrier Demodulator	Validyne CD-19	±0.5%	300 Hz	±3.2 psid thru 25 psid
	Capacitance Diaphram	Rosemount 1151 HP	Built in Trans- mitter 4-20 ma (2-10 VCD thru 500Ω)	Rosemount	±0.25%	20 Hz	0-25 psid 0-17 psid
Temperature	Type K Thermocouples	Thermoelectric & Multicable	Thermocouple Signal Transmitter	Rochester Instr. SC1326W	±3.4% of Reading or ±4°F (whichever larger)	10 Hz	0-800°F
	Platinum RTD	Rosemount Series 78	RTD Transmitter	Rochester Instr. SC 1372	±0.1%	< 1 Hz	0-800°F
Acceleration	Piezoelectric Crystal Accelero- meter (Built in Charge Amplifier)	PCB Piezotronics Model 306MIO (Triaxial)	Voltage/Amplifier Power Supply	PCB Piezotronics Model 494A06	±1% Reading	1-1KHz	0-10g
Force	Strain Gage Load Cells	Lebow 3156	Strain Gage Amplifier	Bell & Howell 1-183	±0.5%	>1 KHz	0-100,000 lb 0- 25,000 lb

Table 3.2 (cont'd)

SUMMARY OF INSTRUMENTATION CHARACTERISTICS

Parameter Measured	Type Transducer	Manufacturer/ Model No.	Type Signal Conditioner	Manufacturer Model No.	System Accuracy % Full Scale	System Freq. Response	Full Scale Range (s)
Position (Displacement)	LVDT	Schaevitz 2000 HCA 3000 HCA 4000 HCA	Carrier Demodulator	Schaevitz	±0.25%	250 Hz	±2", ±4", ±5"
Strain	Strain Gage (Weldable)	BLH Electronics	Strain Gage Amplifier	Bell & Howell 1-183	±0.5%	>1 KHz	0±2000 μE
	Strain Gage (Adhesive, ¼ Bridge)	BLH Electronics	Strain Gage Amplifier	Bell & Howell 1-183	±0.5%	>1 KHz	0±2000 μE 0±400 μE 0±700 μE
Fluid Density	3 Beam Gamma Densitometer	Measurements, Inc. FM-6	Photomultiplier and Amplifiers	Measurements, Inc.	±0.5% Water Density ±1.0% Vapor Density	1 KHz	0-62.4 lbm/ft^3
Fluid Momentum Flux	Drag Disc (Strain Gage)	Ramapo Instruments V5300-6RBDQ	Strain Gage Amplifier	Ramapo Instruments SGA-300 RMB	±0.54%	20 Hz	0-200,000 lbm/ft
Fluid Velocity	Turbine Meter Probe	Flow Technology FTP-16S 12,000 lb 16-12S	Frequency to DC Converter	ANADEX PI-608	±0.64%	10 Hz	20-200 ft/sec
	Full Flow Turbine Meter	Flow Technology FT-128G x 5500LJC(s)	Frequency to DC Converter	ANADEX PI-608	±0.64%	?	20-200 ft/sec

Table 3.3

Dresser Model 31709NA Safety Valve Parameters

Manufacturer	Dresser
Type	Spring-loaded, balanced bellows, and enclosed bonnet
Model Number	Dresser 31709NA
Design pressure, psia	2500
Design Temperature, °F	700
Set pressure (nominal), psia	2500
Minimum required capacity at 3% accumulation, lb/hr.	460,000
ASME rated capacity at 3% accumulation, lb/hr.	504,874
Inlet Diameter, in.	6
Outlet Diameter, in.	8
Orifice area, $in.^2$	4.34
Accumulation, (nominal), %	3
Backpressure, nominal, psig	500
Blowdown, (nominal), %	10
Inlet Flange Rating	2500
Outlet Flange Rating	600

Table 3.4

Dresser Model 31709NA Safety Valve Test

Inlet Piping Data

	Length, in.	I.D., in.
Nozzle	17	6.813
Venturi	38	6.813
Pipe	6	6.813
Reducer	6	6.813/4.897
Inlet Flange	11	4.897

EPRI/CE SAFETY VALVE TEST DATA

Table 3.5

"AS TESTED" COMBUSTION ENGINEERING TEST MATRIX FOR THE DRESSER 31709NA SAFETY VALVE

TEST NO.	TEST TYPE	VALVE RING SETTINGS			INLET PIPING CONFIG.	CONDITIONS AT VALVE OPENING						TRANSIENT CONDITIONS			
						IN TANK 1				AT VALVE INLET					
		UPPER	MIDDLE	LOWER		FLUID	PRESS. (PSIA)	TEMP. (°F)	PRESS. RATE (PSI/SEC)	FLUID	TEMP. (°F)	PEAK TANK 1 PRESS. (PSIA)	PEAK BACK-PRESS. (PSIA)	INDUCED (2) BENDING MOMENT OPENING/CLOSING (IN. LBS.)	MAX. STEADY LIQUID FLOW (GPM)
*201	STEAM	-48	+34	-20	A	STEAM	2486	(1)	400	STEAM	(1)	2680	(3)	137,500	N/A
*603	STEAM	-48	-60	0	B	STEAM	2505	(1)	2.9	STEAM	(1)	2505	174	91,000	N/A
*606	STEAM	-48	-60	0	B	STEAM	2503	(1)	296	STEAM	(1)	2695	195	91,000	N/A
611	STEAM	-48	-60	0	B	STEAM	2530	(1)	322	STEAM	(1)	2697	358	95,550	N/A
614	STEAM	-48	-40	0	B	STEAM	2546	(1)	317	STEAM	(1)	2686	354	100,100	N/A
615	STEAM	-48	-20	0	B	STEAM	2568*	(1)	317	STEAM	(1)	2639	326	100,100	N/A
618	STEAM	-48	-60	0	B	STEAM	2536	(1)	288	STEAM	(1)	2680	530	91,000	N/A
*620	STEAM	-48	-20	0	B	STEAM	2540	(1)	317	STEAM	(1)	2667	194	95,550	N/A
623	TRANS	-48	-60	0	B	STEAM/WATER	2545	(1)	3.0	STEAM	(1)	2545	418	100,100	3801
625	WATER	-48	-60	0	B	WATER	2412	603	3.0	WATER	573	2420	338	91,000	2715
628	TRANS	-48	-20	0	B	STEAM/WATER	2530	(1)	2.7	STEAM	(1)	2530	386	81,900	3305
*630	WATER	-48	-20	0	B	WATER	2393	625	2.5	WATER	589	2393	336	100,100	3735
*1305	STEAM	-48	-20	0	B	STEAM	2530	(1)	308	STEAM	(1)	2652	345	200,200	N/A
1308	WATER	-48	-20	0	B	WATER	2487	562	1.8	WATER	535	2513	145	473,200	1436
*1311	WATER	-48	-20	0	B	WATER	2558	415	2.6	WATER	429	2558	100	445,900	(3)

N/A Not applicable

NOTES:

(1) All tests were initiated at a nominal pressure of 2300 PSIA. For steam tests and steam/water transition tests, the initiation temperature was the saturation temperature.

(2) The reported values are the maximum bending moments on the valve discharge flange during opening or closing.

(3) Unstable conditions precluded reliable measurement.

* The valve was disassembled, inspected, and refurbished as required for representative test performance.

EPRI/CE SAFETY VALVE TEST DATA

Table 3.5 (cont'd)

VALVE TRANSIENT AND LEAKAGE PERFORMANCE DATA FOR THE

DRESSER 31709NA SAFETY VALVE

		PRE-TEST VALVE LEAKAGE				VALVE OPENING AND CLOSING							POST-TEST VALVE LEAKAGE			
TEST NO.	TEST TYPE	MEDIA	NOMINAL VALVE INLET PRESS. (PSIA)	NOMINAL VALVE INLET TEMP. (°F)	LEAKAGE RATE (GPM)	INITIAL OPENING PRESS. (PSIA)	OPENING "POP" PRESS. (PSIA)	OPENING SIMMER TIME (SEC)	OPENING "POP" TIME (SEC)	TANK 1 PRESS. AT VALVE CLOSURE (PSIA)	% BLOWDOWN	VALVE STABILITY	MEDIA	NOMINAL VALVE INLET PRESS. (PSIA)	NOMINAL VALVE INLET TEMP. (°F)	LEAKAGE RATE (GPM)
201	STEAM	STEAM	2300	660	< 0.1	2486	2489	0.011	0.013	2010	20.2	chatter	STEAM	2091	646	0.54
603	STEAM	STEAM	2298	Sat	0.9	2505	2505	0.004	0.012	2160	14.2	stable	STEAM	2286	Sat	1.0
606	STEAM	STEAM	2283	Sat	0.0	2503	2509	0.005	0.015	2166	14.0	stable	STEAM	2200	Sat	1.1
611	STEAM	STEAM	2285	Sat	0.0	2530	2538	0.007	0.017	2290	9.0	stable	STEAM	2290	Sat	1.0
614	STEAM	STEAM	2293	Sat	0.0	2546	2551	0.007	0.016	2294	8.8	stable	STEAM	2300	Sat	1.8
615	STEAM	STEAM	2294	Sat	0.0	2568	2575	0.006	0.018	2327	7.5	stable	STEAM	2285	Sat	1.5
618	STEAM	STEAM	2300	Sat	0.0	2486	2486	0.007	0.015	2277	9.5	stable	STEAM	2285	Sat	2.1
620	STEAM	STEAM	2300	Sat	0.0	2540	2540	0.005	0.017	2227	11.5	stable	STEAM	2300	Sat	1.7
623	TRANS	STEAM	2286	Sat	0.0	2545	2545	0.006	0.015	2052	18.5	stable	STEAM	2285	Sat	0.67
625	WATER	WATER	2300	Sat	0.37	2412	2412	0.010	0.035	2108	16.3	stable	WATER	2300	Sat	0.0
628	TRANS	STEAM	2281	Sat	0.1	2530	2530	0.006	0.017	2090	17.0	stable	WATER	2290	Sat	0.47
630	WATER	WATER	2296	Sat	0.36	2393	2393	0.011	0.037	1950	22.6	stable	WATER	2300	Sat	0.09
1305	STEAM	STEAM	2280	Sat	0.0	2530	2535	0.008	0.023	2301	8.6	stable	STEAM	1800	Sat	0.66
1306	WATER	WATER	2300	544	0.0	2487	2487	0.011	0.059	2398	4.7	stable	WATER	2300	544	0.0
1311	WATER	WATER	2300	429	0.0	2558	2558	<0.01	(1)	(2)	(2)	chatter (3)	(2)	(2)	(2)	(2)

N/A Not applicable

NOTES:

(1) Unstable conditions precluded reliable measurement.
(2) These data were not available
(3) The valve opened, chattered for approximately 3 seconds and then stopped chattering for the remainder of the test.

EPRI/CE SAFETY VALVE TEST DATA

Table 3.5 (cont'd)

VALVE FLOW RATE PERFORMANCE DATA FOR THE

DRESSER 31709NA SAFETY VALVE

TEST NO.	TEST TYPE	CONDITIONS AT 3% ACCUMULATION (1): BASED ON TANK PRESSURE: % RATED LIFT	BASED ON TANK PRESSURE: % RATED STEAM FLOW	BASED ON VALVE INLET PRESSURE: % RATED LIFT	BASED ON VALVE INLET PRESSURE: % RATED STEAM FLOW	CONDITIONS AT 6% ACCUMULATION (1): BASED ON TANK PRESSURE: % RATED LIFT	BASED ON TANK PRESSURE: % RATED STEAM FLOW	BASED ON VALVE INLET PRESSURE: % RATED LIFT	BASED ON VALVE INLET PRESSURE: % RATED STEAM FLOW	LIQUID FLOW MEASUREMENT: TANK CONDITIONS PRESS. (PSIA)	TANK CONDITIONS TEMP. (°F)	MAX. STEADY LIQUID FLOW (GPM)	% RATED LIFT
601	STEAM	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	N/A	N/A	N/A	N/A
603	STEAM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
606	STEAM	109	125	109	125	109	130	109	131	N/A	N/A	N/A	N/A
611	STEAM	104	124	105	124	107	130	107	130	N/A	N/A	N/A	N/A
614	STEAM	98	123	99	124	107	130	107	132	N/A	N/A	N/A	N/A
615	STEAM	83	117	84	119	(3)	(3)	(3)	(3)	N/A	N/A	N/A	N/A
618	STEAM	101	123	100	123	108	130	108	130	N/A	N/A	N/A	N/A
620	STEAM	107	124	107	126	107	130	(3)	(3)	N/A	N/A	N/A	N/A
623	TRANS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2372	653	3801	105
625	WATER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2320	603	2715	38
628	TRANS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2343	647	3304	73
630	WATER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2335	625	3735	62
1305	STEAM	79	114	81	116	(3)	(3)	(3)	(3)	N/A	N/A	N/A	N/A
1308	WATER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2429	562	1436	26
1311	WATER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	(2)	(2)	(2)	(2)

N/A Not applicable

NOTES:

(1) During the valve closing cycle. The valve inlet pressure corresponds to stagnation pressure.
(2) Unstable conditions preclude reliable measurement.
(3) The appropriate measurement conditions were not achieved.

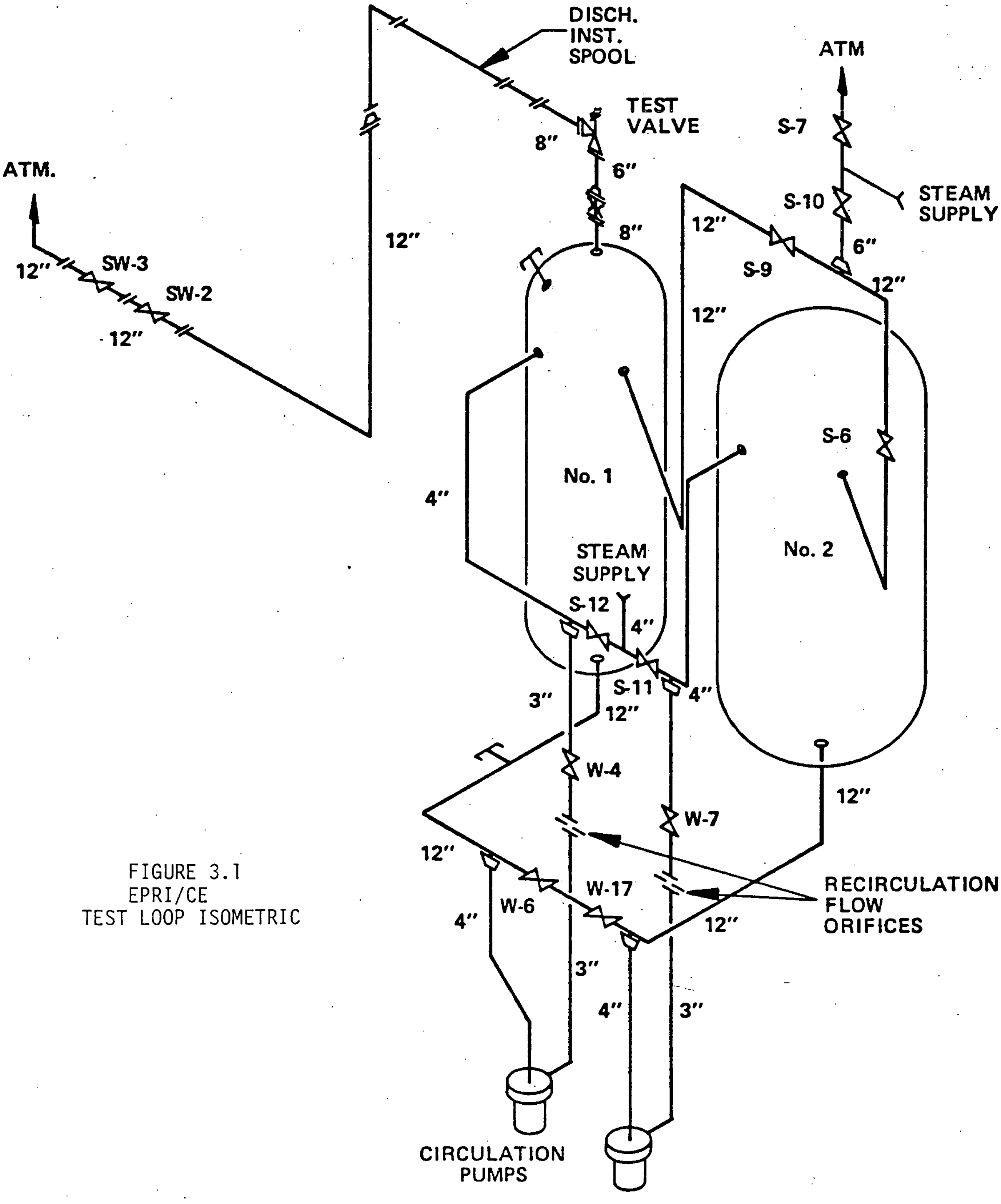


FIGURE 3.1
EPRI/CE
TEST LOOP ISOMETRIC

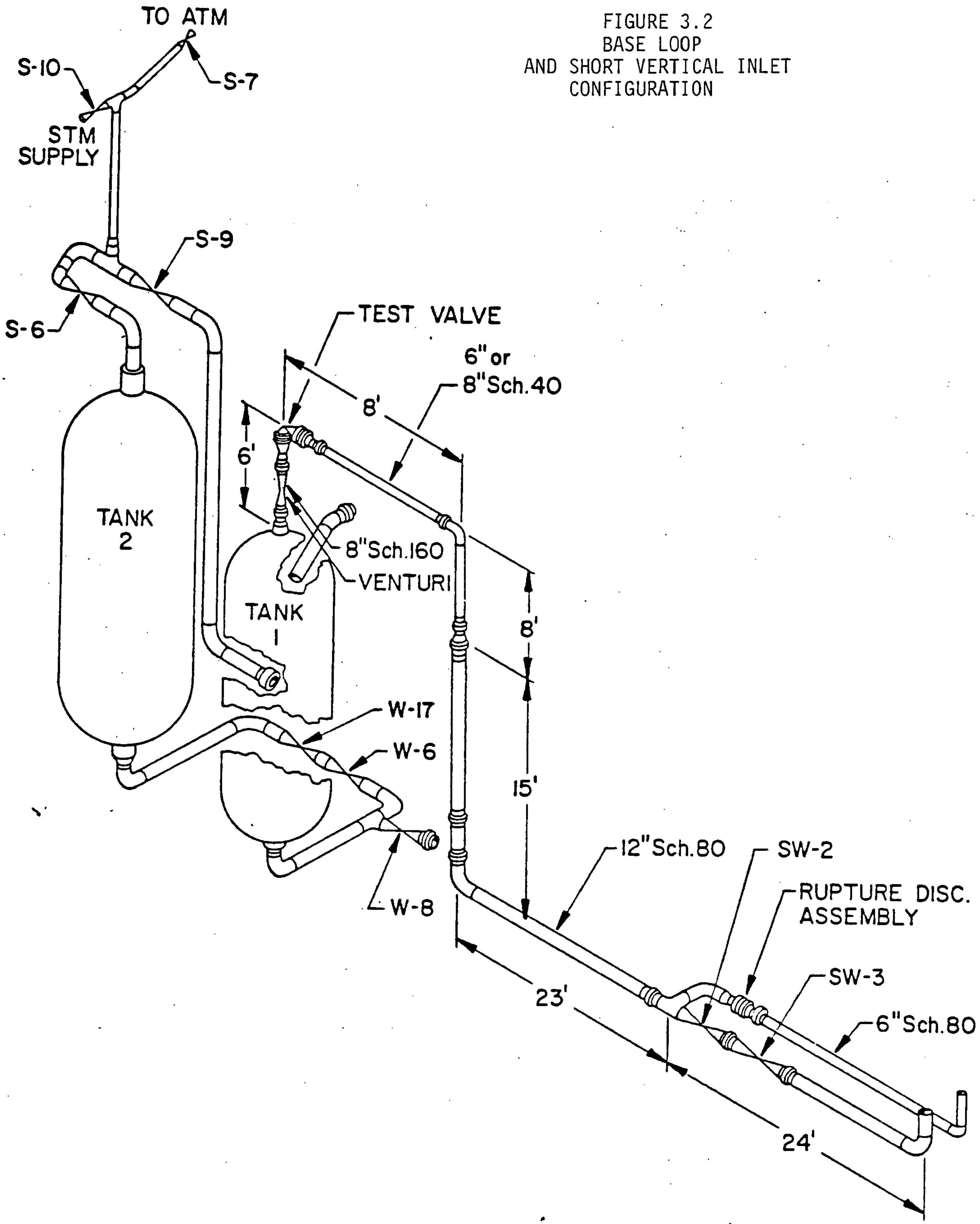


FIGURE 3.2
BASE LOOP
AND SHORT VERTICAL INLET
CONFIGURATION

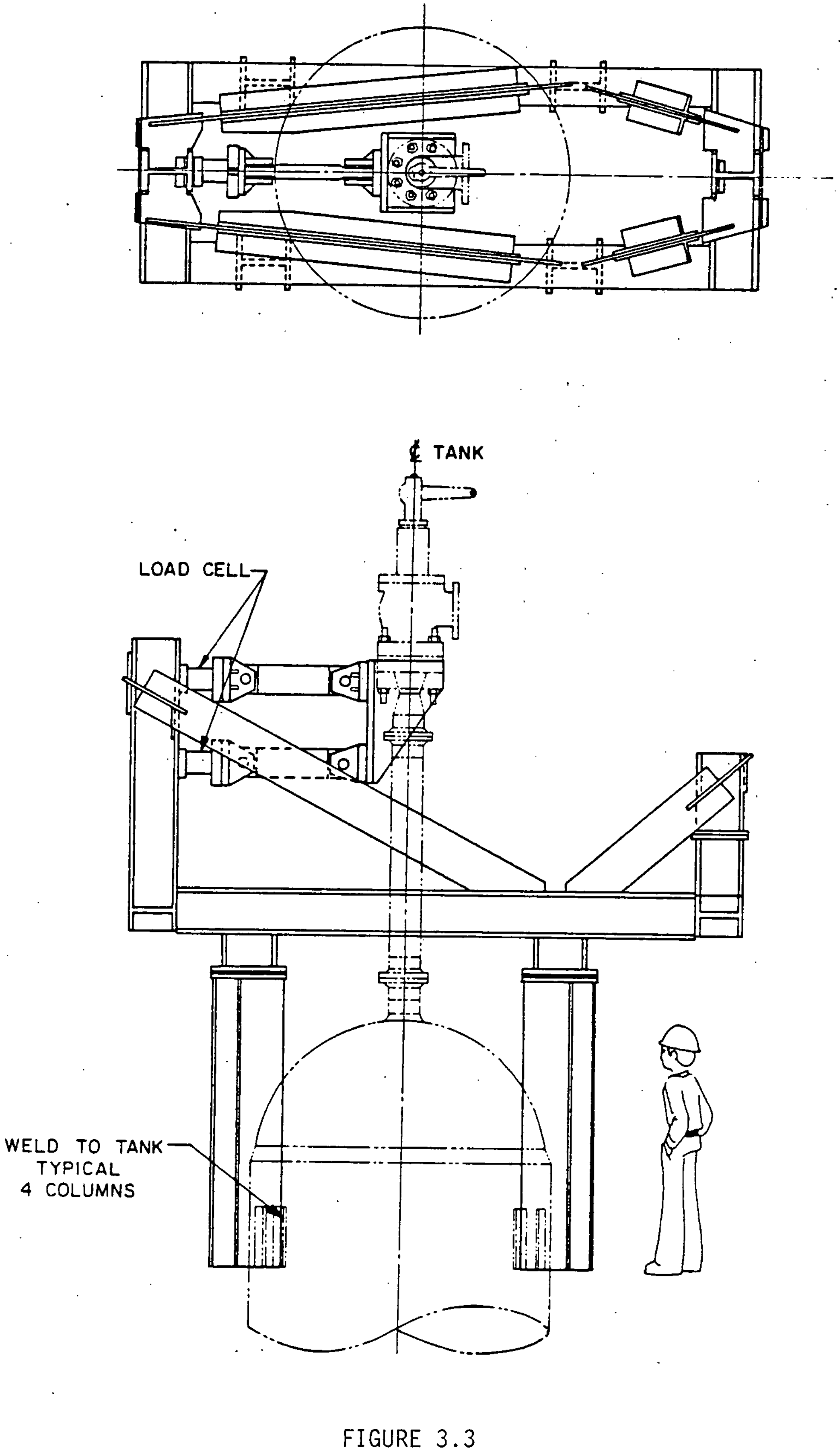


FIGURE 3.3
TEST VALVE SUPPORT STAND

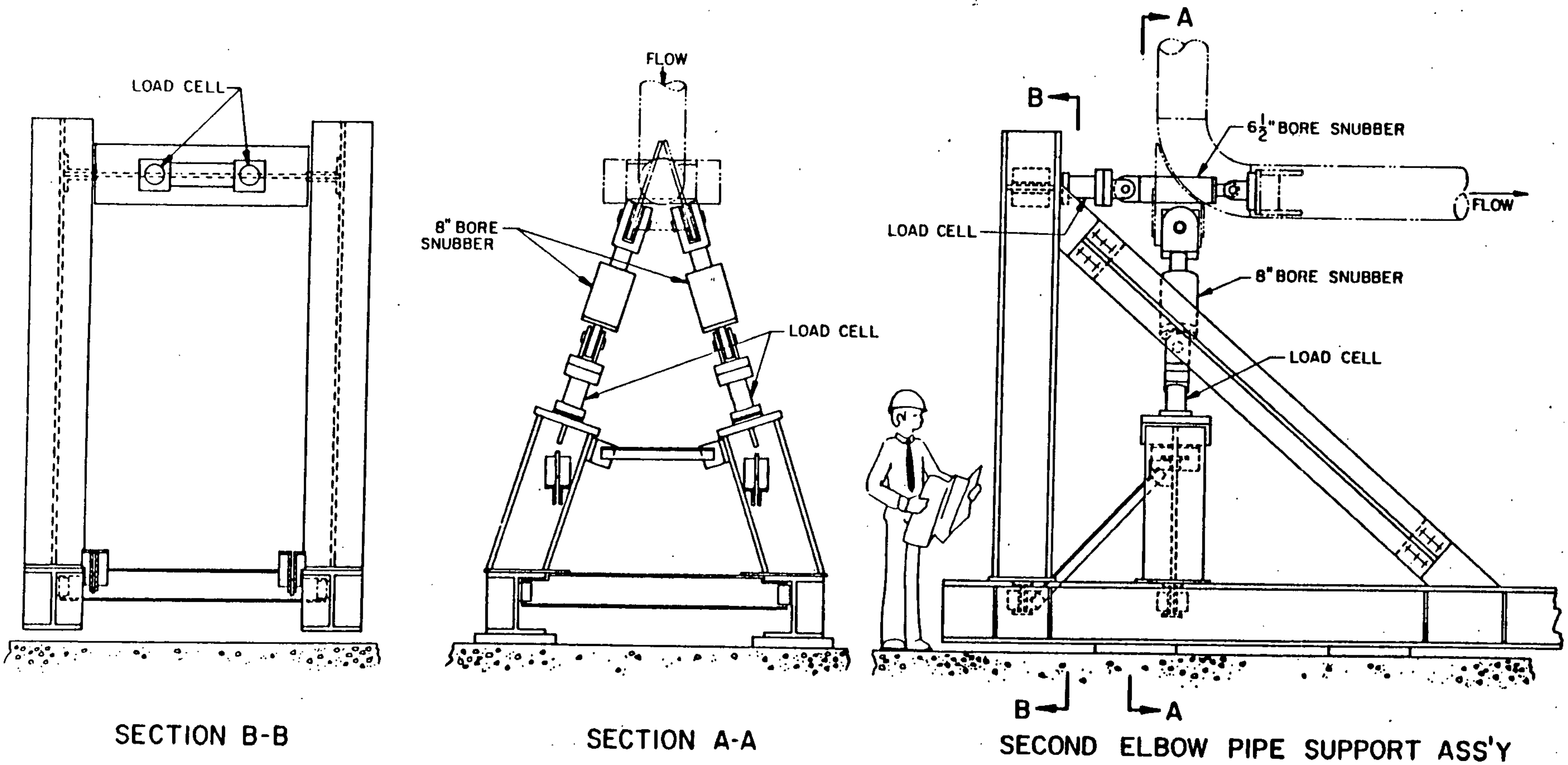
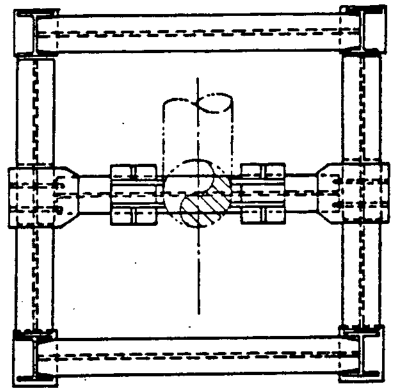


FIGURE 3.4
TEST LOOP SUPPORT AT SECOND DISCHARGE ELBOW



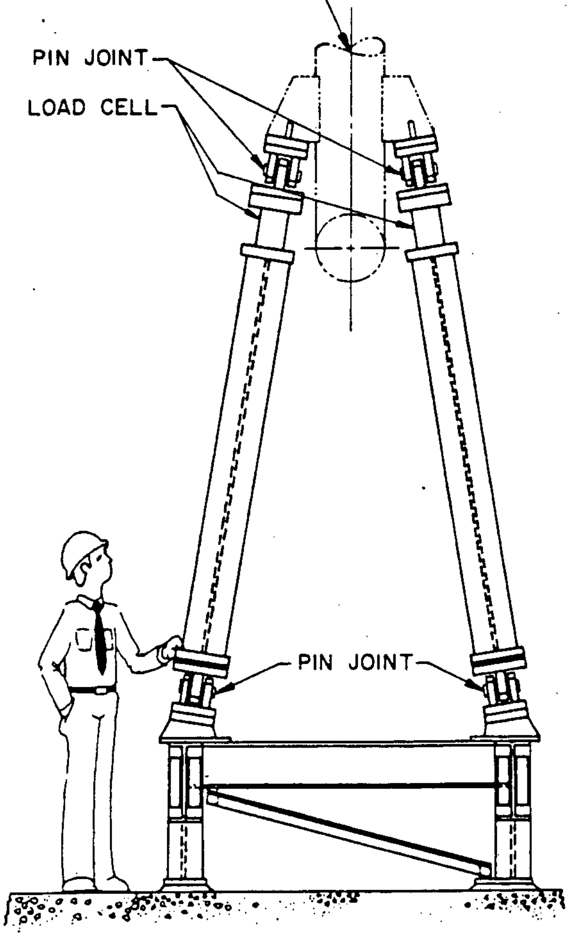
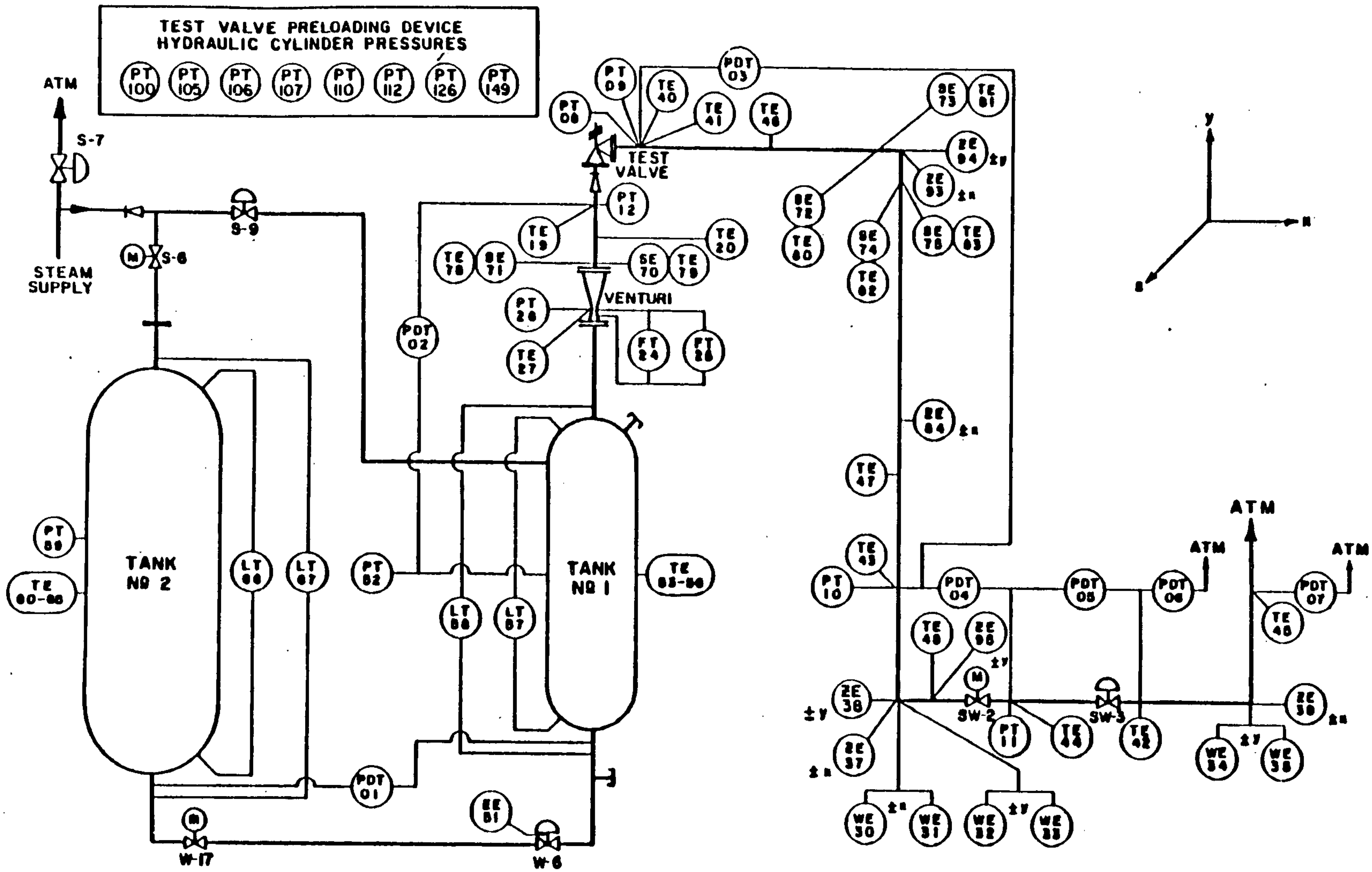
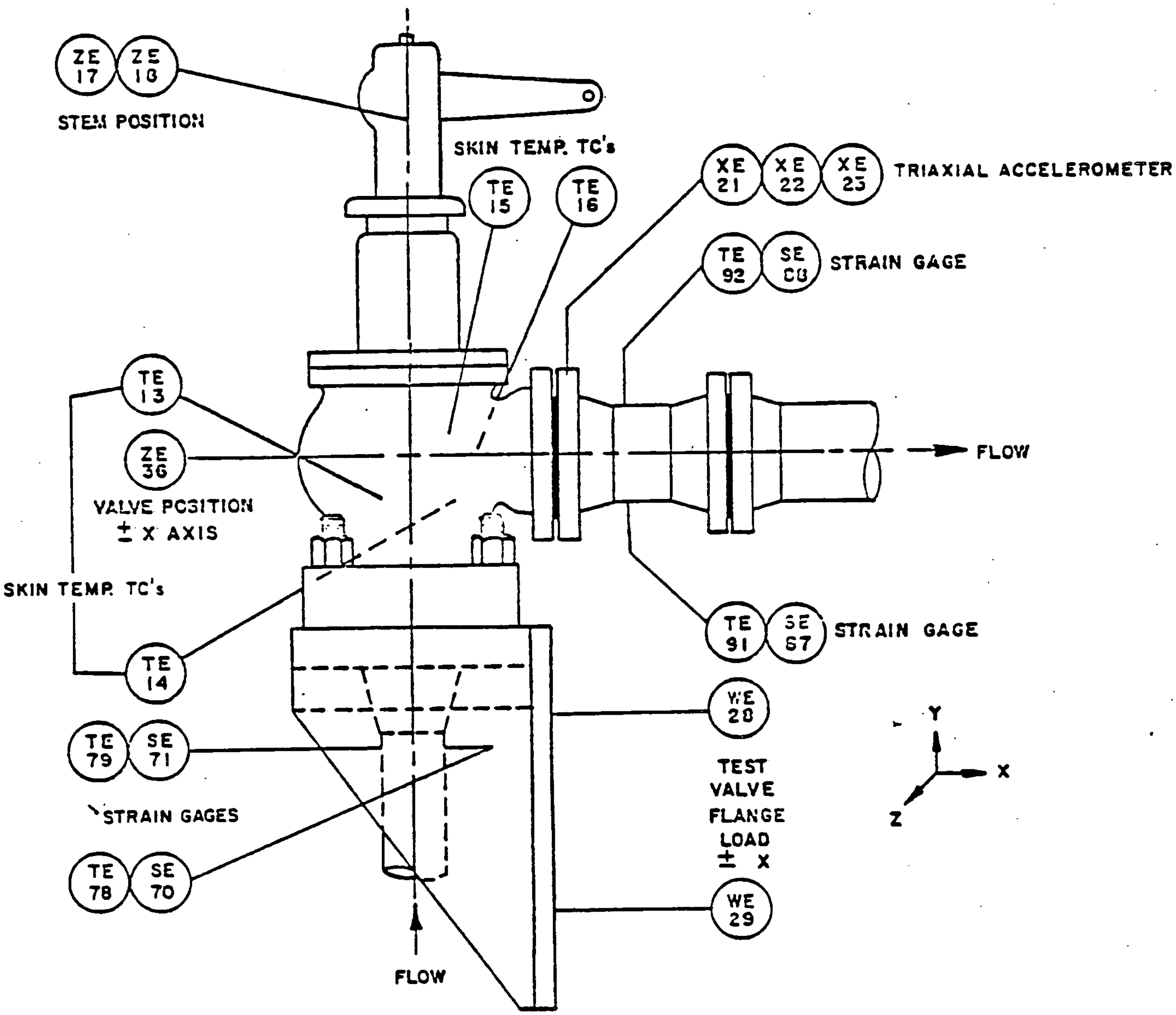


FIGURE 3.5
TEST LOOP SUPPORT AT THIRD DISCHARGE ELBOW



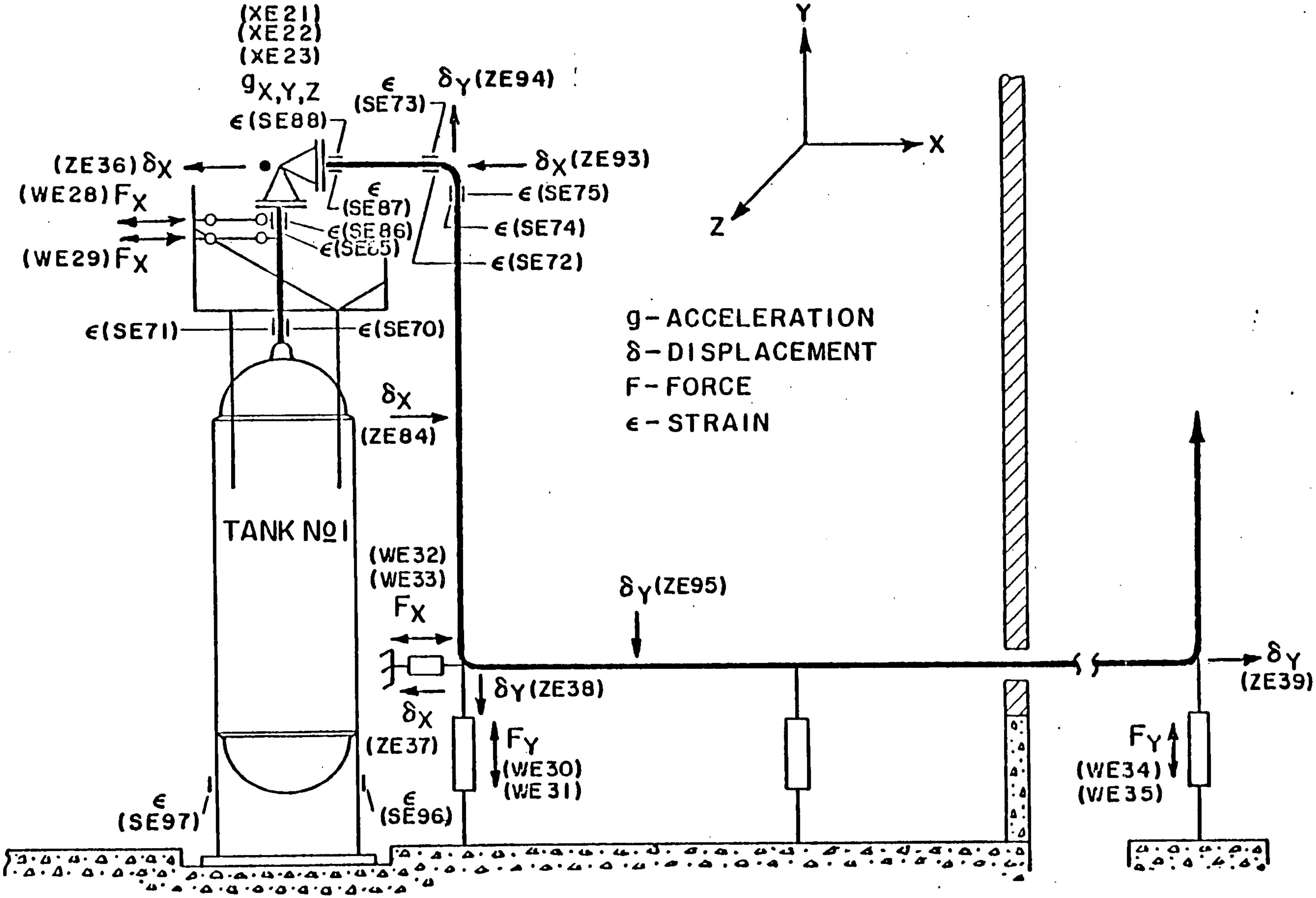
TEST INSTRUMENTATION DIAGRAM
EPRI/C-E SAFETY AND RELIEF VALVE TEST FACILITY

FIGURE 3.6



TEST VALVE INSTRUMENTATION

FIGURE 3.7



PIPING RESPONSE INSTRUMENTS

FIGURE 3.8

FIGURE 3.9
DRESSER MODEL 31709NA SAFETY VALVE

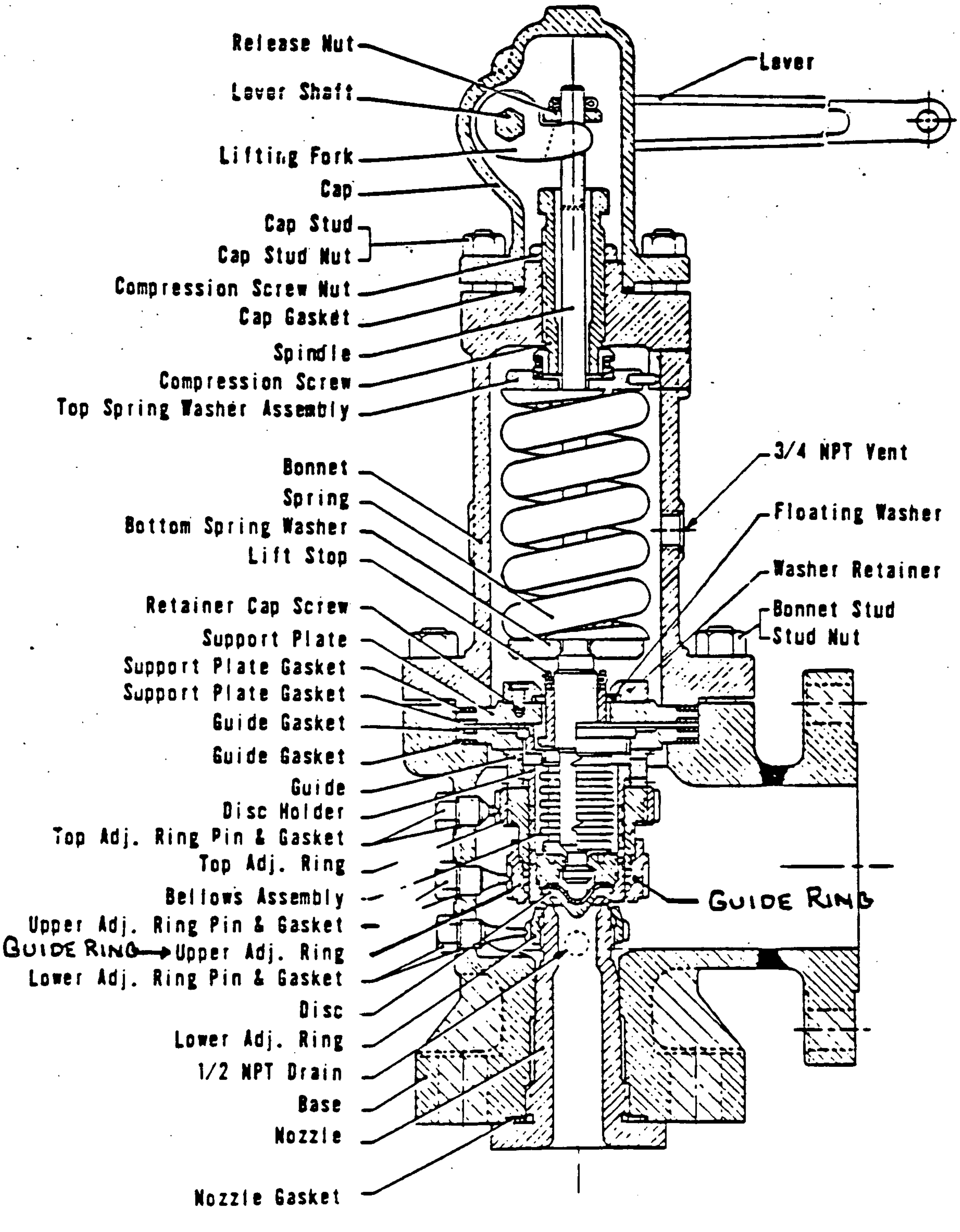


FIGURE 3.10
DRESSER MODEL 31709NA
SAFETY VALVE
ADJUSTING RINGS

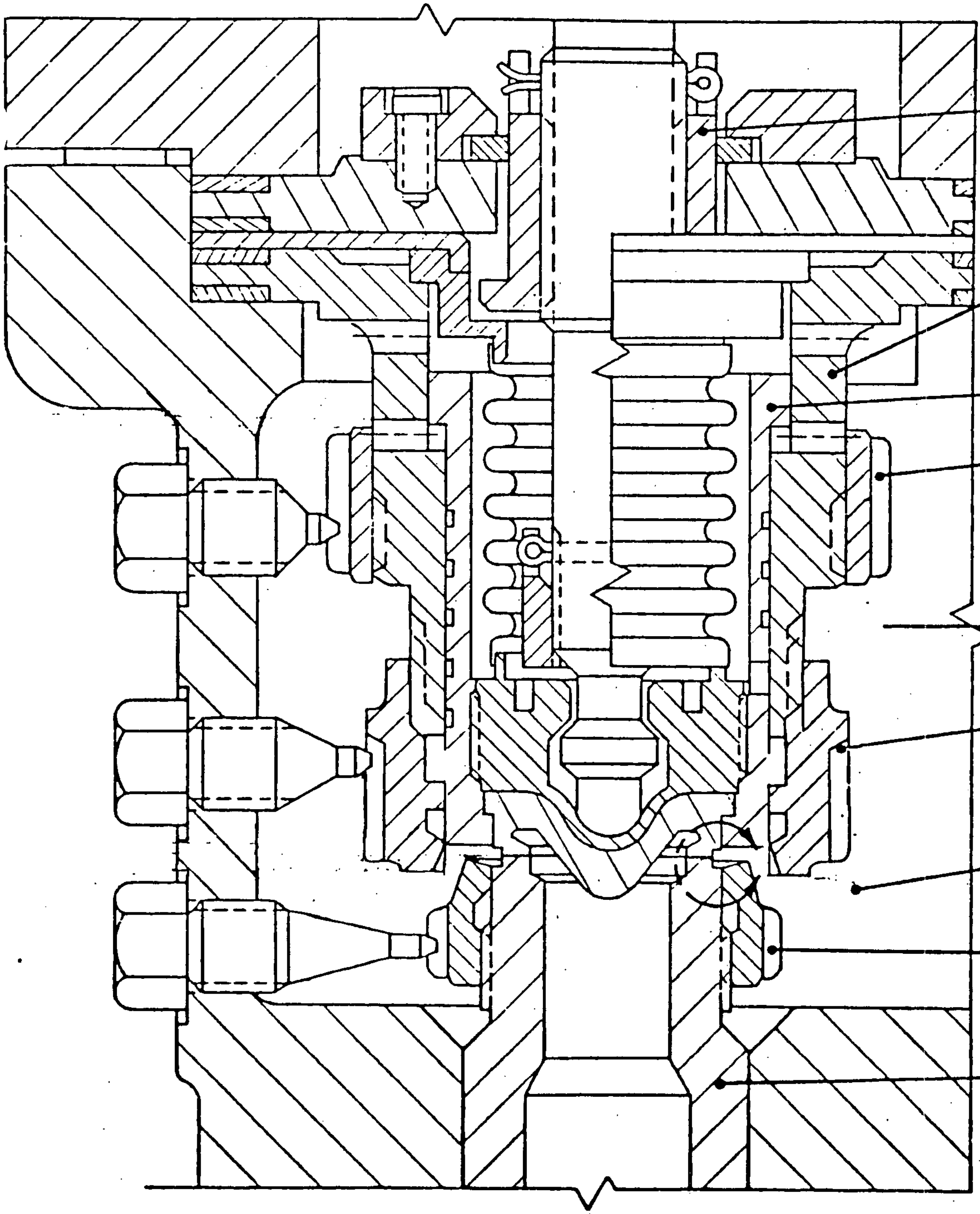


Figure 3.11

EPRI/CE TEST FACILITY INLET PIPING CONFIGURATION
FOR THE DRESSER 31709NA SAFETY VALVE

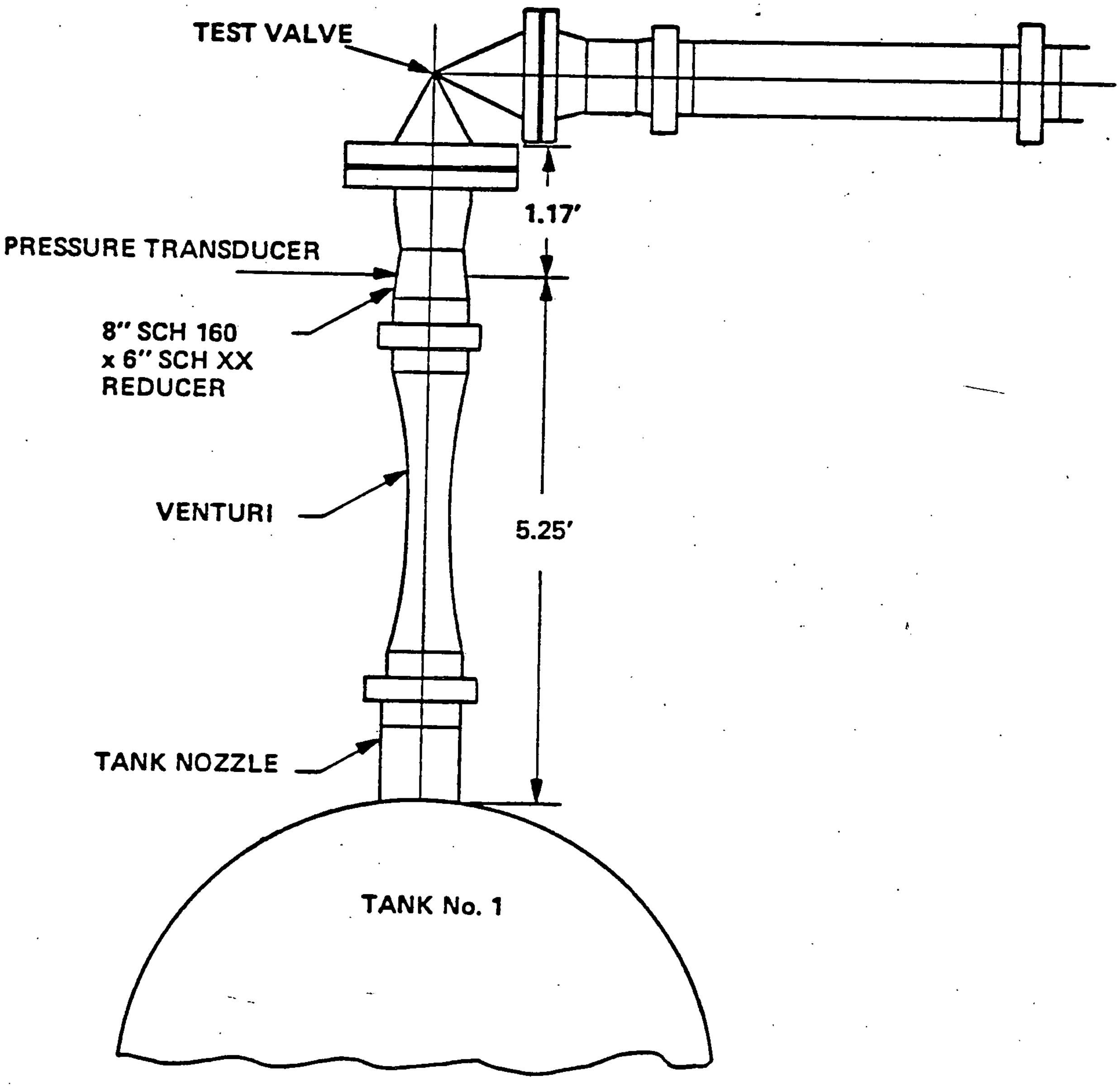


FIGURE 3.12

EPRI/DRESSER 31709NA TEST RESULTS

BLOWDOWN VS BUILTUP BACKPRESSURE

(STEAM TESTS ONLY)

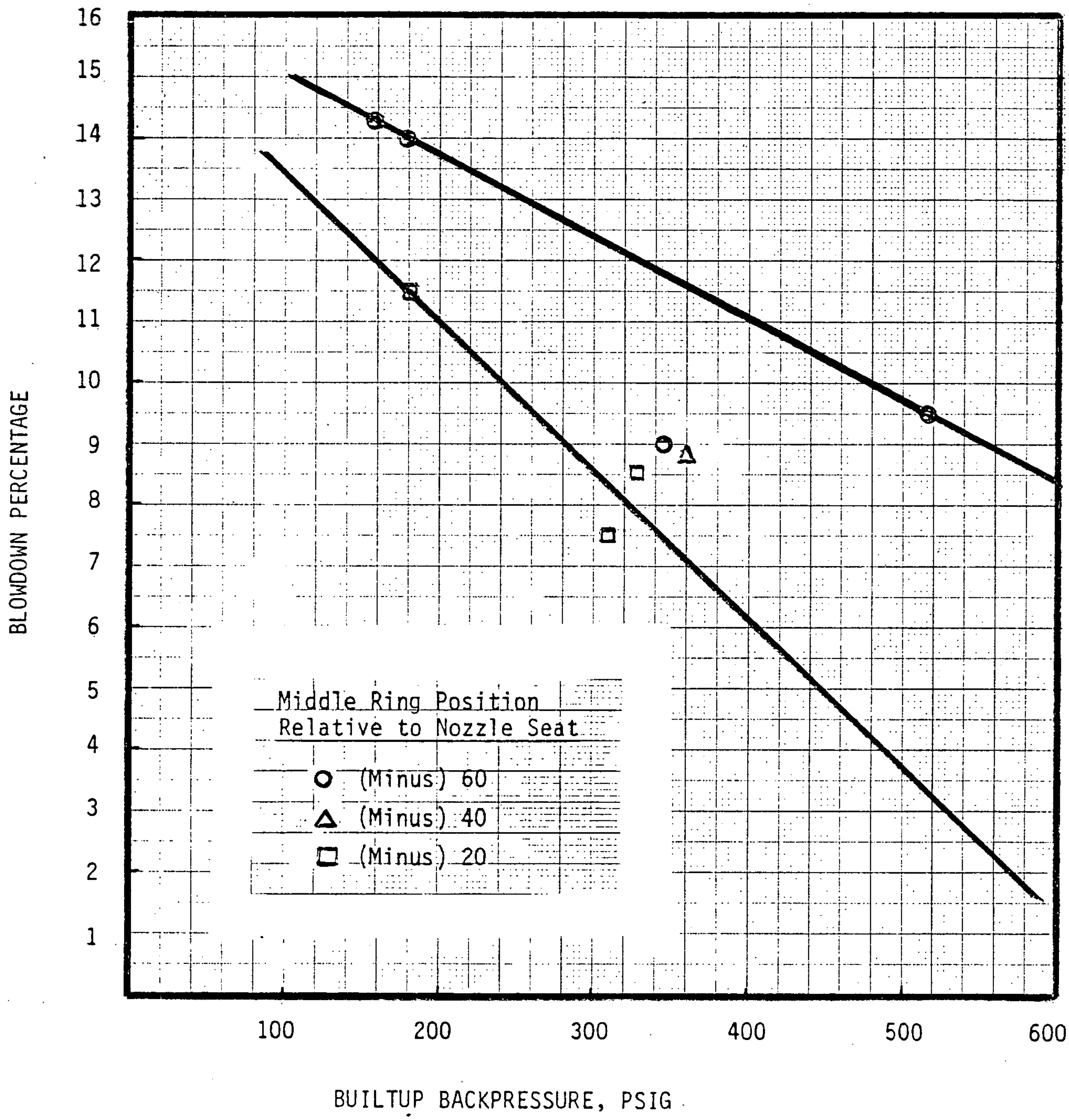
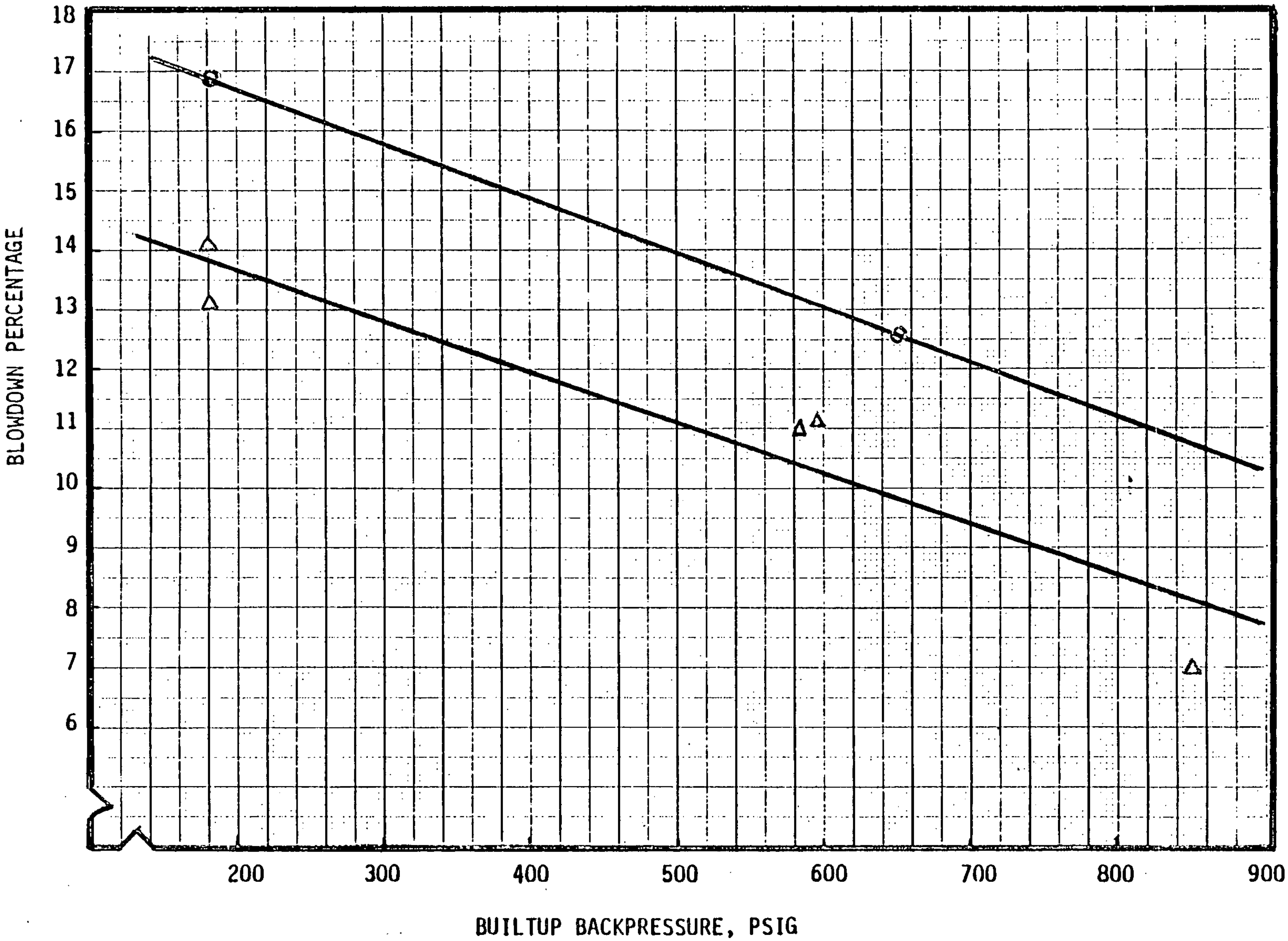


FIGURE 3.13

EPRI/DRESSER 31739A TEST RESULTS

BLOWDOWN VS BUILTUP BACKPRESSURE

(STEAM TESTS ONLY)



4.0 SAN ONOFRE UNITS 2 AND 3 SAFETY VALVES

4.1 Description

The San Onofre Units 2 and 3 reactor coolant system (RCS) is provided with two Dresser Industries Model No. 31709NA safety valves for overpressure protection. Table 3.3 lists the safety valve and design parameters. The safety valve is illustrated in Figure 3.9. These valves are connected by piping to the top of the pressurizer, as shown in Fig. 4.2. They are direct acting, spring-loaded safety valves meeting ASME Code requirements. They have an enclosed bonnet and have a balanced bellows for superimposed backpressure. The safety valves pass sufficient pressurizer steam to limit the reactor coolant system pressure to below 110% of design pressure following a complete loss of turbine generator load without simultaneous reactor trip. A delayed reactor trip is assumed on a high-pressurizer pressure signal.

4.2 Valve Adjusting Ring Settings

The valve manufacturer was requested to recommend, based on the EPRI/C-E test results, an appropriate combination of valve ring adjustments for San Onofre Units 2 and 3. The scope of the EPRI/C-E test program did not allow the establishment of a comprehensive definition of the interrelationship between the various combinations of ring settings and valve behavior. Therefore, it was considered prudent to select a combination of ring settings which were identical to one of the configurations tested, and which provided a blowdown which was not excessive. The recommended ring settings were as follows:

Upper Ring Position: 48 Notches Below Top of Holes in Guide
Middle Ring Position: 20 Notches Below Nozzle Seat
Lower Ring Position: Zero Notches Below Nozzle Seat

The above ring adjustments were used in EPRI/C-E Test Numbers 615, 620, 628, 630, 1305, 1308, and 1311. Figure 4.1 provides a sketch illustrating these ring adjustments.

4.3 Installation

The San Onofre Units 2 and 3 safety valves are piped to provide the shortest inlet piping which is feasible. Figure 4.2 illustrates the current safety valve inlet piping arrangement.

4.4 Inlet Fluid Conditions

4.4.1 FSAR Pressurization Events

The San Onofre Units 2 and 3 safety valve fluid inlet conditions prescribed by the FSAR for various design basis events are summarized in Reference 5. Reference 5 indicates that for all events which result in safety valve lift, the safety valves will discharge only steam. That is, it is not expected that the safety valves will be required to pass liquid or two-phase fluid. The peak pressurizer pressure calculated for FSAR events was 2760 psia. The range of calculated pressurizer ramp rates was 45 to 93 psi/sec.

4.4.2 High Pressure Injection Events

The High Pressure Injection event is the charging of water into the RCS by the high pressure safety injection (HPSI) pumps due to a safety injection actuation signal (SIAS). However, the shutoff head of the San Onofre Units 2 and 3 HPSI pumps (approximately 1500 psia) is below the nominal safety valve setpoint (2500 psia), as well as below normal operating pressure (2250 psia). Therefore, the HPSI pumps are incapable of causing the safety valves to lift. Further, the HPSI pumps are incapable of injecting coolant into the RCS during normal power operation. The lifting of safety valves due to uncontrolled charging by the charging pumps was not considered. This event was not

considered because more than adequate time is available for the operator to take corrective action. The High Pressure Injection event is, therefore, not relevant in a consideration of San Onofre Units 2 and 3 safety valve fluid inlet conditions.

4.4.3 Cold Overpressurization Events

For protection against brittle failure when the RCS is at low temperature, and possibly in a water-solid condition, San Onofre Units 2 and 3 is provided with a spring-loaded relief valve located in the Shutdown Cooling System at the suction of the low pressure safety injection pumps. Cold overpressure protection is therefore not a function of the San Onofre Units 2 and 3 pressurizer safety valves.

4.5 Backpressure

The EPRI/C-E valve tests showed that the Dresser 31709NA valve blowdown was dependent on the discharge backpressure. Based on the current San Onofre Units 2 and 3 safety valve discharge piping arrangement shown in Part C, (Figures 4.1 through 4.5), the calculated backpressure was 427 psig for two safety valves discharging and 245 psig for a single valve discharging. These backpressures are within the range for acceptable valve performance.

Notes:

(1) Vertical displacement of Lower Ring moved 16 notches is equal to Middle Ring displacement when moved 25 notches. For further reference relative to nozzle seat or bottom surface of disk holder, see Section 3.1 and Table 1 (Test 615).

(2) This figure not to scale.

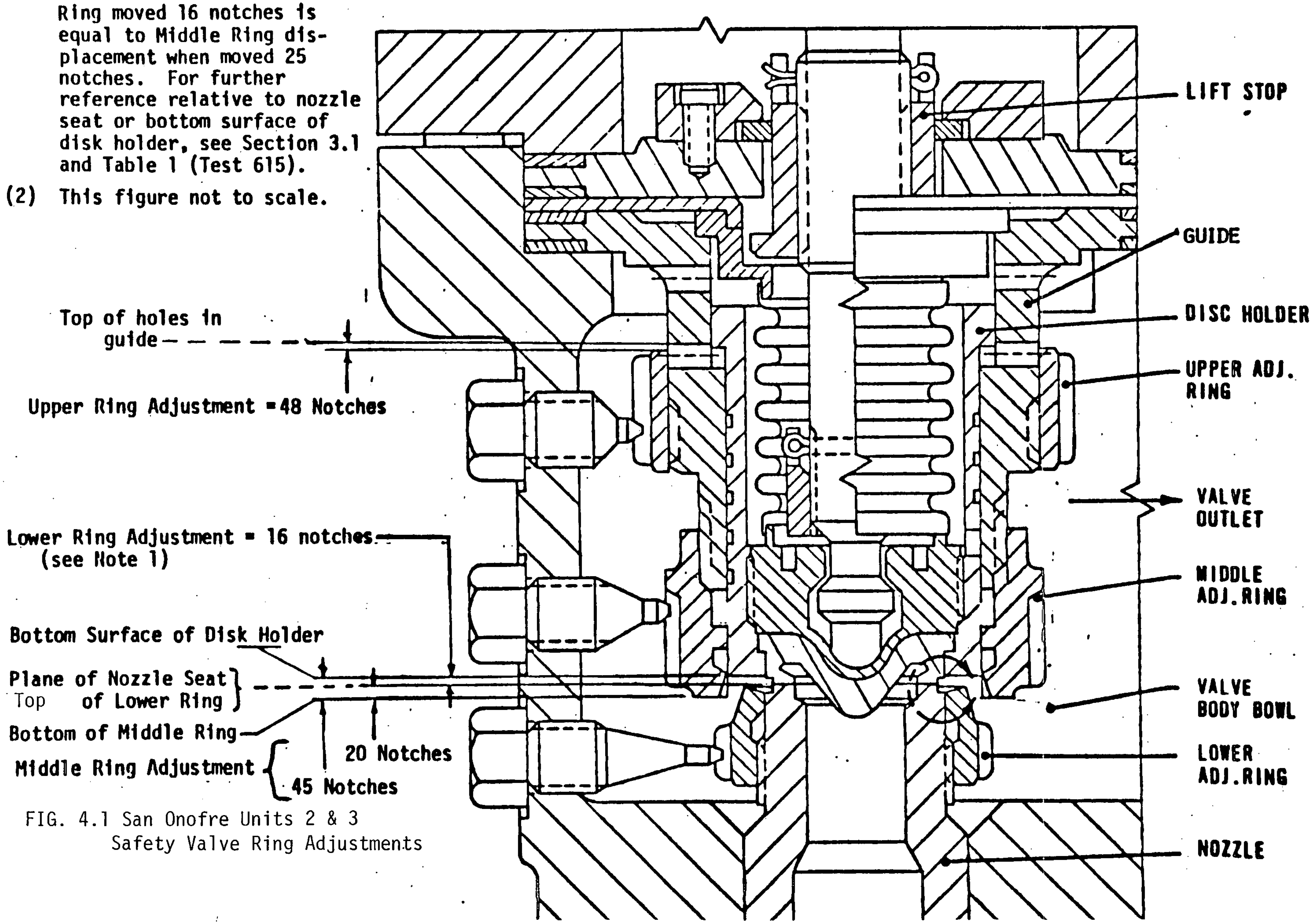
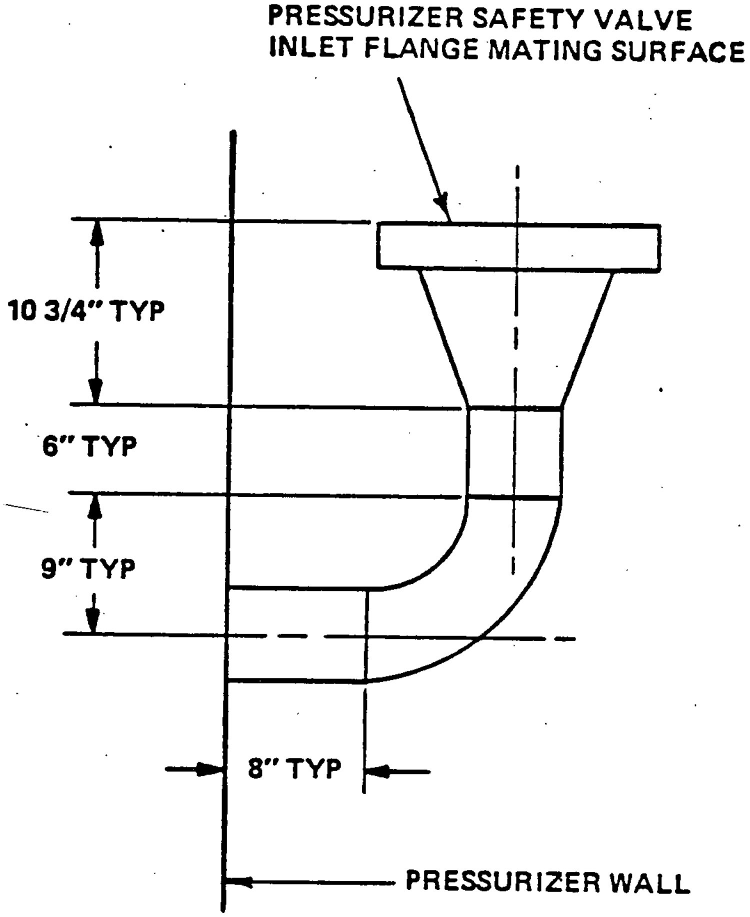


FIG. 4.1 San Onofre Units 2 & 3 Safety Valve Ring Adjustments



NOTES:

1. ALL PIPING IS 6" SCH 160
2. TOTAL LENGTH OF INLET PIPING FROM ID OF PRESSURIZER TO VALVE INLET FLANGE MATING SURFACE = 4.3 FT.

Figure 4.2

SAN ONOFRE UNITS 2 & 3 PRESSURIZER SAFETY VALVES
INLET PIPING CONFIGURATION

5.0 APPLICABILITY OF EPRI/C-E TESTS TO SAN ONOFRE UNITS 2 AND 3 VALVES

The applicability of the EPRI/C-E test results to the San Onofre Units 2 and 3 safety valves is justified below.

5.1 Valve Type

A Dresser Model 31709NA safety valve, the same valve model as used on San Onofre Units 2 and 3, was tested in the EPRI/C-E test program. Test data on the San Onofre Units 2 and 3 valve model was obtained.

5.2 Valve Adjusting Ring Settings

The current ring adjustments for the Model 31709NA San Onofre Units 2 and 3 valves (see Section 4.2) were tested in the EPRI/C-E program in Test Numbers 615, 620, 628, 630, 1305, 1308, and 1311. The results of these tests are directly applicable to the San Onofre Units 2 and 3 valves.

5.3 Inlet Piping Configuration

The EPRI/C-E valve test program showed that safety valve performance was strongly influenced by the length and configuration of the valve inlet piping. The inlet piping to the San Onofre Units 2 and 3 safety valves and to the EPRI/C-E test valve were both relatively short, but the configurations were somewhat different (see Figures 3.11 and 4.2). The San Onofre Units 2 and 3 inlet piping is 6" Schedule 160 and has a single 90° bend. The EPRI/C-E test piping was straight and contained an 8" nominal diameter Venturi and an 8" x 6" reducer. In order to show that EPRI/C-E test results on the Model 31709NA valves could be applied to San Onofre Units 2 and 3, it was necessary to demonstrate that the in-plant inlet piping transient pressure drop (at which occurs valve opening) is not greater than that

for the EPRI/C-E test configuration.

In order to demonstrate the applicability, the EPRI/C-E test inlet piping was modelled and analyzed using the PIPES computer code. Calculated inlet pressure drop vs. time was then compared with the test data from Test No. 615. The calculated pressure drop vs. time from the PIPES model was in excellent agreement with the test data, with the calculated maximum value being about 94% of the test value. These results established the validity of the PIPES analysis. The PIPES code was then used to analyze the San Onofre Units 2 and 3 safety valve inlet piping. The calculated maximum drop in pressure at the San Onofre Units 2 and 3 safety valve inlet was less than that calculated for the EPRI/C-E test configuration. This implies that safety valves with the San Onofre Units 2 and 3 inlet piping configuration would operate more stably, with less potential for chatter, when compared with operation with the EPRI/C-E test inlet configuration. Appendix B-1 describes the details of the San Onofre Units 2 and 3 and EPRI/C-E test inlet piping pressure drop analyses.

5.4 Inlet Fluid Conditions

The San Onofre Units 2 and 3 safety valves are required to lift on steam only. The specific EPRI/C-E tests on valve Model 31709NA, with the current San Onofre Units 2 and 3 ring adjustments, and with steam inlet conditions were Test Numbers 615, 620 and 1305. The range of peak pressures during these runs (2639 to 2667 psia) approximated the calculated San Onofre Units 2 and 3 peak pressure of 2760 psia (Section 4.4). The range of inlet pressure ramp rates calculated for the San Onofre Units 2 and 3 safety valves was 45 to 93 psi/sec, while the EPRI/C-E steam test pressure ramp rates had a range of 308 to 317 psi/sec. Also, an EPRI/C-E steam-water transition test (Test No. 628), with the same ring settings, was run with a low 2.5 psi/sec pressure ramp rate. This ramp rate provided a

lower bound on pressurization rate. Although the test was a steam-water transition test that in total is not applicable to San Onofre Units 2 and 3, the steam condition at the valve opening would apply. The test results, therefore, indicated that the valve stem position response during the lift on steam is not significantly affected by a full range of the pressure ramp rates (i.e., 2.5 to 317 psi/sec). Thus, the inlet fluid conditions for Test Numbers 615, 620, and 1305 were considered to be representative of the range of the calculated San Onofre Units 2 and 3 conditions.

5.5 Backpressure

Since the EPRI/C-E tests showed that the blowdown of the Dresser safety valves decreases with increased builtup backpressure, the backpressure against which the San Onofre Units 2 and 3 safety valves are required to operate governs the magnitude of the system blowdown. The builtup backpressure is a function of the flow rate and the flow resistance of the discharge piping. At a specified flow rate, the backpressure is a measure of valve discharge piping resistance. In a given discharge piping system, the backpressure is a function of the flow rate.

Although the San Onofre Units 2 and 3 safety valves have a nominal opening setpoint of 2500 psia, as a result of the $\pm1\%$ setpoint tolerance, the actual opening setpoint pressures could differ by as much as 50 psi. Therefore, it is possible that during some transients only one of the two safety valves would be challenged. The lower steam flow associated with one safety valve discharging would result in a lower builtup backpressure, and therefore a greater blowdown than when both safety valves were discharging. Even if both safety valves opened simultaneously they would not necessarily close simultaneously. For the case of staggered valve closing, when the first valve closed under a relatively high backpressure, the steam flow would decrease, causing a reduction in the backpressure against which

the second valve was discharging. As a result, the second valve would close at the lower pressure corresponding to the lower backpressure. Therefore, operation of the San Onofre Units 2 and 3 safety valves at the backpressures corresponding to one and two safety valves opening must be considered.

The expected San Onofre Units 2 and 3 safety valve backpressures for one and two safety valves discharging at rated flow are 245 psig and 427 psig respectively. The EPRI/C-E steam tests of the Dresser 31709NA valve with the current San Onofre Units 2 and 3 adjusting ring settings, (Test Numbers 615, 620, and 1305) were performed with maximum backpressures of 311 psig, 179 psig, and 330 psig, respectively. In order to determine the expected blowdowns for the San Onofre Units 2 and 3 safety valve, linear interpolation and extrapolation of the test data (Figure 3.12) was performed. From Figure 3.12, it was estimated the San Onofre Units 2 and 3 safety valve blowdowns would be approximately 10% and 5.5% for one and two safety valves discharging, respectively. Including a $\pm$2% blowdown tolerance recommended by the valve manufacturer to account for uncertainties in achieving a required blowdown, the maximum blowdowns of 12% and 7.5%, respectively, for one and two San Onofre Units 2 and 3 safety valves discharging were derived. A minimum blowdown of 3.5% was estimated for two safety valves discharging.

The acceptability of the range of expected blowdowns for the San Onofre Units 2 and 3 safety valves is discussed in Section 6.0.

5.6 Valve Discharge Flange Bending Moment

In the EPRI/C-E tests of the Dresser 31709NA safety valve, satisfactory valve operability was obtained with bending moments at the valve discharge flange as high as 473,200 inch-lbs during valve operation. In the analysis of the structural adequacy of the San Onofre Units 2 and 3 safety valve discharge

piping (Part C) the calculated maximum piping end load on the valve discharge flange was 92,080 inch-lbs. Thus, the San Onofre Units 2 and 3 safety valve discharge flange will be subjected to loadings which are less than its tested loading capability (Part C, Table 6.2-6).

6.0 ACCEPTABILITY OF SAN ONOFRE UNITS 2 AND 3 SAFETY VALVES RANGE OF EXPECTED BLOWDOWNS

6.1 High Blowdown

With the current valve ring settings for the San Onofre Units 2 and 3 safety valves, blowdowns in excess of 5% are expected. The 1974 ASME Code, to which the San Onofre Units 2 and 3 safety valves were designed and built, required that blowdown not exceed 5%. However, beginning with the Summer 1975 Addenda to the 1974 ASME Code (paragraph NB-7614.2) blowdowns in excess of 5% are permitted if appropriate justification is provided.

The concern with an extended blowdown of the San Onofre Units 2 and 3 safety valves is that the pressurizer pressure might decrease sufficiently below the pressure corresponding to the pressurizer liquid saturation temperature to cause flashing and an increase in the pressurizer two phase level. If the two-phase level reaches the elevation of the safety valve nozzles, the safety valves could discharge a steam-water mixture or water. The San Onofre Units 2 and 3 safety valves were not designed to operate with these fluid conditions.

Analyses which show that the extended blowdowns expected for the San Onofre Units 2 and 3 safety valves will not result in the pressurizer two-phase level reaching the safety valve nozzles are described in Appendix B-2. Based on these analyses, it is concluded that following valve actuation, the steam fluid conditions at the San Onofre Units 2 and 3 safety valves' inlets will be maintained, despite the extended blowdown.

6.2 Low Blowdown

Based on the extrapolation of results of the EPRI/C-E test program, it was estimated that the San Onofre Units 2 and 3 safety valves might have a blowdown as low as 3.5% (i.e., 5.5% $\pm$ 2%) due to the high backpressure when both valves operated in unison. The EPRI/C-E tests indicated that valve instability might be associated with short valve blowdowns. An evaluation used to justify that the San Onofre Units 2 and 3 safety valves would operate stably when operating in unison is given below.

A 3.5% blowdown of the San Onofre Units 2 and 3 safety valves corresponds to a valve closing pressure of 87.5 psi below the opening pressure. The analysis in Appendix B-1 shows that the maximum expected drop in pressure at the valve inlet as the valve opens is 66 psi so that valve inlet pressure remains above the valve closing pressure. Thus, the valve tends to stay open.

The argument above assumes that the maximum backpressure occurs when the transient valve inlet pressure drop is at a maximum. A further contribution to stability is expected when it is considered that, due to the extremely rapid valve opening time (<20 ms), the backpressure has not built up to its maximum value at the time the valve transient inlet pressure drop is at its maximum. (Refer to Figure 5.2 of Part C). At the time of minimum valve inlet pressure, the backpressure has not builtup to its maximum value. Hence, the effective blowdown pressure is lower, increasing the margin between minimum valve inlet pressure and effective blowdown pressure. Based on these arguments, valve instability due to the transient inlet pressure drop is not anticipated for the San Onofre Units 2 and 3 system.

7.0 SUMMARY

The preceeding sections provided a description of the EPRI/C-E Safety Valve Test Program. Tests of the Dresser Model 31709NA

safety valve and a summary of the test results were detailed. The EPRI/C-E test results were then evaluated for their applicability to the San Onofre Units 2 and 3 safety valves. Demonstration of safety valve operability was based on the following:

1. The same model safety valve as provided for San Onofre Units 2 and 3 was tested in the EPRI/C-E Safety Valve Test Program.

2. The identical safety valve adjusting ring settings used for the San Onofre Units 2 and 3 safety valves were tested.

3. Based on a combination of test data and analysis, the San Onofre Units 2 and 3 valve inlet piping configuration was shown to enhance the stability of valve operation relative to the EPRI/C-E test valve inlet configuration.

4. The range of valve inlet fluid conditions used in the testing either enveloped or were basically equivalent to the corresponding conditions estimated for the San Onofre Units 2 and 3 safety valves.

5. The maximum measured bending moment at the test valve discharge flange significantly exceeded the maximum calculated value for the San Onofre Units 2 and 3 valves.

6. The range of blowdowns expected for San Onofre Units 2 and 3 were based on the EPRI/C-E test backpressure vs. blowdown data. This range included a $\pm 2\%$ valve manufacturer's recommended tolerance and was shown to be compatible with steam inlet fluid conditions and with stable valve operation.

8.0 CONCLUSION

The EPRI/C-E test results for the Dresser 31709NA Safety valve, in conjunction with the evaluation discussed in Part B, demonstrate the satisfactory operability of the San Onofre Units 2 and 3 safety valves.

9.0 REFERENCES

1. EPRI/C-E Valve Test Facility Summary Description, Internal Combustion Engineering Report.

2. Dresser Industries Service Manual MA-NC007, Rev. 1, October 1978, Consolidated Closed Bonnet Maxflow Safety Valves Type 31700.

3. EPRI PWR Safety and Relief Valve Test Program-Test Condition Justification Report, Research Project V102, Interim Report, April 1982.

4. EPRI PWR Safety and Relief Valve Test ProgramSafety and Relief Valve Test Report, Research Project V102, Interim Report, April 1982.

5. Valve Inlet Fluid Conditions for Pressurizer Safety and Relief Valves in Combustion Engineering-Designed Plants, NP-Research Project V102-20 (Phase B), Interim Report, March 1982, prepared by Combustion Engineering, Inc. for EPRI.

PART B

Appendix B-1

Comparison of the San Onofre Units 2 and 3 Safety Valve Inlet

Piping and The EPRI/C-E Test Valve Inlet Piping

PART B

Appendix B-1

Comparison of the San Onofre Units 2 and 3 Safety Valve Inlet Piping and the EPRI/C-E Test Valve Inlet Piping

The purpose of this evaluation is to evaluate the difference, with respect to valve inlet transient pressure drop at valve opening, of the San Onofre Units 2 and 3 pressurizer safety valve inlet piping configuration and the inlet piping configuration used for the EPRI/C-E Dresser Valve Model 31709NA tests. Figures B-1-1 and B-1-3 show the inlet piping configurations for the EPRI/C-E test valve and for the San Onofre Units 2 and 3 safety valves, respectively.

The EPRI/C-E test program experimental results, generated during testing of the Dresser safety valve with a vertical inlet piping configuration, along with the PIPES[1] computer code, are used for this purpose. Test measurements are used to verify the adequacy of the analytical method.

The PIPES computer code employs the method of characteristics to solve the equations of conservation of mass, momentum, and energy. Computations of fluid conditions are made for a large number of discrete points within the piping system. The code can track the propagation of pressure waves in a complex piping network following a system perturbation such as a valve opening.

Selected test measurements from EPRI/C-E Test No. 615 are compared with the simulated results to demonstrate the validity of the analytical method. The EPRI/C-E test data provide the valve opening function necessary for the analytical simulation of the EPRI/C-E test program safety valve inlet piping and the San Onofre Units 2 and 3 safety valve inlet piping pressure transients. It is assumed that the small differences between the two piping configurations being analyzed would have negligible effects on the valve opening characteristics (which occurs over an approximate 20 millisecond period). The simulated safety valve mass flow rate is matched to the experimentally measured mass flow rate. The primary test measurement used to verify the analytical method is the valve inlet piping pressure response, since it is a dominant factor in controlling valve performance. Specifically, if the initial transient pressure drop which occurs upon actuation is less than the drop in pressure corresponding to the blowdown pressure, the propensity for stable performance is increased. It is noted that this is a conservative approach since the buildup of backpressure to its maximum value is not instantaneous, so that at the time of minimum valve inlet pressure, the valve is not subjected to the maximum backpressure. The blowdown pressure corresponding to the lower transient backpressure is lower, which tends to stabilize valve operation.

Figure B-1-2 compares the valve inlet analytical static pressure response with the experimental static pressure response for EPRI/C-E Test No. 615. A minor offset between the initiation of the valve inlet pressure ramp for the experimental and analytical data plots was provided in Figure B-1-2 for reasons of clarity.

The sudden drop in pressure occurs when the valve opens. It can be seen that the analytical and experimental pressure transients are quite similar and thus the validity of the analytical method is demonstrated. The analytical pressure response slightly underpredicts (by 11 psi) the maximum experimental transient

pressure drop. Overall, good comparison between the two pressure responses is evident and provides justification for simulating inlet piping pressure responses for other piping configurations during steam discharge.

The pressurizer safety valve inlet piping configuration for the San Onofre Units 2 and 3 is illustrated in Figure B-1-3. This configuration was evaluated with the same physical conditions (steam discharge, 317 psi/sec inlet pressurization rate, experimentally determined 6 x 8 Dresser valve stem position response) that were recorded for Test No. 615. The calculated inlet piping static pressure transient for San Onofre Units 2 and 3 and Test No. 615 experimental test results are illustrated in Figure B-1-4. For reasons of clarity, the experimental and analytical plots were offset as for Figure B-1-2. The transient pressure drop calculated for the San Onofre Units 2 and 3 safety valve inlet piping configuration is less than that calculated for the EPRI/C-E test inlet configuration. Therefore, San Onofre Units 2 and 3 safet valve inlet piping can be viewed as contributing to an increased level of stability in safety valve operation relative to the EPRI/C-E test inlet configuration. This is primarily due to the fact that the San Onofre Units 2 and 3 inlet piping is shorter than the EPRI/C-E test facility inlet piping configuration, which enables a greater pressure to be sustained at the valve inlet.

It is concluded that the San Onofre Units 2 and 3 safety valve inlet piping configuration provides a lower valve inlet transient pressure drop upon valve actuation than the EPRI/C-E test valve inlet configuration. Therefore, it is considered that the San Onofre Units 2 and 3 configuration is more favorable with respect to stable valve operation than the EPRI/C-E test configuration.

REFERENCES:

1 PIPES, "A Program for Calculating Dynamic Hydraulic Forces in Piping Systems," Trans. Am. Nucl. Soc., Pg. 300, (November 1980).

2 Research Project, V102, "EPRI PWR Safety Valve and Relief Valve Test Program," Interim Report, April 1982, Table 3.2.1.

3 Research Project V102-20, "Valve Inlet Fluid Conditions for Pressurizer Safety and Relief Valves In C-E Designed Plants," Interim Report, March 1982, Table 5-15.

Figure B-1-1

EPRI/CE TEST FACILITY INLET PIPING CONFIGURATION
FOR THE DRESSER 31709NA SAFETY VALVE

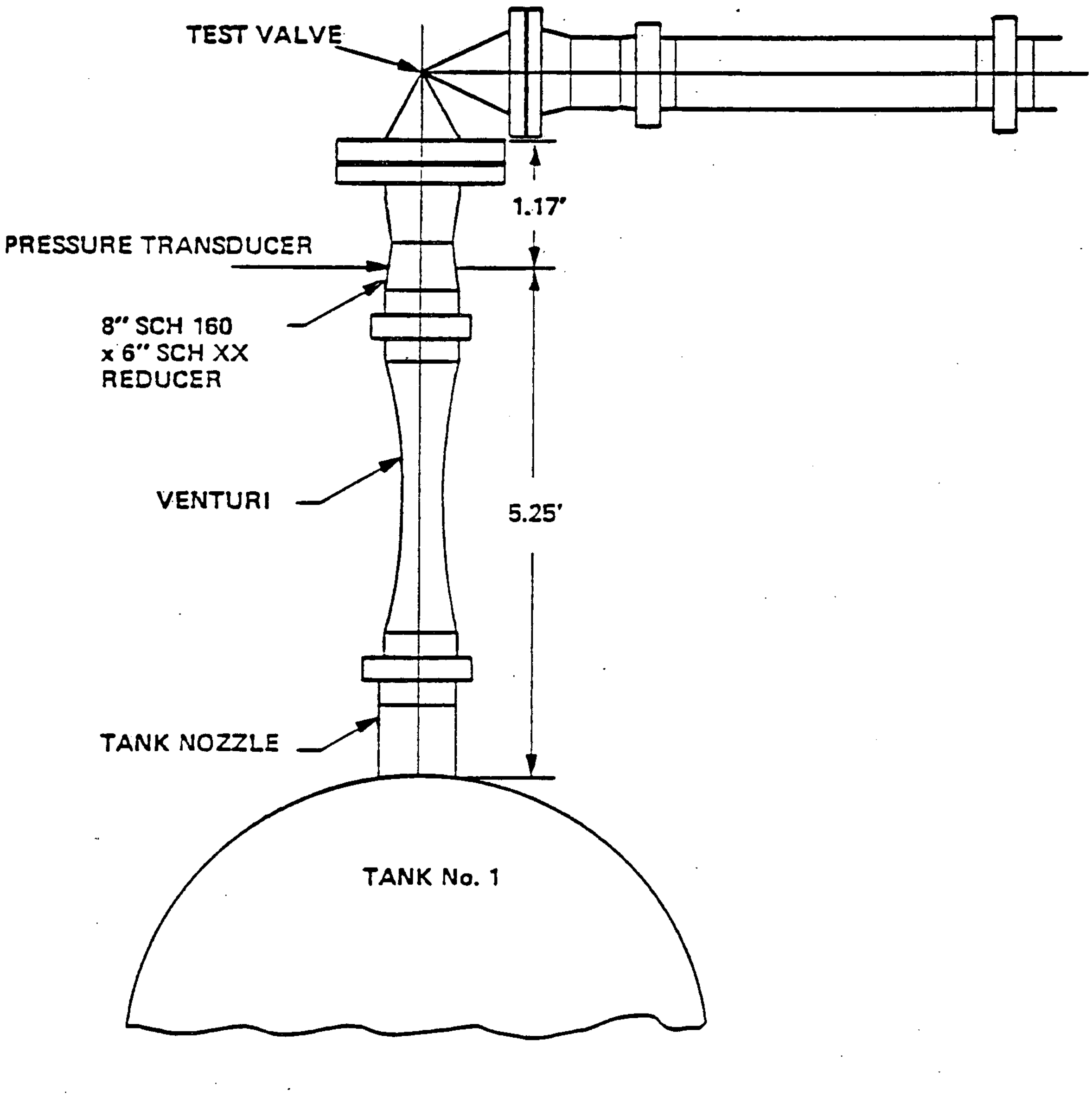
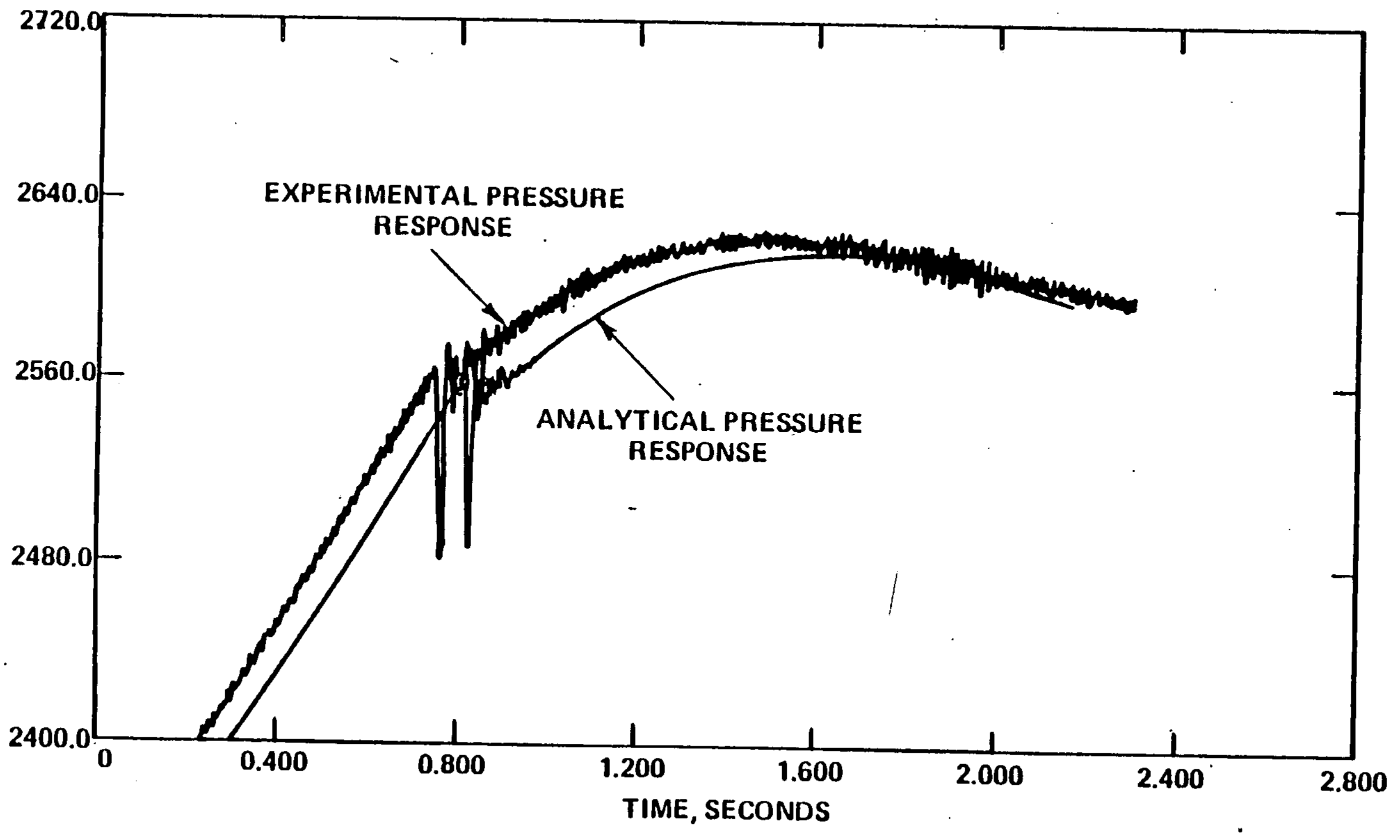
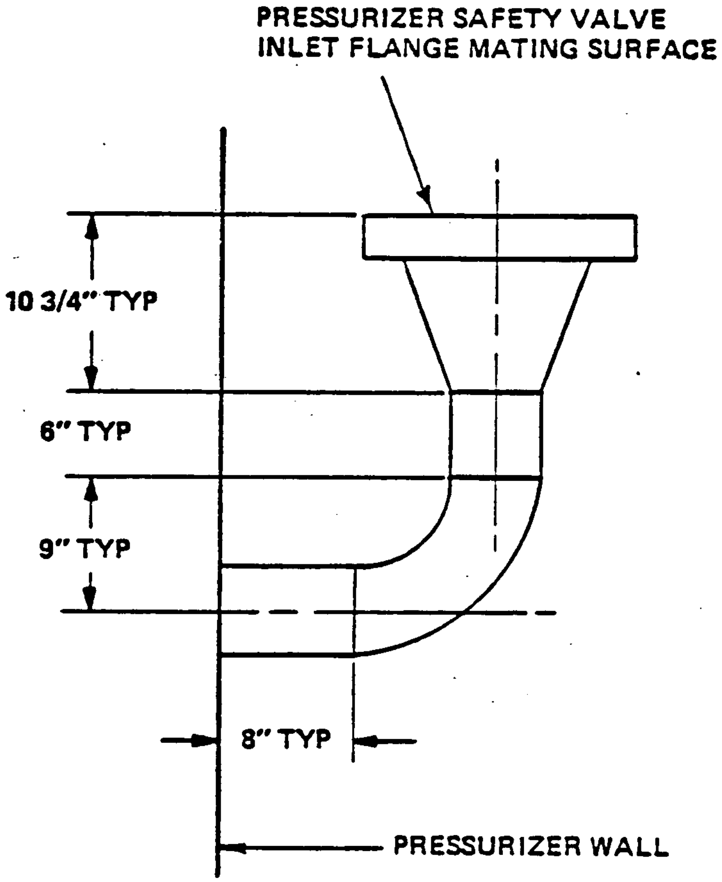


Figure B-1-2
COMPARISON OF ANALYTICAL AND EXPERIMENTAL SAFETY VALVE INLET PIPING PRESSURE TRANSIENT FOR THE EPRI/C-E TEST FACILITY





NOTES:

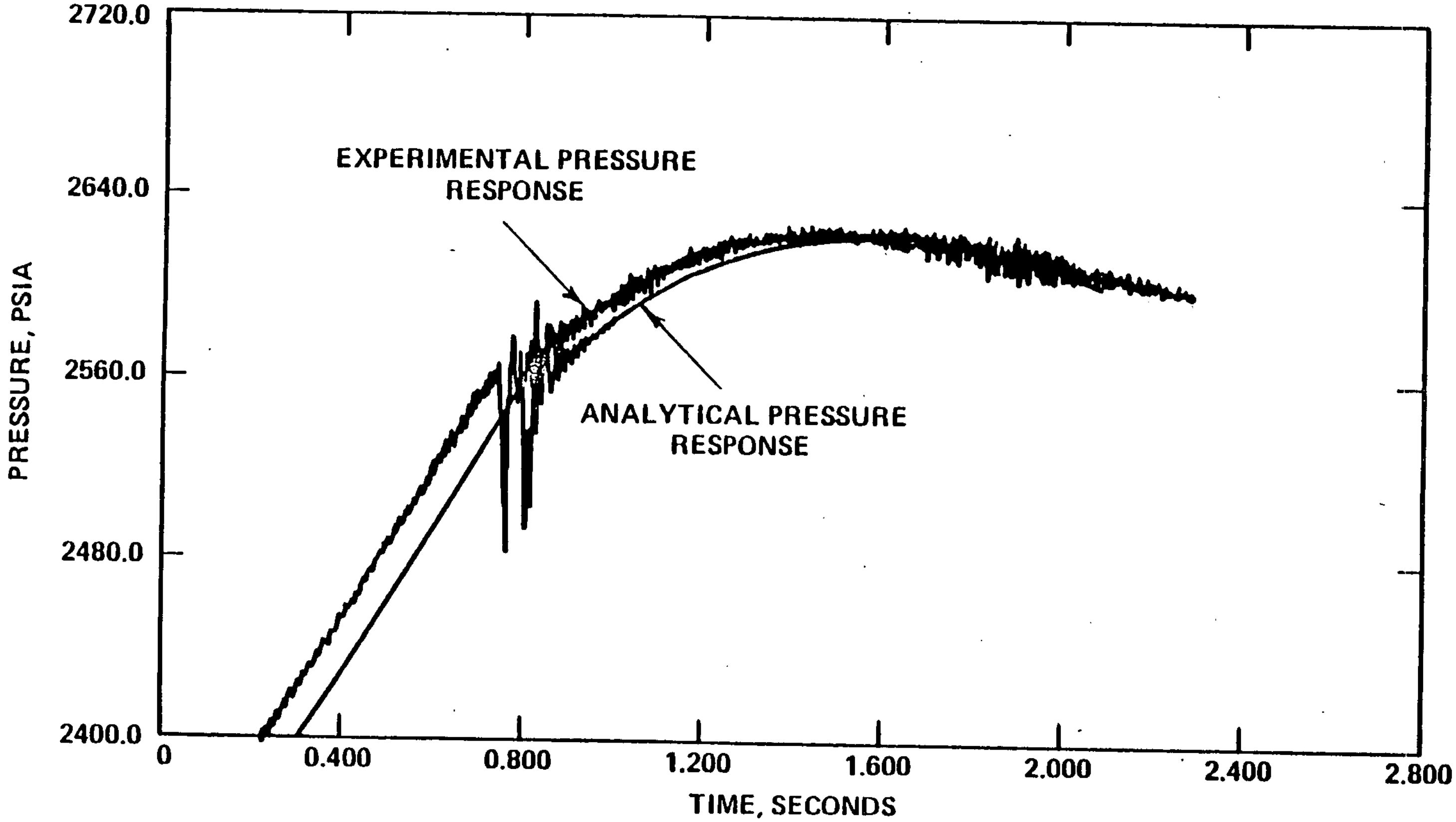
1. ALL PIPING IS 6" SCH 160
2. TOTAL LENGTH OF INLET PIPING FROM ID OF PRESSURIZER TO VALVE INLET FLANGE MATING SURFACE = 4.3 FT.

Figure B-1-3

SAN ONOFRE UNITS 2 & 3 PRESSURIZER SAFETY VALVES INLET PIPING CONFIGURATION

Figure B-1-4

COMPARISON OF ANALYTICAL INLET PIPING PRESSURE RESPONSE FOR THE SAN ONOFRE CONFIGURATION WITH THE EPRI/C-E TEST FACILITY EXPERIMENTAL RESULTS



PART B

Appendix B-2

Justification for Increased San Onofre Units 2 and 3

Safety Valve Blowdown

PART B

APPENDIX B-2

JUSTIFICATION FOR INCREASED SAN ONOFRE UNITS 2 AND 3 SAFETY VALVE BLOWDOWN

1.0 PURPOSE

The purpose of this appendix is to provide the justification for the extended blowdown of the San Onofre Units 2 and 3 safety valves(1). The safety valve ring settings(2) recommended by the valve manufacturer are expected to result in blowdown in excess of the 5% required by the 1974 ASME Code, to which the San Onofre Units 2 and 3 safety valves were designed and built. Beginning with the Summer 1975 Addenda to the 1974 ASME Code, paragraph NB-7614.2, blowdowns in excess of 5% were permitted if appropriate justification was provided.

2.0 SCOPE

The scope of this justification is limited to the pressurizer safety valves supplied to San Onofre Units 2 and 3.

3.0 ANALYSIS

3.1 Method

This analysis is to demonstrate that for the plant transient producing the highest liquid level in the pressurizer, the superimposition of a liquid level swell due to the flashing resulting from a 12% blowdown does not result in the pressurizer two-phase level reaching the safety valve nozzle elevation.

---

(1) Dresser Type 31709NA.

(2) Recommended Valve Ring Settings:

Upper Ring Position, 48 notches below top of holes in guide.

Middle Ring Position, 20 notches below nozzle seat.

Lower Ring Position, Zero notches below nozzle seat.

Of all the FSAR pressurization transients considered for San Onofre Units 2 and 3, the Feedwater Line Break (FWLB) transient (a faulted event) has been found to cause the greatest increase in pressurizer level. Therefore, this transient was selected as the basis of the study of the extended safety valve blowdown. The conservative FSAR Feedwater Line Break with Loss of Offsite Power analysis was reanalyzed using initial conditions and assumptions which would specifically tend to maximize the volume of insurge into the pressurizer. The volume increase due to level swell (resulting from flashing of saturated pressurizer liquid) as a function of the blowdown pressure was determined and added to the maximum insurge volume to determine the maximum two-phase pressurizer level. This level was compared to the elevation of the safety valve nozzles to determine whether two-phase liquid would reach the safety valve inlet.

A similar calculation was performed based on the Loss of Condenser Vacuum (LOCV) analysis in the FSAR, which is similar to (but more adverse than) the Loss of Load transient. The Loss of Load transient is a moderate frequency event, and as such, was considered as the design basis event for the sizing of the safety valves.

3.2 Assumptions

In the rerun of the Feedwater Line Break with Loss of Offsite Power analysis, the same conservative licensing assumptions used in the FSAR were applied, with the following changes in order to maximize the pressurizer two-phase level:

(a) Initial pressurizer liquid volume was increased from 800 ft^3 to 860 ft^3, the pressurizer high level alarm setpoint, to maximize the initial pressurizer liquid inventory.

(b) Initial pressurizer pressure was increased from the normal operating value (2250 psia) to 2300 psia in order to maximize the flashing in the pressurizer during the extended blowdown.

(c) The feedwater line break size was increased from 0.2 ft^2 to 0.3 ft^2 to maximize the volume of insurge into the pressurizer.

In the calculation of the pressurizer level swell due to steam bubble formation the following assumptions were made:

(d) The volume of insurge water into the pressurizer was taken as the maximum calculated value during the entire transient with no credit being taken for any outsurge prior to the closing of the safety valves.

(e) The subcooled reactor coolant insurge into the pressurizer does not mix with the saturated water initially present.

(f) The water initially in the pressurizer remains saturated and the steam bubbles that are flashed from the pressurizer liquid remain in the body of the liquid, effectively raising the liquid level. No flashed steam enters the steam space from the liquid.

For the Loss of Load analysis (considered to be conservatively represented by the more adverse Loss of Condenser Vacuum event) the maximum insurge volume was taken from the FSAR analysis of the LOCV event. In addition, the above assumptions were applied with the exception of Assumption (c), which is not applicable.

4.0 DISCUSSION OF RESULTS

The results of the Feedwater Line Break With Loss of Offsite Power Analysis indicates that a blowdown of 12% would not result in the liquid level exceeding the elevation of the safety valve nozzles. Since the maximum blowdown with two safety valves operating simultaneously is expected to be about 7 1/2% (5 1/2% + 2% tolerance), the conservative analysis indicates that liquid would not reach the valves under these conditions.

If, during the blowdown, there is a significant difference between the closing pressures of the two safety valves, then, after the first valve closes, the steam discharge rate would decrease, causing a reduction in the

backpressure against which the second valve was discharging. As a result of the reduced backpressure, the second valve blowdown could increase to 12% (10% + 2% at 245 psig backpressure), based on the EPRI/C-E valve test results.

Thus, the calculations show that, for the FWLB event, operation of the safety valve(s) against the lower backpressure corresponding to single valve discharge results in the pressurizer two-phase level not exceeding the level of the bottom of the safety valve nozzles. Considering the very conservative assumptions made with respect to mixing in the pressurizer and the disengagement of steam bubbles from within the liquid, as well as the numerous conservatisms inherent in the basic FWLB analysis in the FSAR, the potential for liquid level swell approaching the safety valve inlet is further reduced.

The conservative Loss of Condenser Vacuum analysis indicates that the pressurizer liquid level would remain below the safety valve nozzles for blowdowns up to about 15%, compared with the maximum expected blowdowns of 7 1/2% and 12% for two valve and single valve discharge, respectively. By applying these results to the less severe, moderate frequency Loss of Load Event, which is the design basis for safety valve sizing, it can be concluded that a considerable margin exists between the maximum pressurizer liquid level and the safety valve nozzle elevation for this transient.

5.0 CONCLUSIONS

The increased blowdown resulting from the safety valve ring settings specified herein will ensure steam conditions at the valve when discharging. The increased blowdown will not result in the introduction of liquid water into the valves during the design basis events considered in the plant design.

PART C - SAN ONOFRE UNITS 2 & 3 SAFETY VALVE DISCHARGE PIPING ADEQUACY

Part C - SAN ONOFRE UNITS 2 & 3 SAFETY VALVE DISCHARGE PIPING ADEQUACY

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PART C

SAN ONOFRE UNITS 2 & 3 SAFETY VALVE DISCHARGE PIPING ADEQUACY

1.0 PURPOSE

The purpose of this analysis is to review the design adequacy of San Onofre Units 2 & 3 pressurizer safety valve discharge piping using analytical methods based on the EPRI test program. The valves, discharge piping, and associated piping supports are evaluated during safety valve discharge transient operation.

The analytical method involves a two-step process:

1) Using a thermal-hydraulic code to generate the input forcing function for the piping structural analysis.

2) Perform the piping structural analysis to obtain the piping structural dynamic response solutions.

2.0 GENERAL APPROACH

The general approach used in both thermal-hydraulic and piping structural analyses is described in this Section. A brief description of the computer codes used, together with their modeling technique, is also presented.

2.1 Thermal-Hydraulic Analysis

The purpose of the thermal hydraulic analysis is to generate input forcing functions for the piping structural analysis. Each of these piping forces has three components: pressure force (PA), momentum force ($\rho V^2 A/g_c$) and wave force ($\frac{L}{g_c} \frac{dw}{dt}$). In order to calculate these component forces, the system transient thermal-hydraulic properties such as pressure (P), density (ρ), fluid flow velocity (V), and fluid mass flow rate (w) during the transient are required. The geometrical data such as pipe flow area (A) and pipe length (L) are also required. The term g_c is the

gravitation constant. Two computer codes, RELAP4 and ANSYR, are used. RELAP4 calculates the system transient response while ANSYR, a post-processor of RELAP4, calculates the force vs. time history.

RELAP4 (Reference 1) is a thermal-hydraulic code designed to perform transient analysis of nuclear power plant piping. It solves the three basic conservation equations, conservation of mass, momentum, and energy. In using RELAP4, the system is divided into volumes called control volumes. The flow paths between the control volumes are called junctions. The user identifies the system initial conditions such as pressure, temperature, quality, --- etc. at the volumes and the mass flow rate at the junctions. The code calculates the system transient response after the initiation of an upset condition. Figure 2-1 shows the RELAP4 nodalization diagram for modeling the San Onofre Units 2 & 3 pressurizer safety valve discharge piping system. It has a total of 49 volumes and 51 junctions.

ANSYR (Reference 2) is an interface computer code designed to couple RELAP4 with the structural analysis code, ANSYS, which is used in this analysis. ANSYR retrieves relevant data from RELAP4 to calculate pressure force (PA), momentum force ($\rho V^2 A/g_c$) and wave force ($\frac{L}{g_c} \frac{dw}{dt}$) at specified structural support locations. The output force from ANSYR is the sum of the above three component forces referencing the Cartesian global coordinates. Also, the output format is compatible with the input requirements of the ANSYS structural analysis code.

In this analysis, one structural node is used at each reducer, tee, and nozzle while two structural nodes are used at each elbow. One node is used at the beginning of the elbow and the other node at the downstream end of the elbow. A total of 31 structural nodes are used as shown in Figure 2.1.

RELAP4 Code has been assessed in the EPRI report (Reference 3) as applicable to safety valve discharge piping with saturated steam, which is the case for San Onofre Units 2 & 3 safety valve discharge. The RELAP4/ANSYR package was also used to model the EPRI safety valve dis-

charge sample case. Comparisons between calculated results obtained from RELAP4 and those obtained from RELAP5 using the EPRI sample case showed favorable agreement. Details of this comparison are presented in Section 5.

2.2 Piping Structural Analysis

In order to evaluate the dynamic response of San Onofre Nuclear Units 2 & 3 safety valve discharge piping due to the transient discharge forces, a three dimensional finite element beam model was developed. Time-history analysis using the step-by-step direct integration procedure was performed using the ANSYS code (Reference 4). The reduced linear dynamic analysis version of ANSYS was used. Lumped masses were located at carefully selected master degrees of freedom in order to adequately represent the dynamic behavior of the system. In general, the master degrees of freedom in the axial direction along the pipe run are kept to a minimum, since the axial movements of the masses are restrained by the axial rigidity of the pipe. Also, the axial degree of freedom is released if the axial direction movement is directly restrained by an anchor. If a nodal point is near a restraint, the master degree of freedom in the direction of the restraint can also be released.

The time varying forcing functions, representing the safety valve discharge forces as described in the previous section were applied at locations of direction or area changes-typically at the begining and end of elbows, Tee intersection points and at reducers. Such locations are illustrated schematically in figure 6.2-3.

A description of the analytical method of solving the governing equations is presented in Reference 4.

Results of the piping structural analysis are presented in section 6.2.

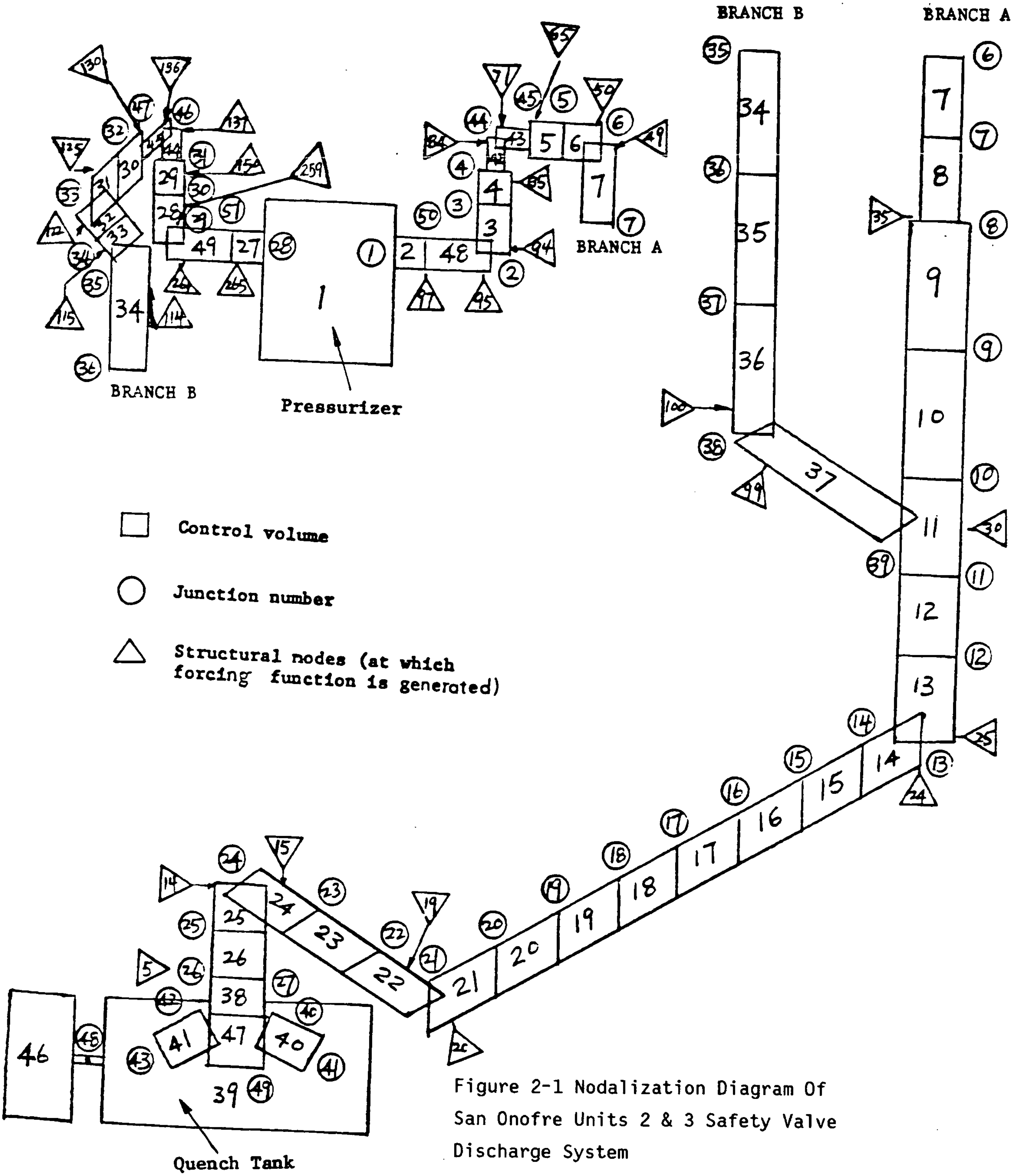


Figure 2-1 Nodalization Diagram Of San Onofre Units 2 & 3 Safety Valve Discharge System

3.0 EPRI TEST PROGRAM

One objective of the EPRI/CE test program was to obtain test data suitable to verify analytical models used to evaluate discharge piping systems. Full flow tests of selected valves were performed under a wide range of fluid conditions. Each test was to demonstrate the operability of the valves as well as obtain data such as valve capacity and fluid flow reaction force. The valve types tested included essentially all generic safety valve types used by power plant designers and included models supplied by each of the major safety valve suppliers. The piping configuration used in the tests are described in Reference 6.

3.1 Inlet piping: Two inlet piping configurations were used - one representing a short vertical inlet pipe and one representing a piping loop seal configuration.

3.2 Outlet piping: A four-segment piping in a vertical plane was used. Pipes and fittings used are typical of those used in PWR plants. Figure 3.1 and 3.2 depicts the test configuration used in Reference 6.

3.3 Pipe supports: Extremely rigid support structures were designed for the test valve stand and the test valve discharge piping to limit the peak dynamic response to 1.1 of the hydraulic forcing function peak value. In addition to the test valve stand, the discharge pipe was supported at the second discharge elbow, midway between the second and the third discharge elbows, and at the third discharge elbow. The piping support structures at the second and third discharge elbows are shown in Figures 3.3 and 3.4 respectively. At the second discharge elbow the pipe is restrained in both the horizontal and vertical directions. The structure midway between the second and third discharge elbows includes hydraulic snubbers and is installed to restrict the out-of-plane vibrations of this relatively long section of piping. The third elbow support allows for free in-plane horizontal motion but is rigid vertically.

Upstream fluid conditions include single phase steam (representing the normal design condition and the majority of postulated plant transient and accidents), single-phase sub-cooled water, and a transition flow test in which the test valve opens and discharge steam followed by a transition to subcooled water flow. Strain gages, load cells and displacement transducers are used for measurement of valve and piping reaction forces.

Only EPRI tests using saturated steam followed by steam discharge are related to San Onofre Units 2 & 3 safety valve discharge piping. See Section 5 for a discussion of applicability of EPRI tests to San Onofre Units 2 & 3 safety valve discharge piping.

Note: This isometric depicts the EPRI Test Facility configuration used to obtain discharge pipe response data. There is no U bend (liquid loop seal) in San Onofre Units 2 & 3 Pressurizer Safety valve piping arragnement.

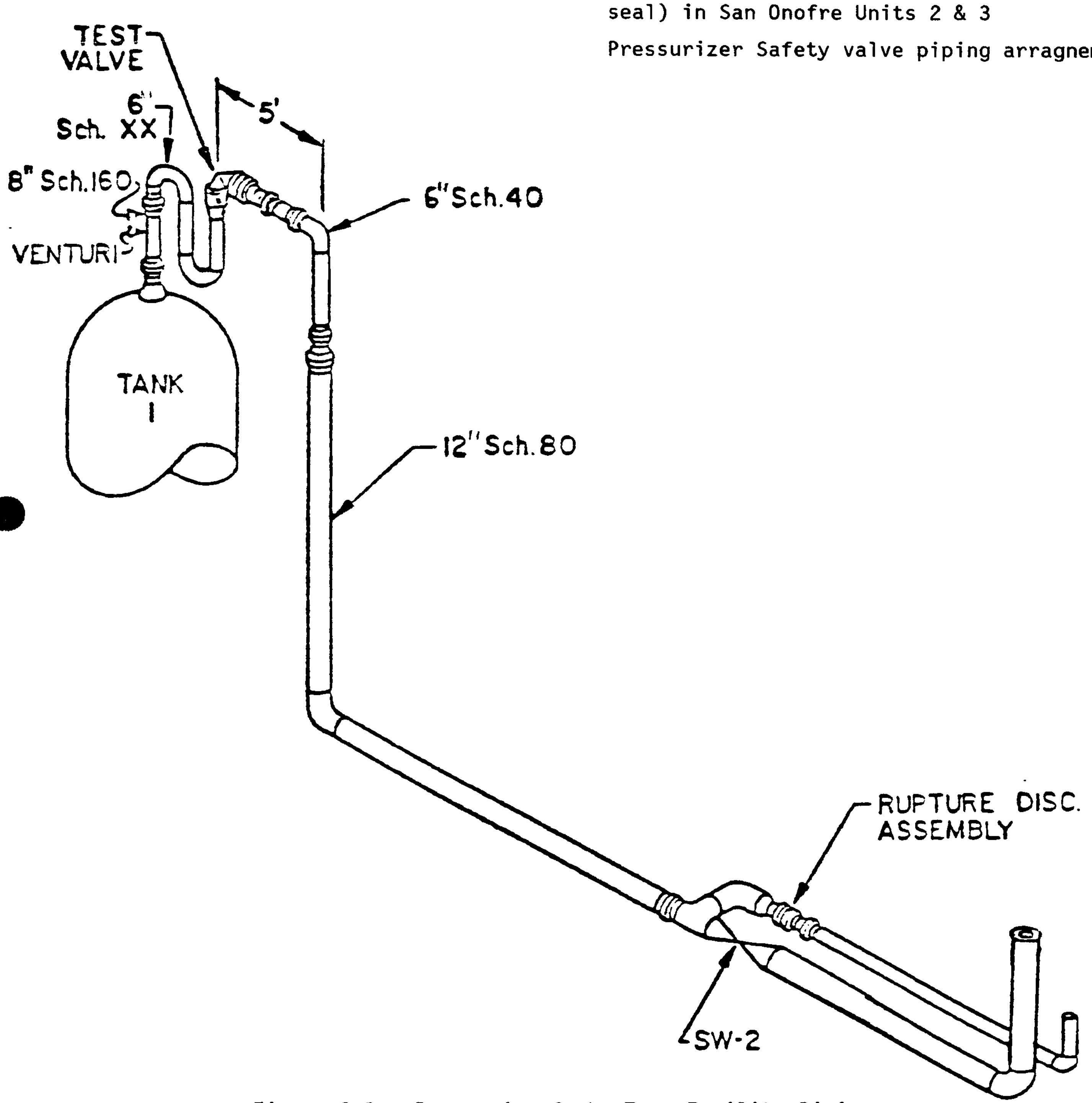


Figure 3-1. Isometric of the Test Facility Piping
(See above note)

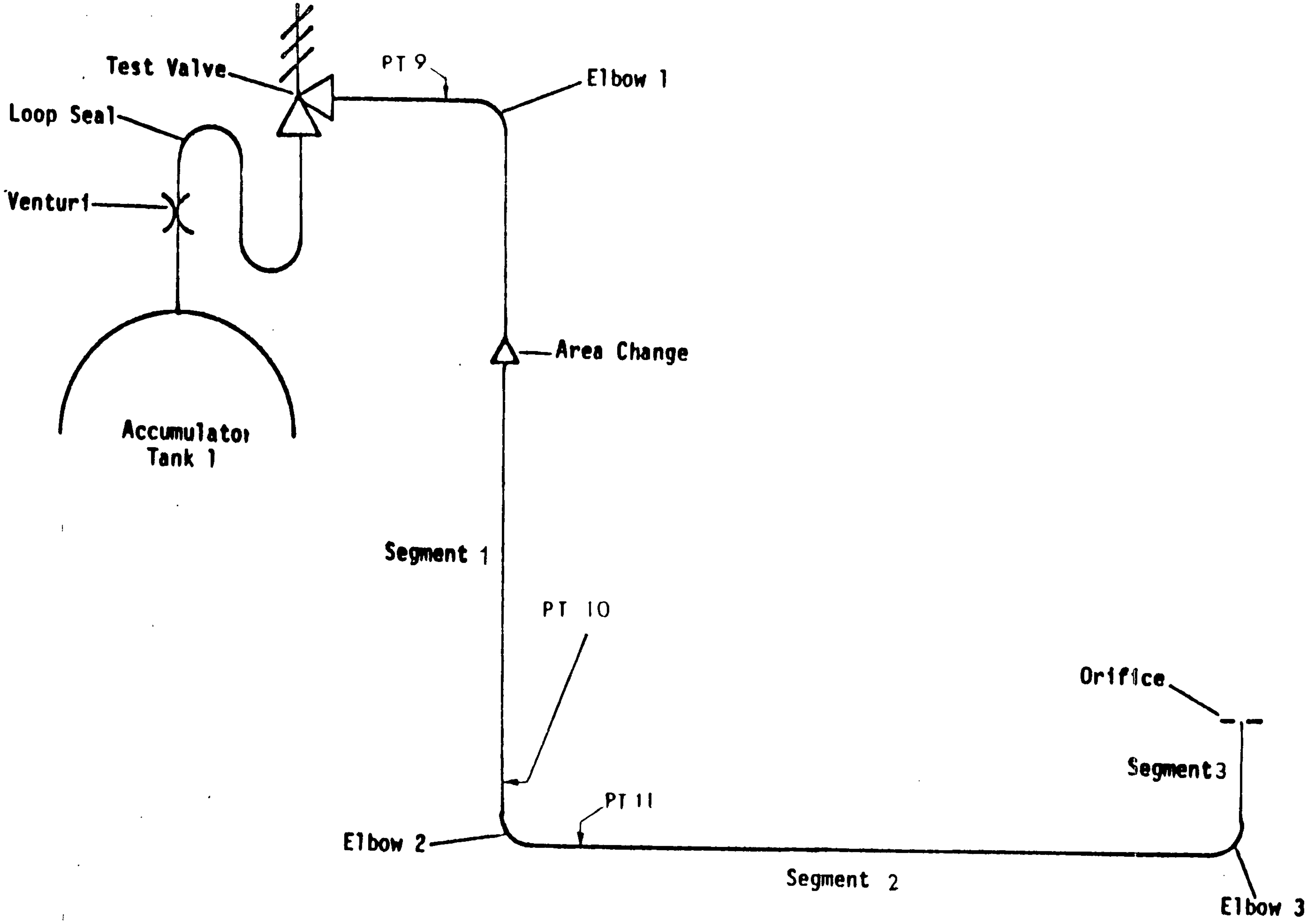


Figure 3-2 Simplified Schematic of the C-E Test Facility

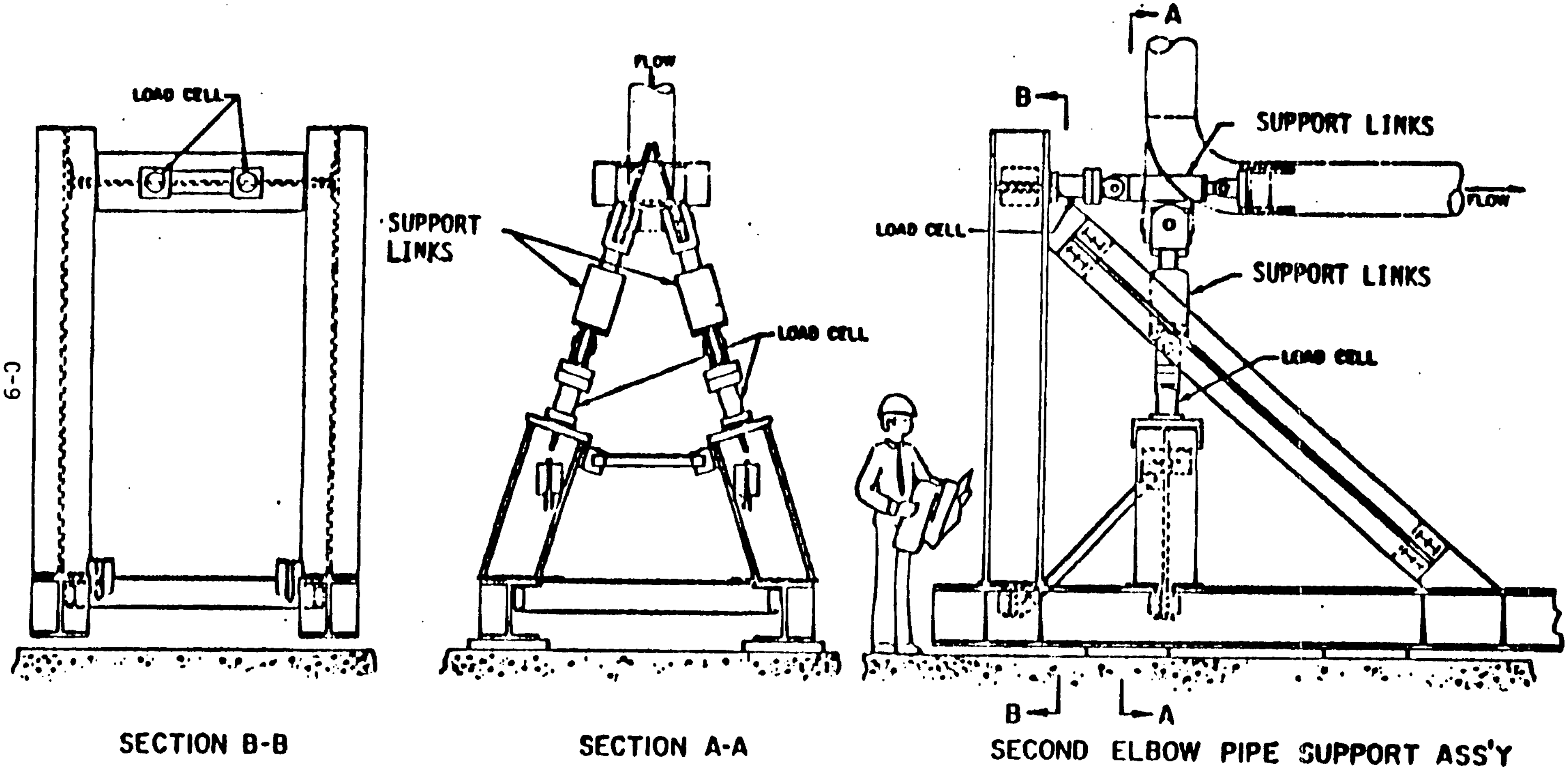
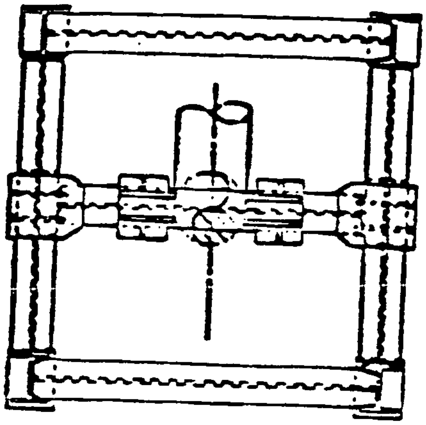


Figure 3-3 Diagram of the Second Elbow Pipe upport Assembly



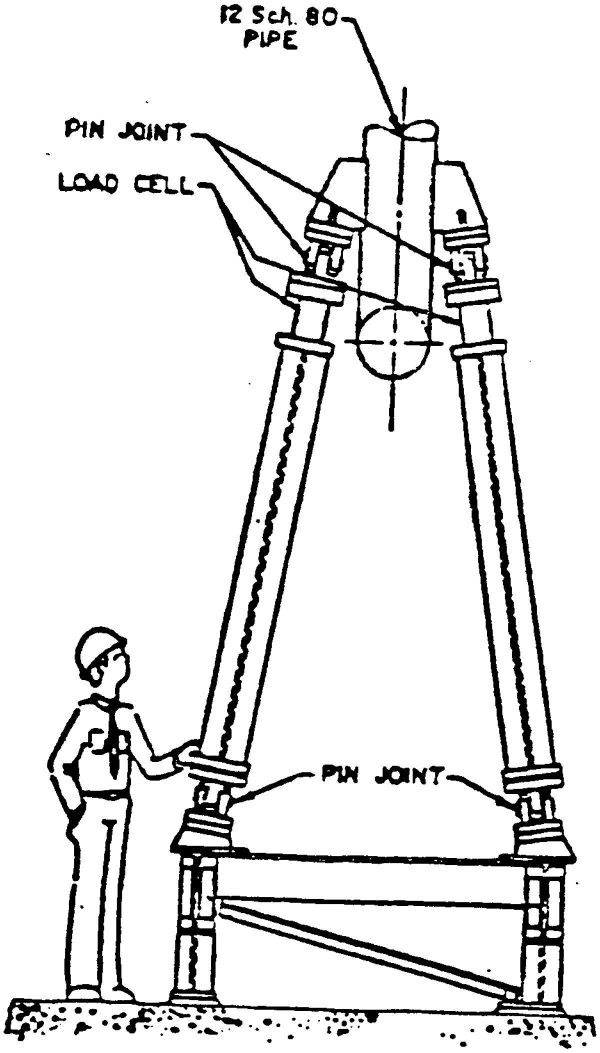


Figure 3-4. Diagram of the Third Elbow Pipe Support Assembly

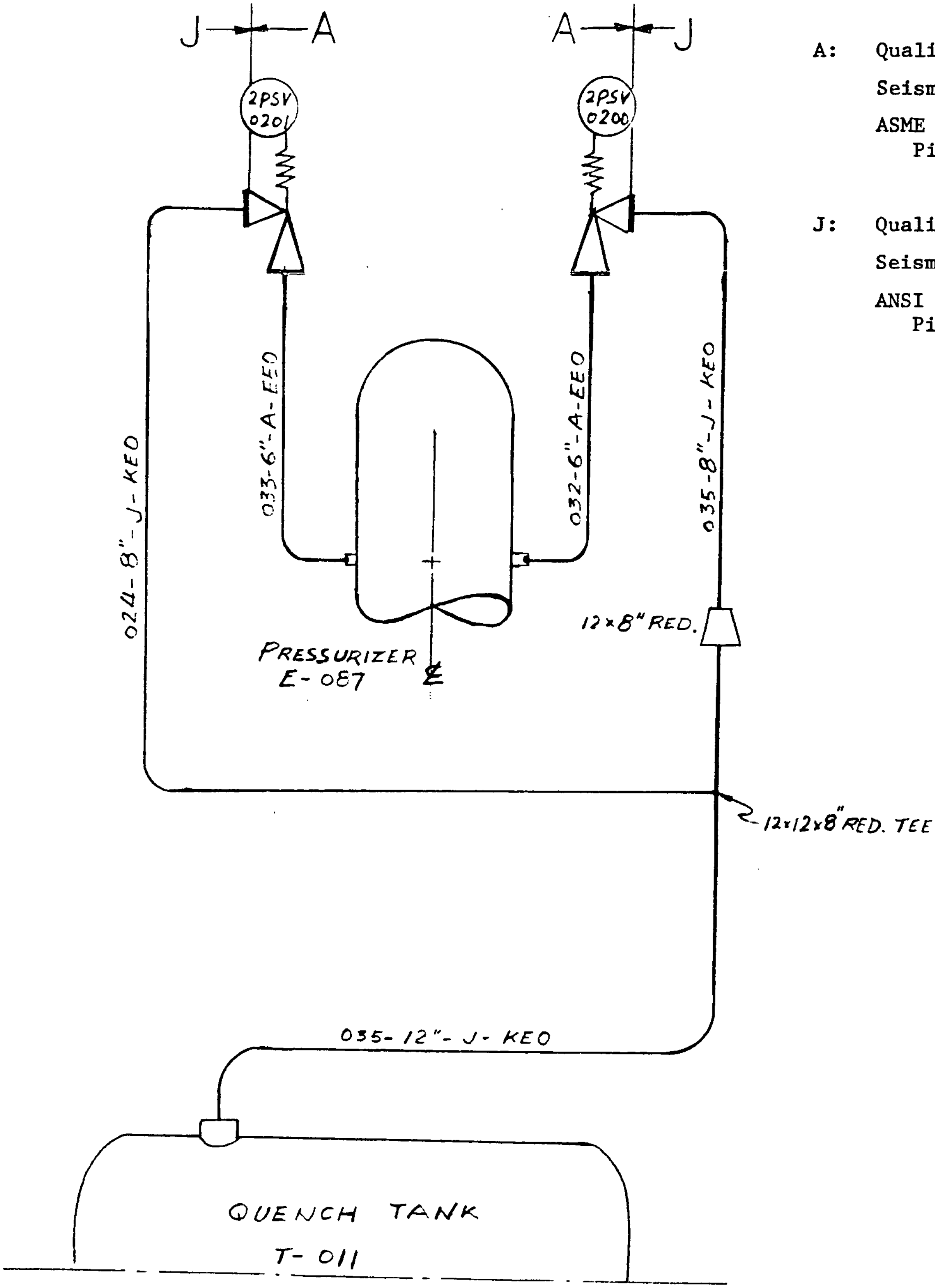
4.0 SAN ONOFRE UNITS 2 & 3 SAFETY VALVE DISCHARGE PIPING ARRANGEMENT

4.1 Physical Description

The pressurizer safety valve discharge piping system extends from the pressurizer safety valve to the quench tank steam inlet nozzle. Each pressurizer safety valve is independently connected to pressurizer nozzle at the top head of the pressurizer through separate 6-inch schedule 160 lines. The discharge pipe from each safety valve is an 8 inch schedule 20 line. The discharge pipe from each valve combine further downstream at a 12 x 12 x 8-inch butt-welding reducing tee into a 12-inch schedule 20 line which continues to the quench tank. The safety valve discharge piping system is Quality Class III, Seismic Category II, non-safety related piping. A schematic diagram showing jurisdictional boundaries of the pressurizer safety valve discharge system is presented in Figure 4-1. The detailed stress isometrics with the piping supports are shown in Figures 4-2 thru 4-5.

4.2 Function of System

The function of the safety valve is to provide overpressure protection and transient pressure control of the pressurizer in the Reactor Coolant System (RCS). The two pressurizer safety valves, as well as the quench tank, are designed to accommodate the full capacity of the discharge of the pressurizer safety valves.



A: Quality Class I, Seismic Category I, ASME Class 1 Piping

J: Quality Class III Seismic Category II ANSI B31.1 Piping

Figure 4-1. Schematic of Jurisdictional Boundaries of Pressurizer Relief System for San Onofre Units 2 and 3

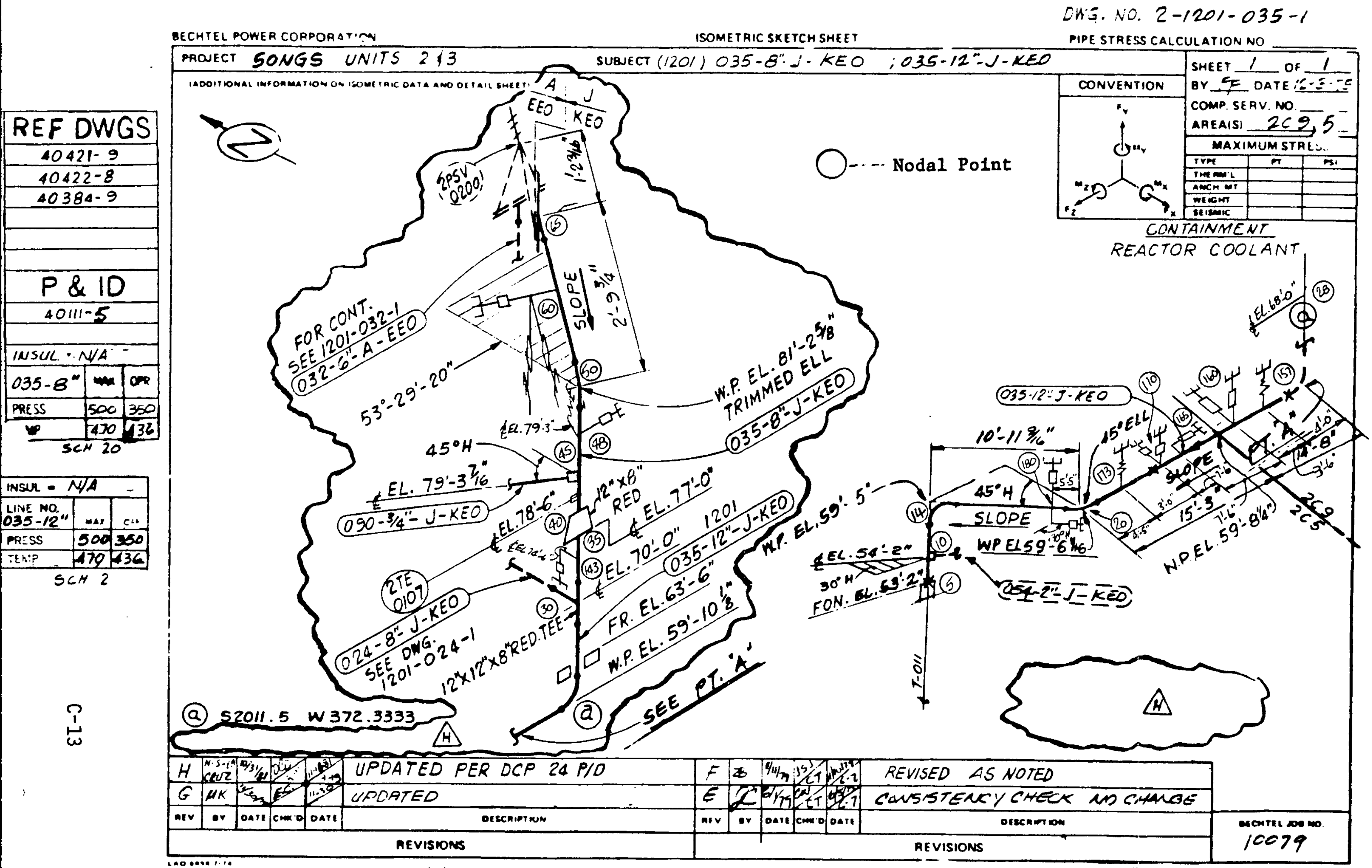


Figure 4-2 San Onofre Units 2 & 3 Pressurizer Safety Relief Piping Layout Drawing

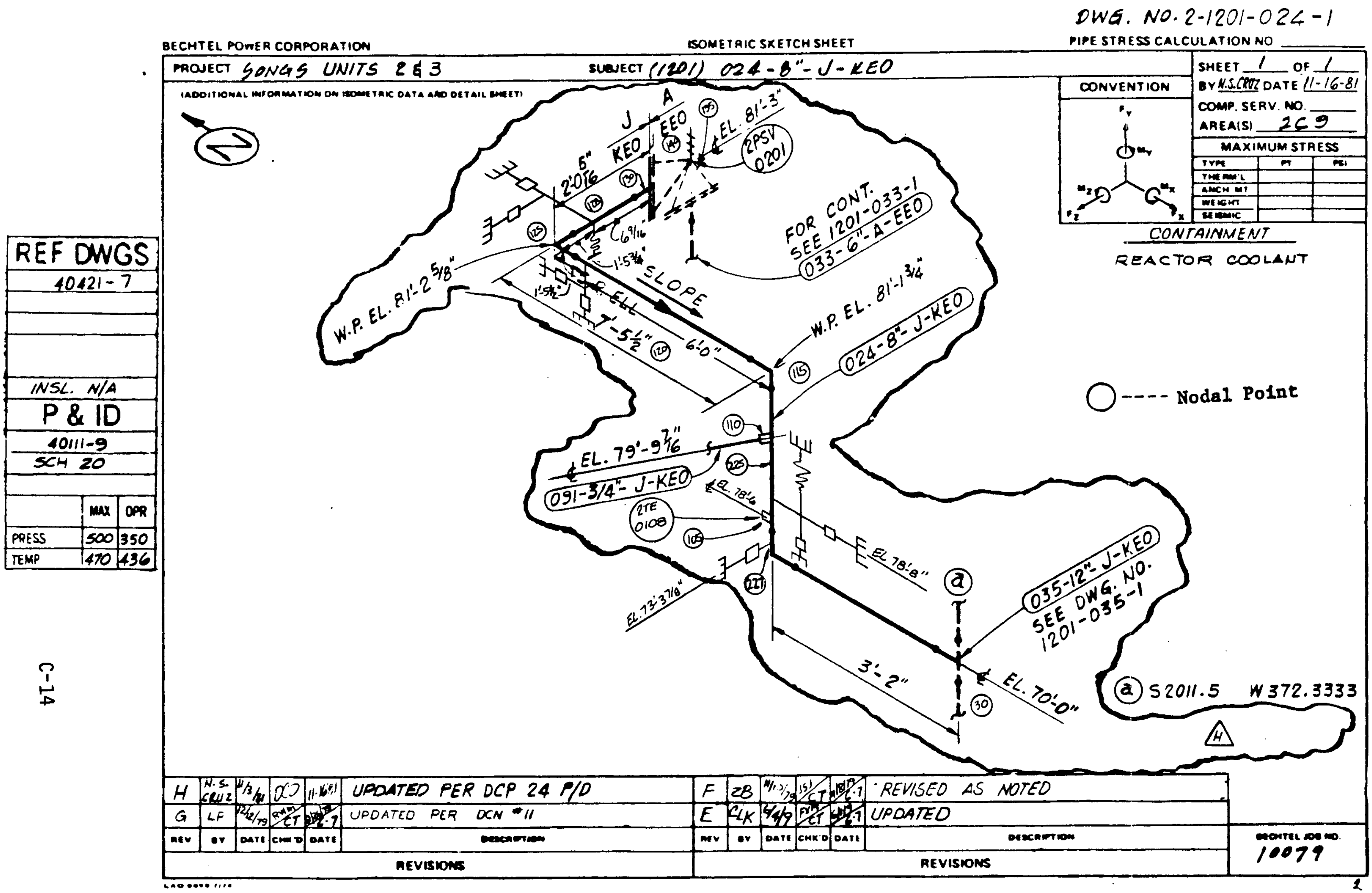


Figure 4-3 San Onofre Units 2 & 3 Pressurizer Safety Relief Piping Layout Drawing

DWG. NO.-2-1201-033-1

BECHTEL POWER CORPORATION — ISOMETRIC SKETCH SHEET — PIPE STRESS CALCULATION NO. ______

PROJECT SONGS UNITS 2 & 3 — SUBJECT (1201) 033-6"-A-EEO

(ADDITIONAL INFORMATION ON ISOMETRIC DATA AND DETAIL SHEET)

SHEET	1 OF 1
BY	N.S. CRUZ
DATE	11/16/81
COMP. SERV. NO.	
AREA(S)	2C9

CONVENTION

MAXIMUM STRESS

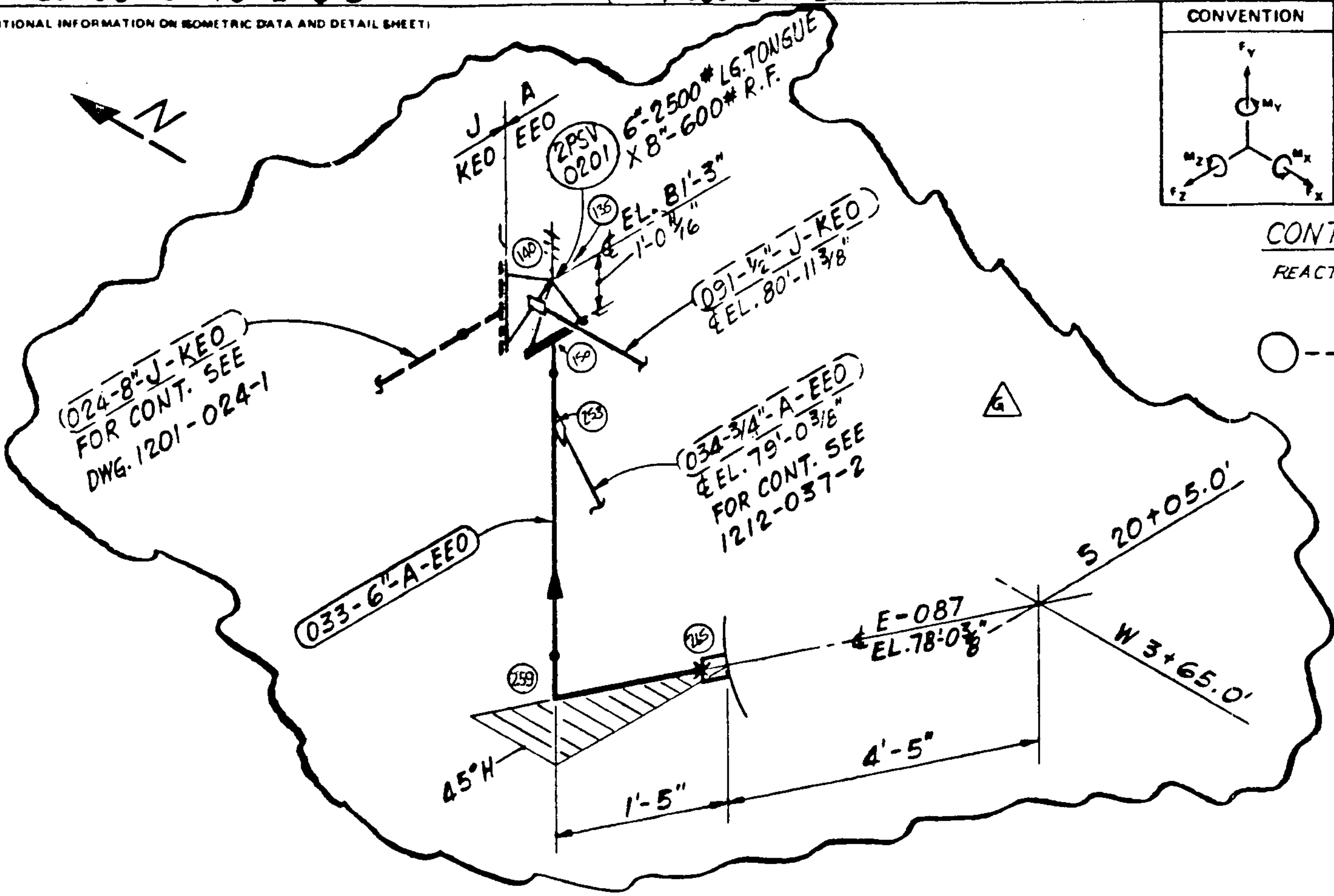
TYPE	P1	PSI
THERM'L		
ANCH MT		
WEIGHT		
SEISMIC		

CONTAINMENT

REACTOR COOLANT

◯ ---Nodal Point

REF DWGS		
40421-7		
P & ID		
40111-9		
SCH 160		
INSUL = 4.5 CHC		
	[illegible]	[illegible]
PRESS	2485	2235
TEMP	700	653



REV.	BY	DATE	CHK'D	DATE	DESCRIPTION
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B	S.S.	[illegible]	FMF/CT	[illegible]	UPDATED
A	PAM	5/21/79	FMF/CT	[illegible]	UPDATED
0	LP	11/10/78	MN	[illegible]	ISSUED FOR STRESS

REVISIONS

BECHTEL JOB NO. 10079-003

Figure 4-4 San Onofre Units 2 & 3 Pressurizer Safety Relief Piping Layout Drawing

DWG. NO. -2-1201-032-1

BECHTEL POWER CORPORATION — ISOMETRIC SKETCH SHEET — PIPE STRESS CALCULATION NO. ______

PROJECT SONGS UNITS 2 & 3 — SUBJECT (1201).032-6"-A-EEO

(ADDITIONAL INFORMATION ON ISOMETRIC DATA AND DETAIL SHEET)

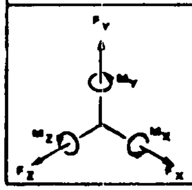
SHEET	1 OF 1
BY	H.S. CRUZ DATE 11-16-81
COMP. SERV. NO.	
AREA(S)	209

REF DWGS
40421-7
P & ID
40111-9
INSUL-4.5 CHC

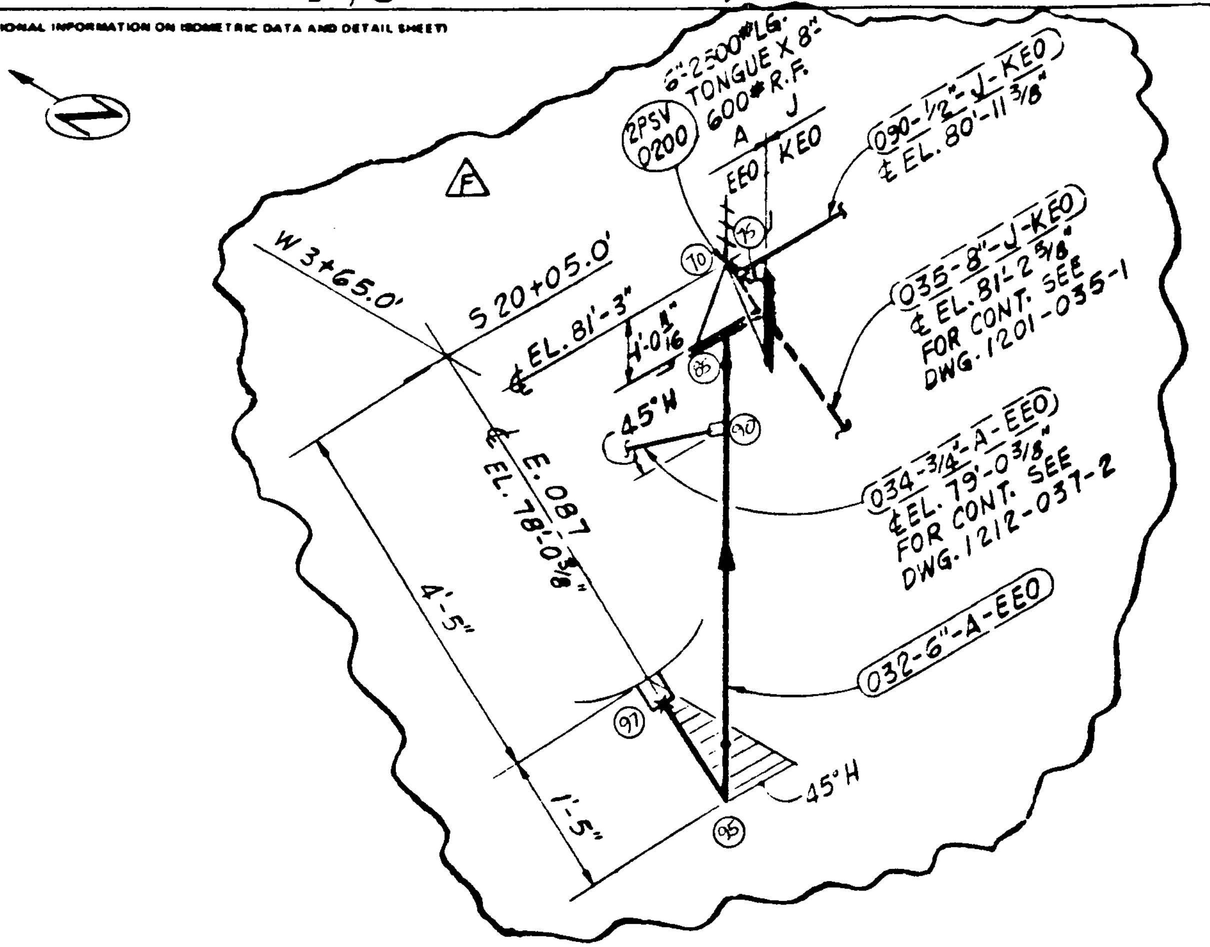
	MAX	OPR
PRESS	2485	2235
TEMP	700	653

MAXIMUM STRESS		
TYPE	PT	PSI
THERM'L		
ANCH. MT		
WEIGHT		
SEISMIC		

CONVENTION



CONTAINMENT
REACTOR COOLANT



○ - - - Nodal Point

CHECK AGAINST UNITS 2

REV	BY	DATE	CHK'D	DATE	DESCRIPTION	REV	BY	DATE	CHK'D	DATE	DESCRIPTION
D	EF	7-9 3-21			CONSISTENCY CHECK (NO CHANGE)	F	H.S. CRUZ	11-11-81	DCD		UPDATED PER DCP 24 P/D
C	LP	11/10/78	MN	11/12/78	UPDATED	E	S.S.				UPDATED
REVISIONS						REVISIONS					

BECHTEL JOB N 10079-003

C-16

19

Figure 4-5 San Onofre Units 2 & 3 Pressurizer Safety Relief Piping Layout Drawing

5.0 APPLICABILITY OF EPRI TESTS TO SAN ONOFRE UNITS 2 & 3 SAFETY VALVE DISCHARGE PIPE MODELING

One of the objectives of the EPRI tests included the verification of the RELAP5 (Reference 5) computer code by comparing analytical results with test data using benchmark problems. The tests were conducted using the following fluid conditions:

1. Steam only

2. Steam with Loop seal

3. Saturated liquid

4. Transition: Steam to saturated liquid.

Most of the test cases performed by EPRI utilized long inlet configuration piping with either Crosby 3K6 or 6M6 valves. Of these tests, five were selected for RELAP5/MOD1 verification (Reference 6). These five sample cases utilized different fluid conditions including steam discharge (Test 1411), hot water loop seal discharge (Test 917), cold water loop seal discharge (Test 908 & Test 1017), and water discharge (Test 1027). In all cases, it was demonstrated that RELAP5/MOD1 satisfactorily predicted discharge piping support loads observed during the testing. It has been concluded that RELAP5/MOD1 is a suitable tool for the prediction of discharge piping hydrodynamic loads in pressurizer safety valve discharge piping system.

RELAP4/ANSYR was used for the thermal-hydraulic analysis of the San Onofre Units 2 & 3 safety valve piping system. RELAP4/ANSYR has been determined applicable for safety valve analysis (Reference 3). Additional verification using the EPRI tests further confirms its applicability. For San Onofre Units 2 & 3, the valve inlet piping is

less than 4 feet long and does not contain the U-bend (liquid loop seal). The fluid condition is steam only. The fluid flow transients through the valve for the EPRI sample case, Test 1411, also includes steam only. Therefore, comparisons are made between the calculations obtained from RELAP5/MOD1 and RELAP4/ANSYR using the EPRI sample case, Test 1411.

5.1 Comparison of RELAP4/ANSYR and RELAP5/MOD1

The schematic diagram of the EPRI test facility is shown in Figure 3-2. The corresponding isometric drawing is shown in Figure 3-1. The test facility consists of an accumulator tank, U-bend, safety valve and discharge piping. Initially, the safety valve is closed. When the valve set pressure is reached, the valve opens and discharges the fluid upstream of the valve into the atmosphere through the discharge piping.

Figure 5-1 shows the RELAP4 nodalization diagram used to model the test facility. It consists of 33 volumes and 33 junctions.

To simulate the condition of Test 1411 closely, RELAP4 follows the same modeling approach used in RELAP5. These conditions are as follows:

1) In the test, the accumulator pressure was ramped from 2410 psia at t=0.0 seconds to 2540 psia at t=0.5 seconds. This pressure ramp was modeled both in RELAP5 and RELAP4.

2) The valve flow area was reduced to 88% of the manufacturer's stated flow area (i.e. 0.0232x0.88=0.0204 ft^2). This achieved the measured steady-state flow rate in the RELAP5 calculation. In the RELAP4 calculation, the reduced area yielded a valve flow rate of $119^{lbm}/sec$ which is close to the test data, $116^{lbm}/sec$.

3) On the test facility, the fluid condition downstream of the valve prior to valve opening shows the fluid temperature at 212°F, indicating valve leakage prior to the transient. Accordingly, it was assumed that the discharge pipe initially contained steam. Since its quality cannot be determined from experimental tests, a wet steam with quality of 0.9 was used in both RELAP5 and RELAP4 modeling.

4) For the steam only discharge test, the valve opening characteristic has a major effect on the resultant loads generated on the downstream pipe segments. Therefore, it was necessary to accurately represent the valve opening characteristic in the calculation. A linearly valve opening characteristic over 20 milliseconds was used in both RELAP5 and RELAP4 calculation. The valve set pressure was 2410 psia. The valve is actuated to open at the initiation of the transient calculation.

Figures 5-2 thru 5-7 show the comparisons of calculated results between RELAP5 and RELAP4. Figures 5-2, 5-3 and 5-4 are the system pressure comparisons at measurement locations P9, P10 and P11 as shown in Figure 3-2. It can be seen that all results at measurement locations indicate acceptable agreement between RELAP5 and RELAP4.

Figures 5-5 thru 5-7 show the forcing function comparisons at segment 1, 2 and 3 respectively in the discharge piping. It shows RELAP5/MOD1 and RELAP4/ANSYR have the same trend in the force vs. time history. With respect to magnitude, RELAP4/ANSYR yields more conservative results than RELAP5/MOD1.

5.2 Summary of the Comparision Results

The following conclusions are drawn from the verification comparison discussed above:

1) The system pressure comparison shows acceptable agreement between RELAP4 and RELAP5.

2) The force vs. time-history obtained from RELAP4/ANSYR package follows the same trend as that shown for RELAP5/MOD1.

3) The forcing function obtained from RELAP4/ANSYR is more conservative than that of RELAP5/MOD1.

These conclusions confirm the applicablilty of RELAP4/ANSYR package for use in modeling the San Onofre Units 2 & 3 safety valve discharge piping system.

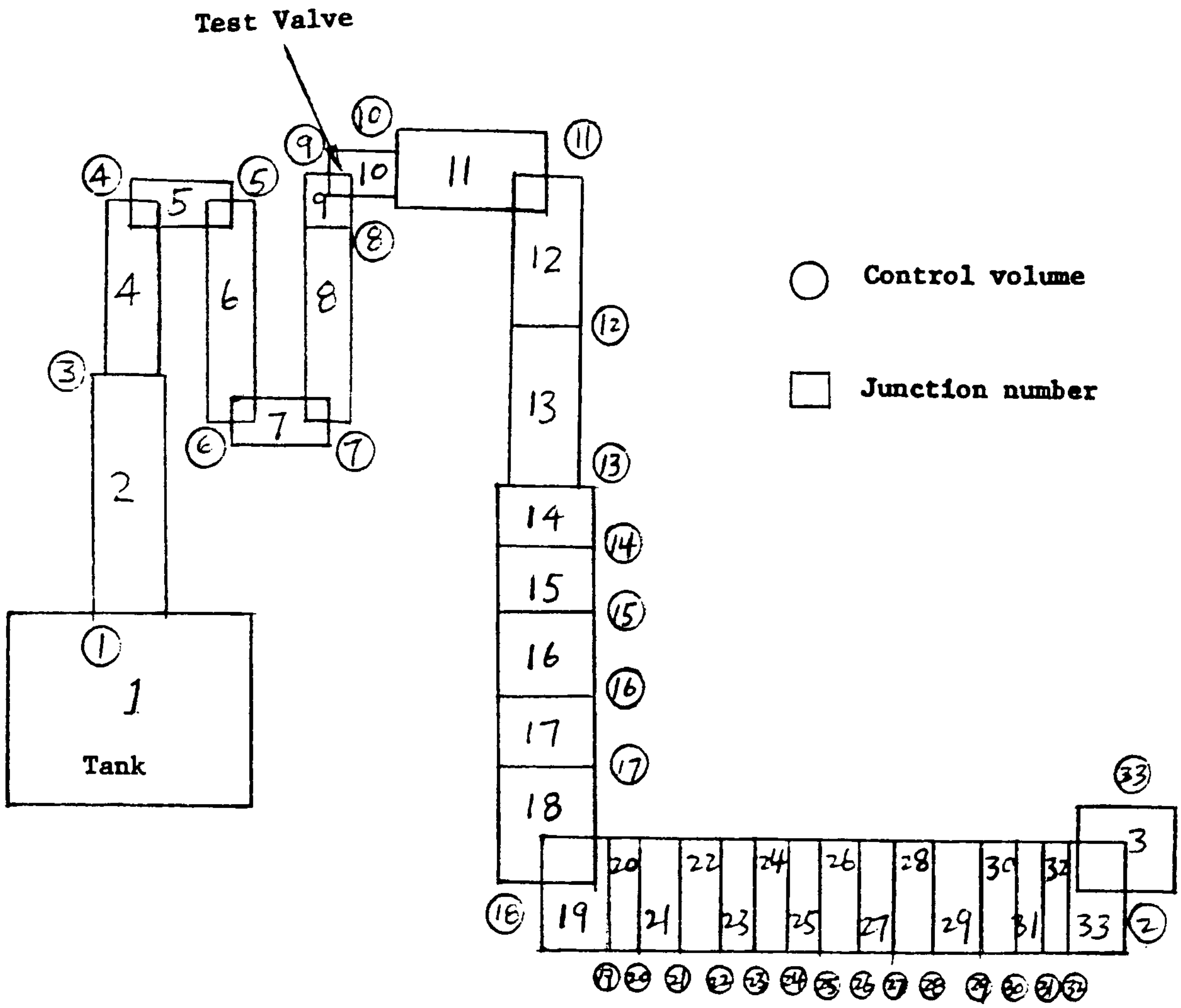


Figure 5-1. RELAP/ANSYR Nodalization Diagram of EPRI Test 1411

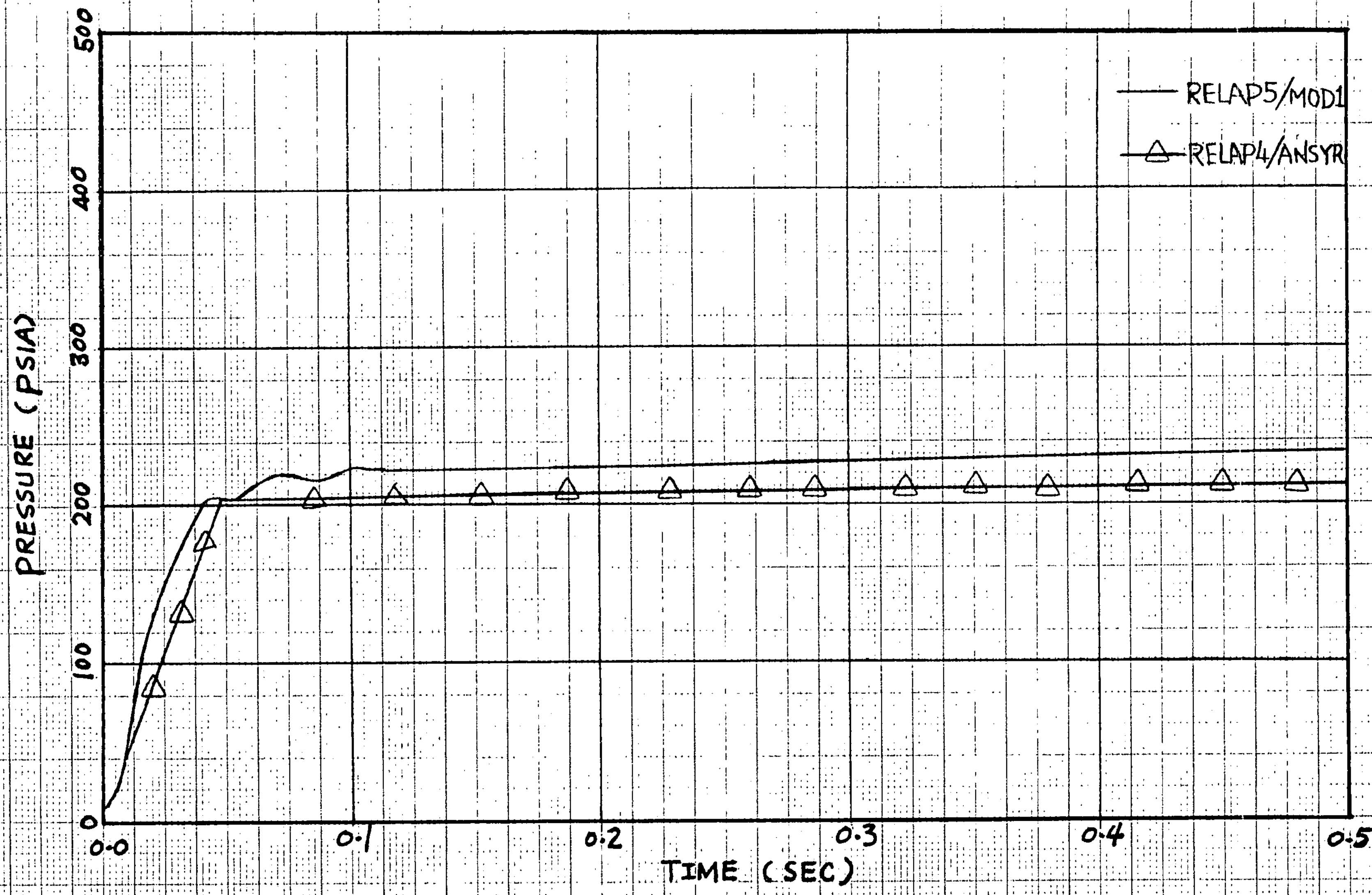


Figure 5-2 Comparison Of System Pressure @ Measurement Location pq

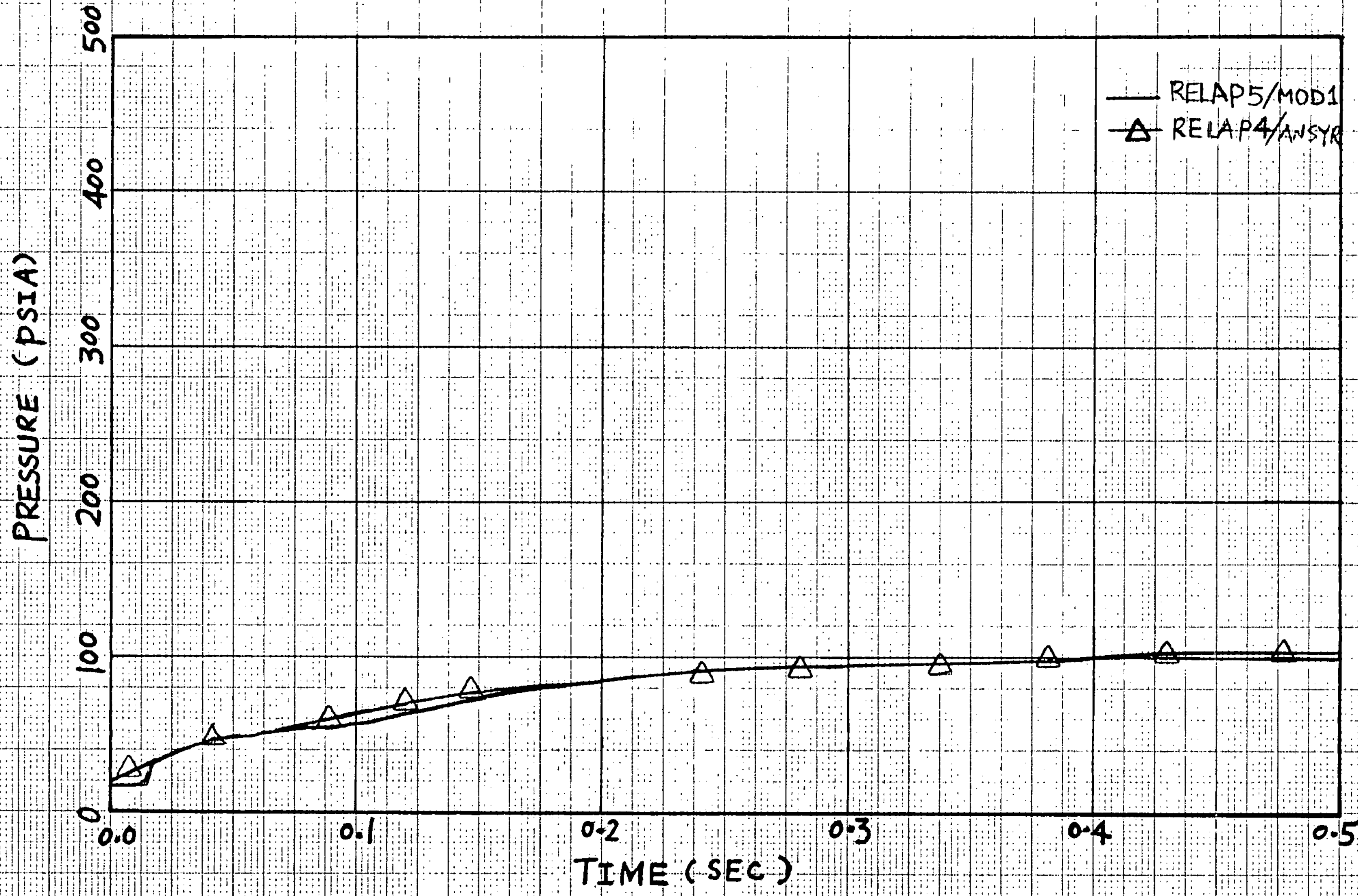


Figure 5-3 Comparison Of System Pressure @ Measurement Location P10

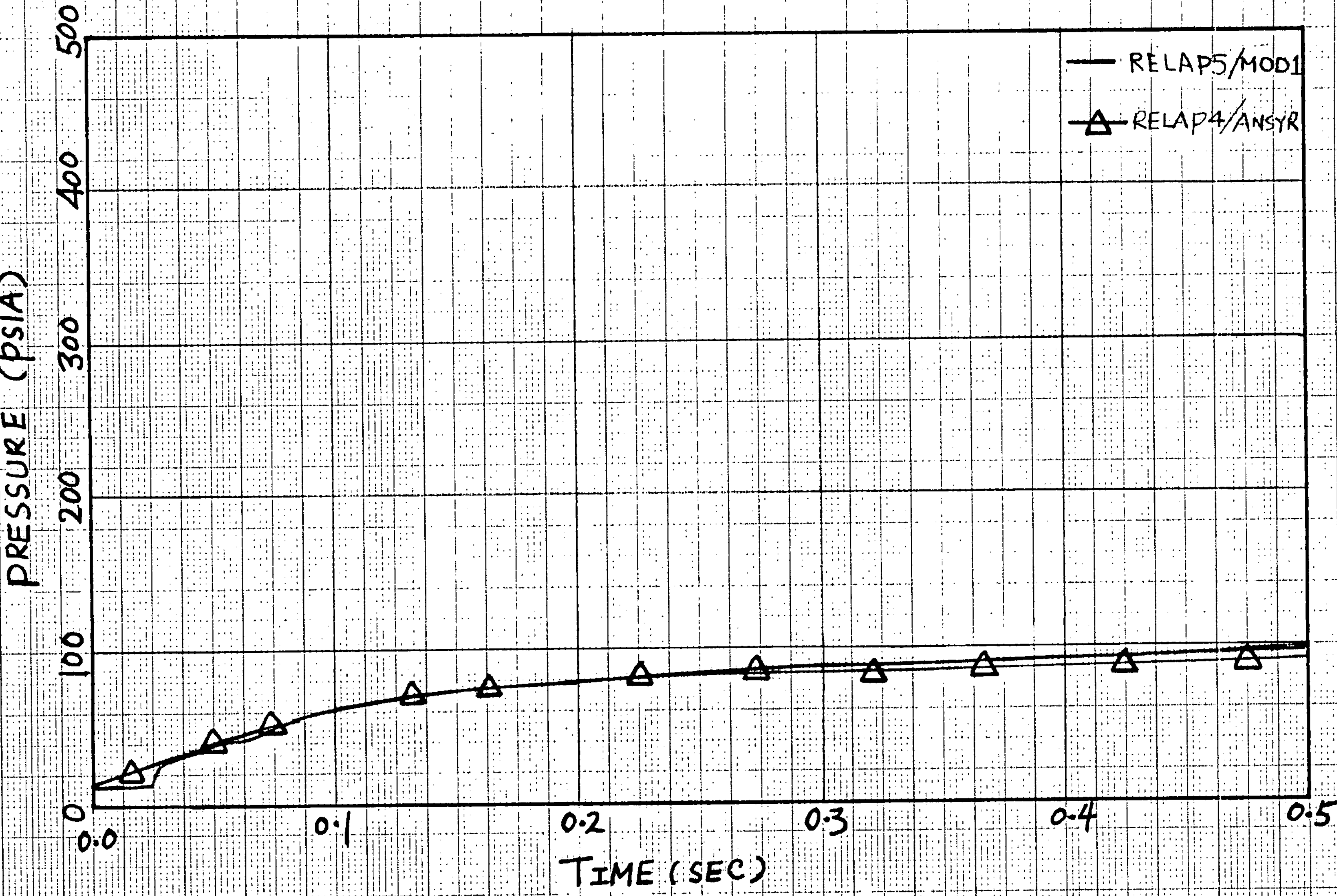


Figure 5-4 Comparison Of System Pressure @ Measurement Location P11

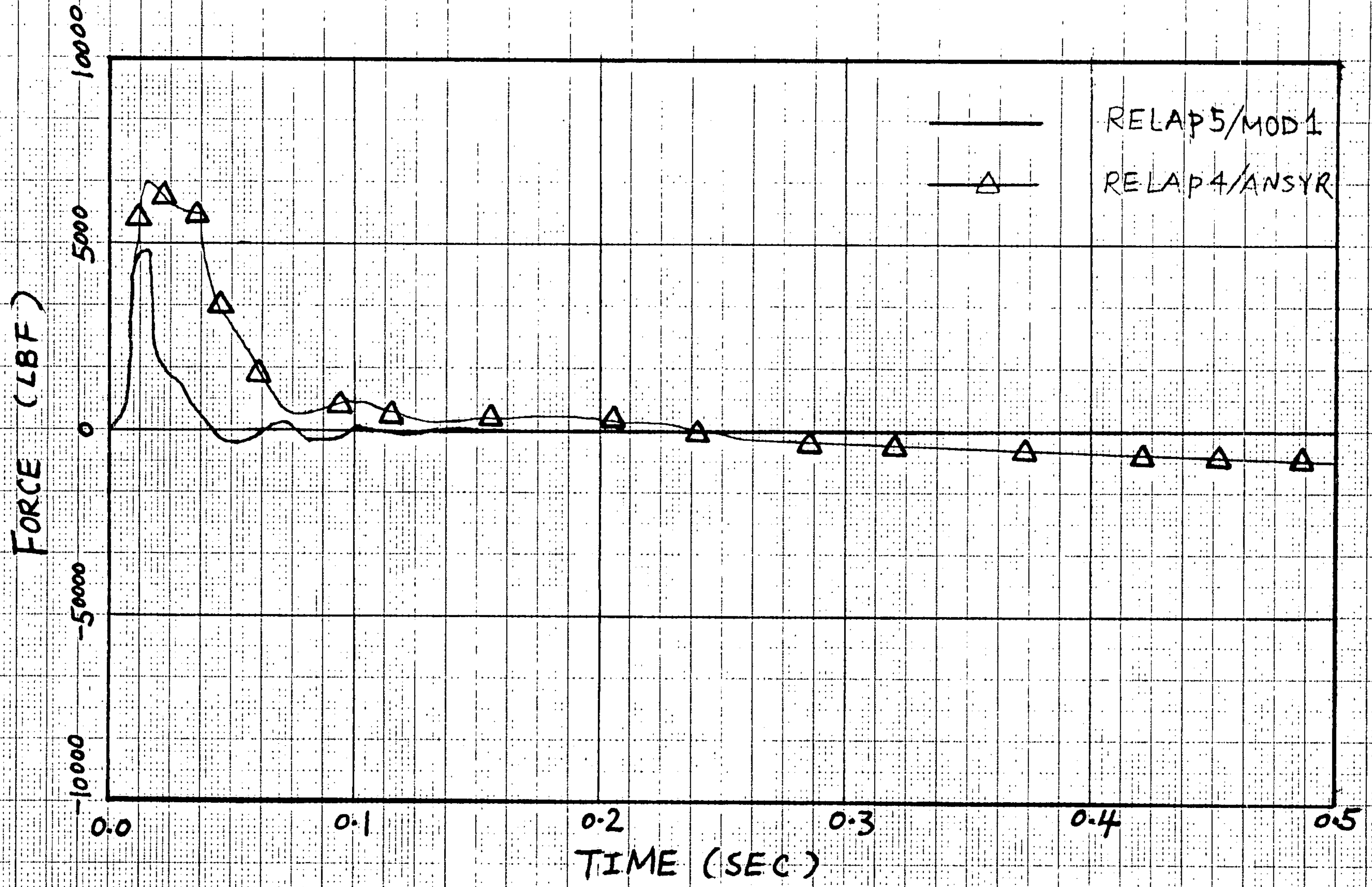


Figure 5-5 Comparison Of Segment 1 Force

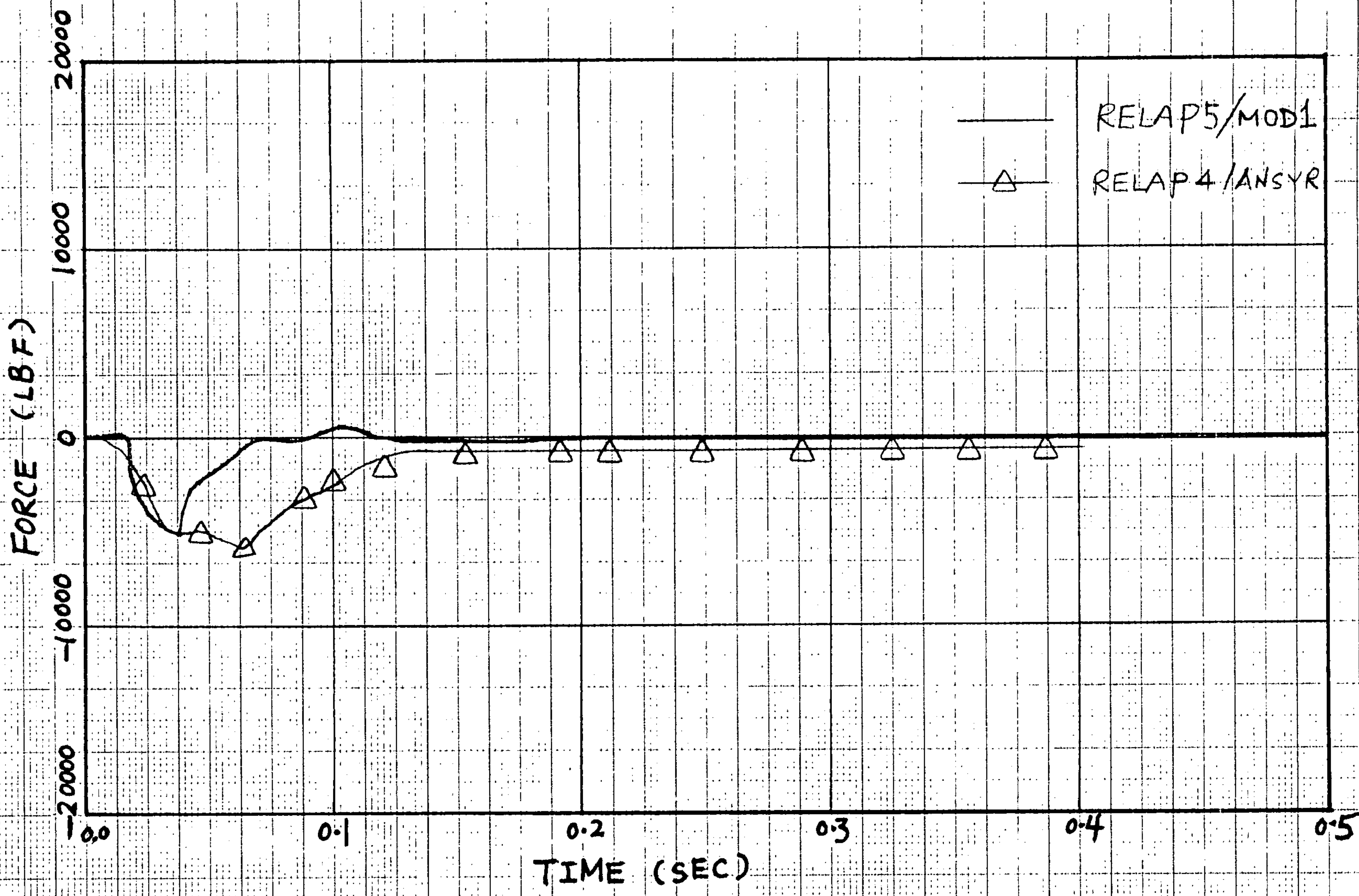


Figure 5-6 Comparison Of Segment 2 Force

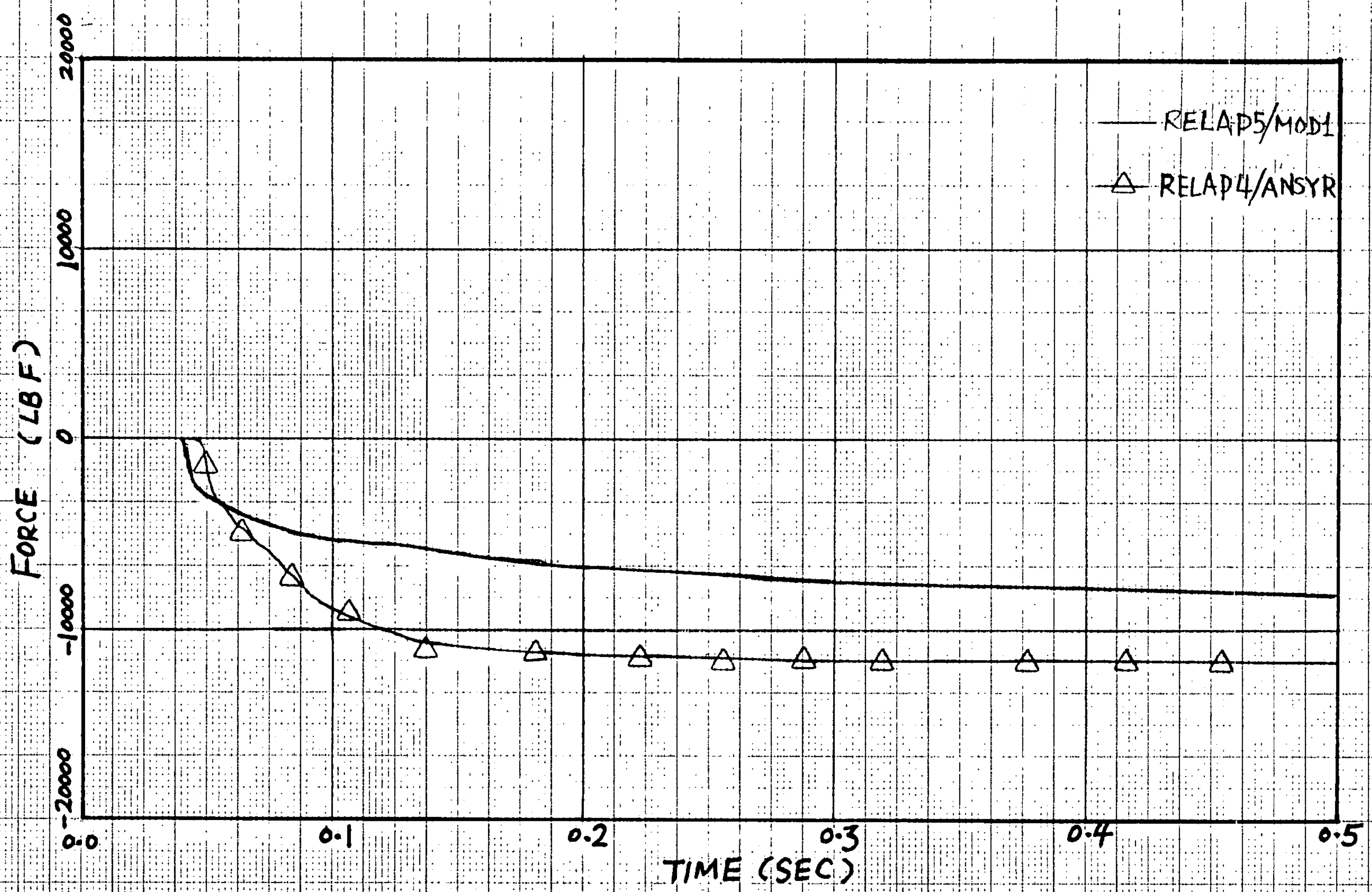


Figure 5-7 Comparison Of Segment 3 Force

6.0 EVALUATION OF SAN ONOFRE UNITS 2 & 3 SAFETY VALVE DISCHARGE PIPING

The input forcing function for the piping structural analysis was obtained from the RELAP4/ANSYR Code. The ANSYS code was used to perform the piping structural analysis. Three cases were evaluated with different safety valve opening times.

6.1 Forcing Function Obtained From RELAP4/ANSYR

The San Onofre Units 2 & 3 safety valve discharge piping system was modeled with 49 volumes linked together by 51 junctions. A total of 31 structural nodes were used. The valve volumes upstream and downstream of the orifice were also modeled. The system forcing functions were calculated at each change in the piping direction. As shown in Figure 2-1, each elbow has two structural nodal points to take the direction change into account.

The following conditions were used in calculating the force vs. time history:

1) Upstream of the valve, including the pressurizer, the initial condition is conservatively assumed to be saturated steam at 2600 psia. This pressure condition is used to generate higher flowrate to match Test Case 1305 (Reference 7) of the Dresser valve. The recorded flow rate is 640,000 lbs/hr at an inlet pressure of 2651 psia. The rated flow of San Onofre Units 2 & 3 safety valve at 2500 psia is 504,875 lb/hr. At 2600 psia the discharge flow rate is 626,400 lbs/hr by calculation.

2) Downsteam of the valve, including the quench tank, the initial condition is conservatively assumed to be saturated steam at 14.7 psia.

3) The valve opens linearly in 16 msec.

4) The quench tank has a disc which ruputures open to atmosphere when the pressure inside the tank reaches 100 psia.

Condition 1 represents the final ramped pressurizer pressure prior to safety valve opening. Conditions 1 and 2 together represent a steam blowdown case. Since this is a single phase phenomenon, the application of RELAP4 is valid. Condition 3 is a conservative simplification made to model the valve three-dimensional discharge pattern and a parabolic flow-vs-time curve with a variable opening time. The opening time of 16 msec. was obtained from experimental tests. Since the flow through the valve is choked, the valve discharge rate is controlled by the flow area rather than the downstream pressure. Consequently, the usual parabolic flow-vs-time curve was conservatively replaced by the linear area vs. time curve during the 16 milliseconds opening time.

Three transient cases were run using RELAP4:

Case 1) Both valves open simultaneously

Case 2) One valve (valve mark No. 2PSV 0200) opens first. When the system reaches steady state, the other valve opens. (See Figure 4-1 for valve mark No.)

Case 3) One valve (valve mark No. 2PSV 0200) opens first. When this valve is half-open, the other valve opens.

The case of both valves opening simultaneously is reasonable in that both safety valves have the same set pressure.

Samples of force vs. time history plots applied to each structural nodal point for each transient case are shown in Figures 6.1-1 thru 6.1-6. The forces presented in these plots are the total force, i.e. the sum of pressure, momentum and wave forces.

6.2 Structural Response Analysis of San Onofre Units 2 & 3 Safety Valve Discharge Piping System

6.2.1 Mathematic Model

Four types of elements of the ANSYS Code: STIF 9 for straight pipe, STIF 29 for curved pipe, STIF 14 for support restraint and STIF 21 for 3-dimensional mass were used. Figure 6.2-1 shows the full finite element model with the nodal and element numbering system. Figure 6.2-2 shows the reduced model with the assigned master degrees of freedom. The master degrees of freedom were selected to give a reasonable range of the modes which characterize the motion of the subject system. Knowledge of the natural frequencies of the discharge piping system is helpful in choosing the integration time-step "Δt" size and the number of time steps required in a time-history dynamic analysis. The natural frequencies of the San Onofre Units 2 & 3 safety valve discharge piping system are obtained from Bechtel's in-house verified computer program, ME101 (Reference 9). The results are shown as follows:

Mode	Natural Frequencies	Mode	Natural Frequencies
1	14.36	13	42.94
2	14.38	14	47.32
3	17.05	15	48.70
4	17.13	16	48.77
5	17.46	17	49.24
6	20.67	18	57.05
7	28.51	19	57.07
8	28.54	20	62.26
9	33.27	21	67.62
10	33.75	22	82.26
11	33.77	23	88.83
12	33.96	24	95.52

The integration time-step size must be small to characterize the input thermal-hydraulic force curve. $\Delta t = 0.0005$ seconds was selected in the displacement pass of the ANSYS run. The integration time step "Δt" is calculated using the equation $\Delta t = 1/Nf$, where N is integration points per cycle and f is the highest frequency of interest. From ANSYS code, N is approximately equal to 25 based on 1% equivalent damping ratio. Therefore, the time step of 0.0005 seconds represents a cut-off frequency, "f" approximately equal to 80 Hz. The integration time "Δt" was maintained constant throughout the entire analysis.

6.2.2 Loading Conditions

As stated in Section 6.1, the forcing functions due to the three cases have been analyzed.

The forcing functions were obtained from a post-processor, ANSYR, with time interval equal to 1 millisecond. The forcing functions are in ANSYS input format which was stored in the file, "Tape 23." However, the time interval of 0.5 millisecond was used in the displacement pass of piping structural analysis by using the linearly interpolated option available in the ANSYS code. The forcing functions applied to the piping were calculated at each piping direction change and any change in cross section of the subject piping system in the global coordinate. Figure 6.2-3 shows the nodes at which forces are applied.

6.2.3 Loading Combinations and Applicable Codes

6.2.3.1 Safety Valve Discharge Piping

As noted previously, the discharge piping from the outlet of the safety valves to the pressure relief tank (nodal points 65 and 130 through 5) is classified as Quality Class III, Seismic Category II non-safety related piping. The applicable code for this piping is ANSI B31.1, 1974. The valve discharge transient loads are included in the following loading combination:

Loading combination: $Po + |DW| + |RVC|$ (See next section for explanation)

Allowable stress: $1.8\ S_h$

The allowable stress is selected as $1.8\ S_h$ which is 50% increased over $1.2\ S_h$ (Equation 12 of ANSI B31.1 piping). The reasons are; 1) the discharge piping is not safety related, 2) the probability of actual safety valve actuation is extremely low. A meeting of the S/RV Piping Subcommittee held in EPRI on October 29, 1981 (Reference 8) recommended that a service level C be used for the safety valve discharge transient loads based on the extremely low probability of actual safety valve actuation. Therefore, the allowable stress of $1.8\ S_h$ is compatible with EPRI's recommendations. The safety valves operability will be demonstrated by considering the loads imposed from the discharge piping (safety valve operability is discussed in Part B of this report).

6.2.3.2 Piping Support Design Loads

Load combination sets used to obtain maximum pipe support design loads for ANSI B31.1 piping in each direction that the support acts are:

TH + DW + DBE	}	whichever is larger
TH + DW + RVC		

TH: Thermal load

DW: Deadweight

Po: Internal pressure

RVC: Safety valve discharge load for closed system

DBE: Design Basis earthquake

6.2.4 Results of Discharge Piping Structural Analysis

6.2.4.1 Displacement Solution

The three cases of loading conditions given in Section 6.1 were analyzed to determine the displacement response. Approximately 670 total iterations were applied for Case 1, 1800 iterations for Case 2 and 1200 iterations for Case 3. The time interval (Δt) between two iterations was selected as 0.5 milliseconds for all three cases. The maximum displacement occurs at the common joint (12" x 12" x 8" tee), nodal point 30, in the discharge piping. The results are shown in the following table.

Displacement at nodal point 30

Case	Time sec	Direction	Displacement in.
1	0.4930E-01	X	0.3276
2	0.6475	X	0.3083
3	0.1140	X	0.3496

A typical displacement vs. time plot at nodal point 30 for case 1 is shown in Figure 6.2-4.

6.2.4.2 Stress Solution

The time interval selected for the stress solution was Δt =1.0 millisecond. The stress solution from the ANSYS run results in stress intensities, $2\tau_{max}$, at each element. Also printed are the forces and moments at each element and their corresponding stresses. However, Paragraph 104.8 of the ANSI B31.1 Code uses the simplified method for calculating stress using stress indices. Therefore, the stresses obtained from ANSYS run were recalculated to comply with the applicable code. The moments were obtained from the ANSYS printout at the time of iteration based on the highest values of the stress intensity, ($2\tau_{max}$), shown in the Post 24 run for elements of interest.

The maximum stresses in the safety valve discharge pipe were calculated by hand for B31.1 piping with the moments obtained from ANSYS run. The maximum stress occurs at the common joint, nodal point 30. Case 1 and Case 3 are the critical cases. The results are shown in Tables 6.2-1 through 6.2-2a. Only those nodal points having higher stress levels are shown in Tables 6.2-1 and 6.2-2a. All the piping components of the ANSI B31.1 piping meet the design allowable stress of 1.8 S_h (28,620 psi). Maximum combined pipe support design loads are shown in Tables 6.2-7a thru 6.2-7d. All existing pipe supports, including snubbers and their structures, have been checked against the design loads listed in Tables 6.2-7a thru 6.2-7d. The results indicated that one snubber, a "Y" snubber at nodal point 60, was found to have loads exceeding the manufacturer's load rating due to dynamic loads resulting from the discharge transients. The snubber was rated at 10,380 lbs consistent with the requirements of the original design static load calculations. The calculated

discharge load at this node, as a result of the dynamic load analysis based on the EPRI/C-E test data, was approximately 18,000 lbs. As a result of this increase over the manufacturer's recommended load rating of the "Y" snubber at nodal point 60 due to the dynamic analysis, alternatives which included removal or replacement of this snubber were evaluated.

When the system was reanalyzed using Case 3 (the most limiting case) without the "Y" snubber at nodal point 60, the results indicated that the piping and its associated supports could safely withstand safety valve operation for this most limiting case.

The analysis without the "Y" snubber at nodal point 60 showed that:

1). An increase in the calculated bending moments on one of the two safety valve discharge flanges by approximately 15%. The loading on the other safety valve flange decreased slightly. Table 6.2-5 shows the bending moments on the flanges with "Y" snubber at nodal point 60 and Table 6.2-6 shows the moments on the flanges without "Y" snubber at nodal point 60. A comparison of the two tables shows that the bending moments for one of the two flanges increased from 80,446 in-lb to 92,280 in-lbs, while the bending moments on the other flange decreased from 17,822 in-lbs to 17,670 in-lbs. In the EPRI/C-E test of the Dresser 31709 NA safety valve, satisfactory safety valve operability was obtained with bending moments at the valve discharge flange as high as 473,200 in-lbs during valve operation. Thus it can be concluded that the flange can safely withstand the bending moment of 92,080 in-lbs which has been calculated without the "Y" snubber at nodal point 60.

2). The stress calculated at nodal point 30 (the maximum stress point in the discharge piping) without the "Y" snubber at nodal point 60 as shown in Table 6.2-2b, is approximately the same as that of the values shown in Table 6.2-2a (stress calculated with the "Y" snubber at nodal point 60), and is below the allowable design stress of 1.8 S_h.

3). The pipe support design loads with the "Y" snubber at nodal point 60 are shown in Tables 6.2-7a thru 6.2-7d. The pipe support design loads without the "Y" snubber at nodal point 60 are shown in Tables 6.2-8a thru 6.2-8d. The capability of the safety valve discharge piping including pipe supports, snubbers, and their structures to withstand the revised loadings without the "Y" snubber at nodal point 60 has been verified.

A seismic analysis of the subject system was also performed without the "Y" snubber at nodal point 60. The results of the analysis confirmed the structural adequacy of the San Onofre Units 2 & 3 pressurizer safety valve discharge piping without this snubber.

Accordingly, the "Y" snubber at nodal point 60 has been deleted from the San Onofre Units 2 & 3 safety valve discharge piping configuration.

6.2.4.3 Maximum Loads on the Safety Valve Discharge Flange

Loads applied to the discharge flange of the pressurizer safety valves with "Y" snubber at nodal point 60 in the system are shown in Table 6.2-3. These values are the extreme values which envelop Cases 1 and 3. The combined bending moments are shown in Table 6.2-5. Loads applied to the discharge flanges of the safety valves that were caculated using Case 3 (the most limiting case), without the "Y" snubber at nodal point 60 are presented

in Tables 6.2-4 and the combined bending moments are shown in Table 6.2-6. As discussed previously, these loads without the "Y" snubber are well within the 473,200 in-lbs loading which was encountered by the safety valve discharge flange during the test program.

TABLE 6.2-1. Maximum Stresses for Discharge Piping with "Y" Snubber at Nodal Point 60, (Eq. 12 of ANSI B31.1) - Case 1

Element	Nodal Point I	Nodal Point J	Component	Z* in^3	@ Time Sec Max. S.I. Occurs	Moments, in-lb Mx	My	Mz	Mr	i	$0.75i \frac{Mr}{z}$ psi (1)	** σ_{w+p} (2)	Eq. (12) (1)+(2) psi
18	28	(30)	W Tee, 12"Ø	30.68	0.0420	-25692	-12180	-161190	163678	2.866	11467	4078	15,545
19	(30)	143	W Tee, 12"Ø	30.68	0.0495	27739	27055	277417	280110	2.866	19625	4003	23,628
21	(35)	40	Red, 8"Ø	13.77	0.0470	26642	18378	70164	77269	2.0	8417	2822	11,239
25	(49)	50	Elbow, 8"Ø	13.77	.110	28823	27782	32478	51550	2.92	8198	3045	11,243
25	49	(50)	Elbow, 8"Ø	13.77	.1665	-40742	12042	20650	47237	2.92	7512	2838	10,350
50	(114)	115	Elbow, 8"Ø	13.77	0.0495	4108	40859	2099	41118	2.92	6539	2648	9,187
43	(30)	99	W Tee, 8"Ø	13.77	0.0525	-2790	-6662	-133049	133244	2.866	20799	2745	23,544
21	35	(40)	BRA, 8"Ø	13.77	0.0470	-26642	-16443	-23385	39077	3.05	6491	2850	9,341

P = 325 psi at discharge piping obtained from RELAP4 run.

Allowable = 1.8 S_h = 1.8 x 15900 = 28,620 psi @ 700°F for SA-312 Grad. TP304.

*where $Z = \pi r^2 t$

** σ_{w+p} = Stress due to pressure and weight obtained from Bechtel in-house computer program, ME101 (Reference 6)

(N) indicates stress value @ node N.

TABLE 6.2-2a. Maximum Stresses for Discharge Piping with "Y" Snubber at Nodal Point 60, (Eq. 12 of ANSI B31.1) - Case 3

Element	Nodal Point I	Nodal Point J	Component	Z* in^3	@ Time Sec Max. S.I. Occurs	Moments, in-lb Mx	Moments, in-lb My	Moments, in-lb Mz	Moments, in-lb Mr	i	$0.75i \frac{Mr}{z}$ psi ①	σ^{**}_{w+p} ②	Eq. (12) ①+② psi
18	28	(30)	W Tee, 12"Ø	30.68	0.045	-18669	-3655	-162883	163990	2.866	11489	4078	15,567
19	(30)	143	W Tee, 12"Ø	30.68	0.053	28547	28734	283810	286685	2.866	20085	4003	24,088
43	(30)	99	W Tee, 8"Ø	13.77	0.058	-2570	-9118	-154567	154857	2.866	24173	2745	26,918

TABLE 6.2-2b. Maximum Stresses for Discharge Piping without the "Y" snubber at Nodal Point 60, (Eq. 12 of ANSI B31.1) - Case 3

Element	Nodal Point I	Nodal Point J	Component	Z* in^3	@ Time Sec Max. S.I. Occurs	Moments, in-lb Mx	Moments, in-lb My	Moments, in-lb Mz	Moments, in-lb Mr	i	$0.75i \frac{Mr}{z}$ psi ①	σ^{**}_{w+p} ②	Eq. (12) ①+② psi
18	28	(30)	W Tee, 12"Ø	30.68	0.045	-19537	-3206	-164855	166039	2.866	11633	4078	15,710
19	(30)	143	W Tee, 12"Ø	30.68	0.053	30069	27037	284772	287628	2.866	20151	4003	24,154
43	(30)	99	W Tee, 8"Ø	13.77	0.058	-2160	-8217	-152139	152376	2.866	23785	2745	26,530

P = 325 psi at discharge piping obtained from RELAP4 run.

Allowable = 1.8 S_h = 1.8 x 15900 = 28,620 psi @ 700°F for SA-312 Grad. TP304.

*where $Z = \pi r^2 t$

** σ_{w+p} = Stress due to pressure and weight obtained from Bechtel in-house computer program, ME101 (Reference 6)

(N) indicates stress value @ node N.

Table 6.2-3 Maximum Piping Loads On Safety Valve Discharge Flange With "Y" Snubber At Nodal Point 60.

Valve Mark No.	Nodal Pt.	Force lbs						Moment in-lb					
		Fx		F_y		F_z		M_x		M_y		Mz	
		max	min	max	min	max	min	max	min	max	min	max	min
2PSV0200	65 Outlet	2192	-5244	10595	0	2189	-1501	47858	-10915	0	-14912	79052	0
2PSV0201	130 Outlet	233	-8881	0	-552	726	-687	4580	-484	5344	-9074	15409	-616

where:

X, Y, Z: Global Coordinates

x,y,z: Element Coordinates

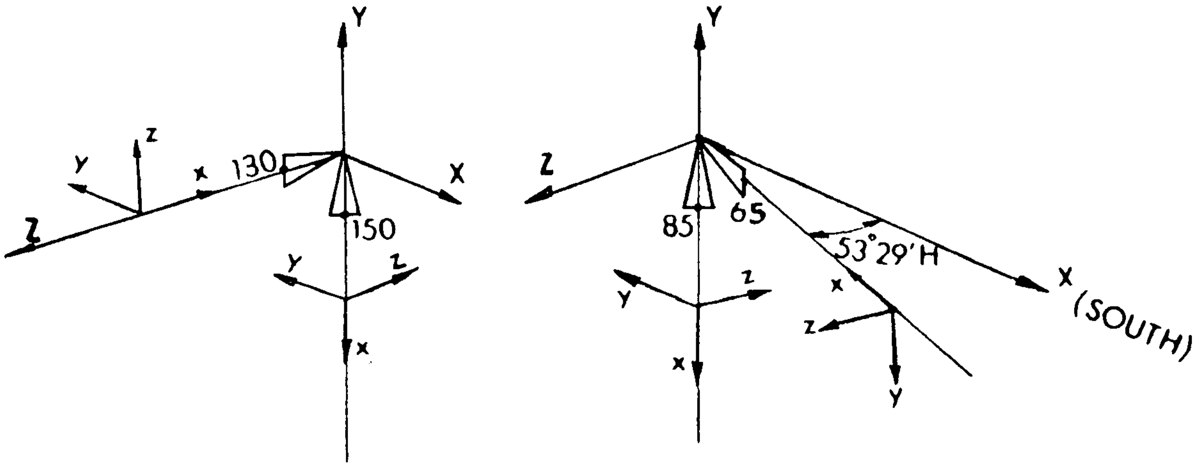


Table 6.2-4 Maximum Piping Loads On Safety Valve Discharge Flange Without "Y" Snubber At Nodal Point 60.

Valve Mark No.	Nodal Pt.	Force lbs						Moment in-lb					
		F_x		F_y		F_z		M_x		M_y		M_z	
		max	min	max	min	max	min	max	min	max	min	max	min
2PSV0200	65 Outlet	0	-14242	371	-5007	2150	-1540	49303	-10360	3308	-10011	91534	-9471
2PSV0201	130 Outlet	231	-8889	0	-546	723	-695	4533	-522	5568	-8910	15259	-815

where:

X, Y, Z: Global Coordinates

x,y,z: Element Coordinates

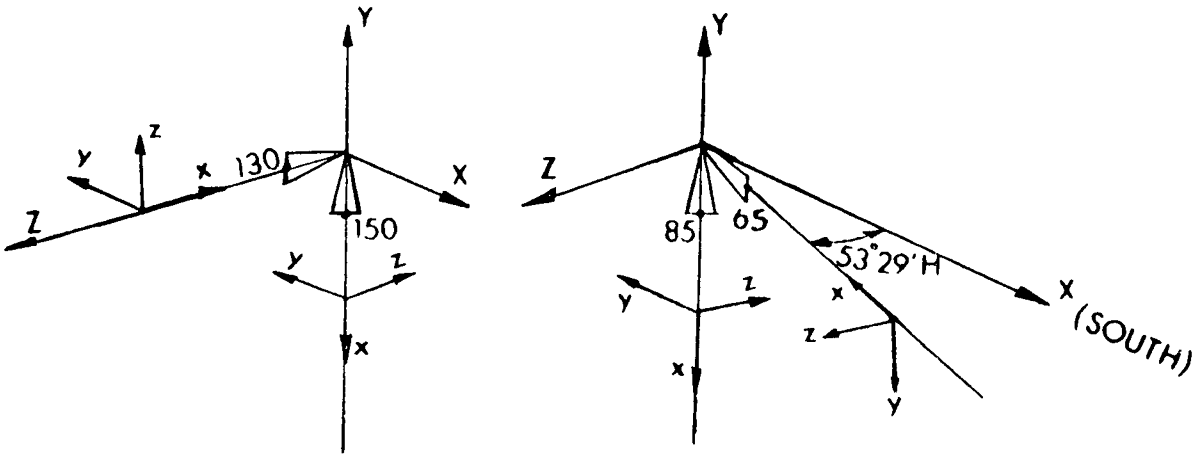


Table 6.2-5 Bending Moments Applied to Safety Valve Discharge Flange with "Y" Snubber at Nodal Point 60

Valve Mark No.	Nodal Pt.	Bending Moments in-lb*
2PSV0200	65 Outlet	80446
2PSV0201	130 Outlet	17882

Table 6.2-6 Bending Moments Applied to Safety Valve Discharge Flange without "Y" Snubber at Nodal Point 60

Valve Mark No.	Nodal Pt.	Bending Moments in-lb*
2PSV0200	65 Outlet	92080
2PSV0201	130 Outlet	17670

* $M_b = \sqrt{M_y^2 + M_Z^2}$

SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 & 3
PIPE SUPPORT DESCRIPTION LIST
JOB NO. 10079

* 1201-032-1
1201-034-1
1201-035-1

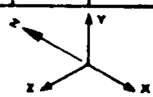
PROBLEM NO. PSG-283 M-1201-032-AB
STRESS ISO DWG NO. 1201-032-1 PAGE ___ OF ___
ORIGINATOR P. [illegible] DATE 4-20-82
CHECKER [illegible] DATE 4-22-82 REV 3 DATE ___

TITLE PRESSURE RELIEF VALVE LINE

PS NO. / DATA PT NO. / TAG NO.	SUPPORT TYPE / FORM NO. PER STDS	*SUPPORT LOCATION ON PIPE (N-S / ELEV / E-W)	PER P.S.G.	WEIGHT LOADS (X / Y / Z, LBS)	HYDRO TEST LOADS	DBE LOADS (2)	THERM LOADS	‡S.A.M. LOADS DBE (ZPA (DBE))	OTHER LOADS (FORCING FUNCTION) (2) (3)	DBE MOV'T (X / Y / Z, INCH)	THERM MOV'T	‡S.A.M. MOV'T DBE	OTHER MOV'T	DESIGN (3) LOADS (LBS)	DESIGN MOV'TS (INCHES)	APPR'L DATE	COMMENTS:
	Y	2011.5								.010	.349				.359 / -.010		MIN. SPRING PRELOAD = 728 #L
48	SPR	79.734		-728	-1619						1.679			⊖ / -1619	1.679 / ⊖		WT. LOAD = 652#
		372.331									.302				.302 / ⊖		UPWARD FORCE ON PIPE = 728-652 = 76 lbs
	Z	2011.5								.010	.349				.359 / -.010		
48	SNB	79.734									1.679				1.679 / ⊖		
		372.331				4744			3499 / -853		.302			4744 / -4744	.302 / ⊖		
	PARALLEL	2010.409				2350		1441	1719 / -1584		.306			2756 / -2756	.306 / ⊖		
60 (62)	SNB	81.234									1.767				1.767 / ⊖		
		370.858				3176		1947	2327 / -3144		.348			3725 / -3725	.348 / ⊖		
	⊥	2010.409				6118			1563 / -1148		.306			611 / -6118	.306 / ⊖		
60 (61)	SNB	81.234									1.767				1.767 / ⊖		
		370.858				4530			850 / -1157		.348			4530 / -4530	.348 / ⊖		
	Y	2010.409									.306				.306 / ⊖		
60	SNB	81.234				4984			18183 / ⊖		1.767			18183 / -4984	1.767 / ⊖		
		370.858									.348				.348 / ⊖		

*SUPPORT LOCATIONS ARE GIVEN IN THE OVERALL PLANT COORDINATE SYSTEM
'ON PIPE' SUPPLIED BY STRESS INCLUDES A ± 12" TOLERANCE OR AS NOTED.
'PSG' IS LOCATION SHOWN ON PIPE SUPPORT DETAIL SHEET.
‡ S.A.M. = SEISMIC ANCHOR MOVEMENT ANALYSIS

XX SEE SNUB NB 247
(2) REVISED SEISMIC AND FORCING FUNCTION LOADS DUE TO DELETION OF SNUBBERS AT D.P. 28.
(3) REVISED HYDRO-THERMAL LOADS CASE 3



	STRESS CALC. NO.	SNUMB NO.	DATE
THERM		NB 644	7-31-81
WEIGHT		NB 352	9-14-81
SEIS. INT.		NB 140 (2)	11-05-81
FORCING FUNCTION		NB 144 (2)	11-05-81
SUMMARY			

PP-1852 (10079) 9/76

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Table 6.2-7a Pipe Support Design Loads With A "Y" Snubber At Nodal Point 60

SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 & 3
PIPE SUPPORT DESCRIPTION LIST
JOB NO. 10079

*1201-032-1
1201-034-1
1201-035-1

TITLE PRESSURE RELIEF VALVE LINE

PROBLEM NO. PSG-283
STRESS ISO DWG NO. *1201-032-1 PAGE ____ OF ____
ORIGINATOR [illegible] DATE 6-20-82
CHECKER [illegible] DATE 4-22-82 REV 3 DATE ____

PS NO. / DATA PT NO. / TAG NO.	SUPPORT TYPE / FORM NO. PER STDS	*SUPPORT LOCATION ON PIPE (N-S / ELEV / E-W)	SUPPORT LOCATION PER P.S.G.	WEIGHT LOADS (X / Y / Z LBS)	HYDRO TEST LOADS	DBE LOADS 2	THERM LOADS	‡S.A.M. LOADS DBE (ZPA (DBE))	OTHER LOADS (FORCING FUNCTION) 3	DBE MOV'T (X / Y / Z INCH)	THERM MOV'T	‡S.A.M. MOV'T DBE	OTHER MOV'T	DESIGN 3 LOADS 2 (LBS)	DESIGN MOV'TS (INCHES)	APPR'L DATE	COMMENTS:
		2002.333				9526			2370 / -1643		-.215			9526 / -9526	θ / -.215		
120	X SNB	81.234									1.790				1.79 / θ		
		372.331								.015	.393				.408 / -.015		
		2002.333									-.215				θ / -.215		
120	Y SNB	81.234				824			810 / -227		1.790			824 / -824	1.79 / θ		
		372.331								.015	.393				.408 / -.015		
		2000.875				15210			1620 / -2216		-.279			15210 / -15210	θ / -.279		
128	X SNB	81.234								.001	1.762				1.763 / -.001		
		371.039									.350				.350 / θ		
		2000.875									-.279				θ / -.279		MIN SPRING PRELOAD = 676 #L.
128	Y SPR	81.234		-676	-845					.001	1.762			θ / -845	1.763 / -.001		WT. LOAD = 607 **
		371.039									.350				.350 / θ		UPWARD FORCE ON PIPE 676-607 = 69 lbs
		2000.875									-.279				θ / -.279		
128	Z SNB	81.234								.001	1.762				1.763 / -.001		
		371.039				1218		2400	238 / -3987		.350			2691 / -3987	.350 / θ		
		2011.5								.011	.325				.336 / -.011		
143	Y SNB	74.5				6064		1644	18105 / -7833		1.574			18105 / -7833	1.574 / θ		
		372.331								.006	-.281				.006 / -.287		

*SUPPORT LOCATIONS ARE GIVEN IN THE OVERALL PLANT COORDINATE SYSTEM
'ON PIPE' SUPPLIED BY STRESS INCLUDES A ± 12" TOLERANCE OR AS NOTED.
'PSG' IS LOCATION SHOWN ON PIPE SUPPORT DETAIL SHEET.
‡ S.A.M. - SEISMIC ANCHOR MOVEMENT ANALYSIS

** SEE SNUB NB 247
2 REVISED SEISMIC AND FORCING FUNCTION LOAD
3 REVISED HYDRO-THERMAL LOADS CASE 3

Y, X, Z

	STRESS CALC. NO.	SNUMB NO.	DATE
THERM		NB 644	7-31-81
WEIGHT		NB 352	9-14-81
SEIS. INT.		NB 140 2	11-05-81
FORCING FUNCT [illegible]		NB 144 2	11-05-81
SUMMARY			

PP-1532 (10079) 9/76

Table 6.2-7b Pipe Support Design Loads With A "Y" Snubber At Nodal Point 60

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SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 & 3
PIPE SUPPORT DESCRIPTION LIST
JOB NO. 10079

* 1201-032-1
1201-034-1
1201-035-1

PROBLEM NO. PSG - 283
STRESS ISO DWG NO. 1201 - 052-1 PAGE ___ OF ___
ORIGINATOR [illegible] DATE 4-20-82
CHECKER [illegible] DATE 4-22-82 REV 3 DATE ___

TITLE PRESSURE RELIEF VALVE LINE

PS NO. / DATA PT NO. / TAG NO.	SUPPORT TYPE / FORM NO. PER STDS	*SUPPORT LOCATION ON PIPE (N-S / ELEV / E-W)	PER P.S.G.	WEIGHT LOADS (X / Y / Z) LBS	HYDRO TEST LOADS	DBE LOADS (2)	THERM LOADS	§S.A.M. LOADS DBE (ZPA (DBE))	OTHER LOADS (FORCE) (2) (3)	DBE MOV'T (X / Y / Z) INCH	THERM MOV'T	§S.A.M. MOV'T DBE	OTHER MOV'T	DESIGN (3) LOADS (2) (LBS)	DESIGN MOV'TS (INCHES)	APPR'L DATE	COMMENTS:
		2011.5								.021	.486				.507 / -.021		MIN SPRING PRELOAD: 944 LB.
157	Y SPR	59.417		-910	-2313						1.407			⊖ / -2313	1.407 / ⊖		WT. LOAD: 740 **
		376.331									-1.547				⊖ / -1.547		UPWARD FORCE ON PIPE:
		2011.5				3260			4831 / -4908		.465			3260 / -4908	.465 / ⊖		910 - 740 = 170 lbs
160	X SNB	59.417									1.256				1.256 / ⊖		
		379.831									-1.384				⊖ / -1.384		
		2011.5									.465				.465 / ⊖		
160	Y SNB	59.417				462			91 / -560		1.256			462 / -560	1.256 / ⊖		
		379.831									-1.384				⊖ / -1.384		
		2011.5								.013	.406				.419 / -.013		
165	Z SNB	59.417								.002	.926				.928 / -.002		
		387.331				1668			⊖ / -17605		-1.056			1668 / -17605	⊖ / -1.056		
		2011.5				2280			5632 / -602		.340			5632 / -2280	.340 / ⊖		
170	X SNB	59.417									.578				.578 / ⊖		
		394.831									-.687				⊖ / -.687		
		2011.5									.340				.340 / ⊖		
170	Y SNB	59.417				172			221 / -61		.578			221 / -172	.578 / ⊖		
		394.831									-.687				⊖ / -.687		
		2011.5								.002	.316				.318 / -.002		
173	Y SPR	59.417		-807	-2136					.001	.554			⊖ / -2136	.555 / -.001		
		397.831									-.548				⊖ / -.548		

*SUPPORT LOCATIONS ARE GIVEN IN THE OVERALL PLANT COORDINATE SYSTEM
'ON PIPE' SUPPLIED BY STRESS INCLUDES A ± 12" TOLERANCE OR AS NOTED.
'PSG' IS LOCATION SHOWN ON PIPE SUPPORT DETAIL SHEET.
§ S.A.M. = SEISMIC ANCHOR MOVEMENT ANALYSIS

** SEE SNUB NB 247
(2) REVISED SEISMIC AND FORCING FUNCTION LOADS
(3) REVISED HYDRO-THERMAL LOADS CASE 3

	STRESS CALC. NO.	SNUMB NO.	DATE
THERM		NB 644	7-31-81
WEIGHT		NB 552	9-14-81
SEIS. INT.		NB 140 (2)	11-05-81
FORCING FUNCTION		NB 144 (2)	11-05-81
SUMMARY			

PP-1832 (10079) 9/76

Table 6.2-7c Pipe Support Design Loads With A "Y" Snubber At Nodal Point 60

C-45

SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 & 3
PIPE SUPPORT DESCRIPTION LIST
JOB NO. 10079

*1201-032-1
1201-034-1
1201-035-1

PROBLEM NO. PSG - 283
STRESS ISO DWG NO. *1201-032-1 PAGE ____ OF ____
ORIGINATOR [illegible] DATE 4-20-82
CHECKER [illegible] DATE 4-22-82 REV 3 DATE ____

TITLE PRESSURE RELIEF VALVE LINE

PS NO. / DATA PT NO. / TAG NO.	SUPPORT TYPE / FORM NO. PER STDS	*SUPPORT LOCATION ON PIPE (N-S / ELEV / E-W)	PER P.S.G.	WEIGHT LOADS (X LBS / Y / Z)	HYDRO TEST LOADS	DBE LOADS △2	THERM LOADS	‡S.A.M. LOADS DBE ZPA (DBE)	OTHER LOADS Forcing Function △3 △2	DBE MOV'T (X INCH / Y / Z)	THERM MOV'T	‡S.A.M. MOV'T DBE	OTHER MOV'T	DESIGN LOADS △2 (LBS)	DESIGN MOV'TS (INCHES)	APPR'L DATE	COMMENTS:
	Y	2007.67									.120				.120 ⊖		
180	SNB	59.417				444			521 / -107		.529			521 / -444	.529 ⊖		
		406.078									-.120				⊖ -.120		
	PARALLEL	2007.67				858		1044	2957 / -2045		.120			2957 / -2045	.120 ⊖		
180 (181)	SNB	59.417									.529				.529 ⊖		
		406.078				858		1044	2045 / -2957		-.120			2045 / -2957	⊖ -.120		
	⊥	2007.67		-55	19	136	1174		1494 / -80		.120			1494 / -1140	.120 ⊖		
180 (182)	RAD	59.417									.529				.529 ⊖		
		406.078		-55	19	136	1174		1494 / -80		-.120			1494 / -1140	⊖ -.120		
	X	2008.333				4734			2236 / -7072		.146			4734 / -7072	.146 ⊖		
225	SNB	78.667									1.906				1.906 ⊖		
		372.331								.081	.123				.204 -.081		
	Y	2008.333									.146				.146 ⊖		
225	SNB	78.667				3610		609	7744 / -1727		1.906			7744 / -3610	1.906 ⊖		
		372.331								.071	.123				.204 -.081		
	Y	2008.333									.146				.146 ⊖		MIN. SPRING PRELOAD = 708 [illegible]
225	SPR	78.667		-708	-1057						1.906			-1057	1.906 ⊖		WT. LOAD = 357**
		372.331								.081	.123				.204 -.081		UPWARD FORCE ON PIPE = 708 - 357 = 351 lbs
	Z	2008.333									.194				.197 -.003		
227	SNB	73.323									1.663				1.663 ⊖		
		372.331				1994			180 / -314		-.365			1994 / -1994	⊖ -.365		

*SUPPORT LOCATIONS ARE GIVEN IN THE OVERALL PLANT COORDINATE SYSTEM 'ON PIPE' SUPPLIED BY STRESS INCLUDES A ± 12" TOLERANCE OR AS NOTED.
'PSG' IS LOCATION SHOWN ON PIPE SUPPORT DETAIL SHEET.
‡ S.A.M. = SEISMIC ANCHOR MOVEMENT ANALYSIS

** SEE SNUB NB 247
△2 REVISED SEISMIC AND FORCING FUNCTION LOADS
△3 REVISED HYDRO-THERMAL LOADS CASE 3

Y, Z, X

	STRESS CALC. NO.	SNUMB NO.	DATE
THERM		NB 644	7-31-81
WEIGHT		NB 352	9-14-81
SEIS. INT.		NB 140 △2	11-05-81
FORCING FUNCTION		NB 144 △2	11-05-81
SUMMARY			

PF-1552 (10079) 9/76

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Table 6.2-7d Pipe Support Design Loads With A "Y" Snubber At Nodal Point 60

SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 & 3
PIPE SUPPORT DESCRIPTION LIST
JOB NO. 10079

* 1201-032-1
1201-034-1
1201-035-1

PROBLEM NO. PSG-283 1[illegible]1-032-AB
STRESS ISO DWG NO. *1201-032-1 PAGE ___ OF ___
ORIGINATOR J. Lim DATE 6-22-82
CHECKER [illegible] DATE 6-23-82 REV 4 DATE ___

TITLE PRESSURE RELIEF VALVE LINE

PS NO. / DATA PT NO. / TAG NO.	SUPPORT TYPE / FORM NO. PER STDS	*SUPPORT LOCATION ON PIPE (N-S / ELEV / E-W)	PER P.S.G.	WEIGHT LOADS (X Y Z LBS)	HYDRO TEST LOADS	DBE LOADS (△4, △2)	THERM LOADS	‡S.A.M. LOADS DBE (ZPA (DBE))	OTHER LOADS (FORCING FUNCTION) (△2, △3, △4)	DBE MOV'T (X Y Z INCH)	THERM MOV'T	‡S.A.M. MOV'T DBE	OTHER MOV'T	DESIGN (△4, △3) LOADS (LBS)	DESIGN MOV'TS (INCHES)	APPR'L DATE	COMMENTS:
		2011.5								.010	.349				.359 / -.010		MIN. SPRING PRELOAD = 728 #?
48	Y SPR	79.734		-728	-1619						1.679			⊖ / -1619	1.679 / ⊖		WT. LOAD = 652**
		372.331									.302				.302 / ⊖		UPWARD FORCE ON PIPE = 728 -652 = 76 lbs
		2011.5								.010	.349				.359 / -.010		
48	Z SNB	79.734									1.679				1.679 / ⊖		
		372.331				4584			2992 / -1161		.302			4584 / -4584	.302 / ⊖		
		2010.409				3504		1441	⊖ / -6751		.306			3789 / -6751	.306 / ⊖		
60 (62)	PARALLEL SNB	81.234									1.767				1.767 / ⊖		
		370.858				4734		1947	⊖ / -9138		.348			5119 / -9138	.348 / ⊖		
		2010.409				6418			1228 / -1357		.306			6418 / -6418	.306 / ⊖		
60 (61)	⊥ SNB	81.234									1.767				1.767 / ⊖		
		370.858				4752			1005 / -908		.348			4752 / -4752	.348 / ⊖		
		2010.409									.306				.306 / ⊖		
60	Y SNB	81.234				⊖			⊖ / ⊖		1.767			⊖ / ⊖	1.767 / ⊖		
		370.858									.348				.348 / ⊖		

*SUPPORT LOCATIONS ARE GIVEN IN THE OVERALL PLANT COORDINATE SYSTEM
'ON PIPE' SUPPLIED BY STRESS INCLUDES A ± 12" TOLERANCE OR AS NOTED.
'PSG' IS LOCATION SHOWN ON PIPE SUPPORT DETAIL SHEET.
‡ S.A.M. = SEISMIC ANCHOR MOVEMENT ANALYSIS

** SEE SNUB NB 247
△2 REVISED SEISMIC AND FORCING FUNCTION LOADS DUE TO DELETION OF SNUBBERS AT D.P. 22.

Y, X, Z (coordinate axes)

	STRESS CALC. NO.	SNUMB NO.	DATE
THERM			
WEIGHT			
SEIS. INT.			
S.A.M.			
SUMMARY			

PF-1532 (10079) 9/76

△3 REVISED HYDRO-THERMAL LOADS CASE 3 △4 DELETED "Y" SNUBBER @ DATA POINT 60.

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Table 6.2-8a Pipe Support Design Loads Without A "Y" Snubber At Nodal Point 60

BECHTEL

SAN ONOFRE NUCLEAR GENERATING STATIO[illegible]TS 2 & 3
PIPE SUPPORT DESCRIPTIO[illegible] LIST
JOB NO. 10079

*1201-032-1
1201-034-1
1201-035-1

TITLE PRESSURE RELIEF VALVE LINE

PROBLEM NO. PSG-283
STRESS ISO DWG NO. *1201-032-1 PAGE ___ OF ___
ORIGINATOR [signature] DATE 6-22-82
CHECKER [signature] DATE 6-26-82 REV 4 DATE ___

PS NO. / DATA PT NO. / TAG NO.	SUPPORT TYPE / FORM NO. PER STDS	*SUPPORT LOCATION ON PIPE (N-S / ELEV / E-W)	*SUPPORT LOCATION PER P.S.G.	WEIGHT LOADS (X LBS / Y / Z)	HYDRO TEST LOADS	DBE LOADS (4) (2)	THERM LOADS	‡S.A.M. ~~LOADS DBE~~ ZPA (DBE)	OTHER LOADS (FORCING FUNCTION) (4) (3)	DBE MOV'T (X INCH / Y / Z)	THERM MOV'T	‡S.A.M. MOV'T DBE	OTHER MOV'T	(4) (3) DESIGN LOADS (2) (LBS)	DESIGN MOV'TS (INCHES)	APPR'L DATE	COMMENTS:
		2002.333				9512			7395/-6615		-.215			9512/-9512	Ø/-.215		
120	X SNB	81.234									1.790				1.79/Ø		
		372.331								.015	.393				.408/-.015		
		2002.333									-.215				Ø/-.215		
120	Y SNB	81.234				830			803/-245		1.790			830/-830	1.79/Ø		
		372.331								.015	.393				.408/-.015		
		2000.875				15270			1671/-2145		-.279			15270/-15270	Ø/-.279		
128	X SNB	81.234								.001	1.762				1.763/-.001		
		371.039									.350				.350/Ø		
		2000.875									-.279				Ø/-.279		HLD SPRING PRELOAD: 676 H.L.
128	Y SPR	81.234		-676	-845					.001	1.762			Ø/-845	1.763/-.001		WT. LOAD: 607 **
		371.039									.350				.350/Ø		UPWARD FORCE ON PIPE 676-607 = 69 lbs
		2000.875									-.279				Ø/-.279		
128	Z SNB	81.234								.001	1.762				1.763/-.001		
		371.039				1214		2400	237/-3989		.350			2690/-3989	.350/Ø		
		2011.5								.011	.325				.336/-.011		
143	Y SNB	74.5				5240		1649	19313/-5179		1.574			19313/-5492	1.574/Ø		
		372.331								.006	-.281				.006/-.287		

*SUPPORT LOCATIONS ARE GIVEN IN THE OVERALL PLANT COORDINATE SYSTEM 'ON PIPE' SUPPLIED BY STRESS INCLUDES A ± 12" TOLERANCE OR AS NOTED.
'PSG' IS LOCATION SHOWN ON PIPE SUPPORT DETAIL SHEET.
‡ S.A.M. = SEISMIC ANCHOR MOVEMENT ANALYSIS

** SEE SPEC DB-47
(2) REVISED SEISMIC AND FORCING FUNCTION LOAD
(3) REVISED HYDRO-THERMAL LOADS CASE 3
(4) DELETED "Y" SNUBBER @ DATA POINT 60

Z, Y, Z, X

	STRESS CALC. NO.	SNUMB NO.	DATE
THERM			
WEIGHT			
SEIS. INT.			
S.A.M.			
SUMMARY			

PF-1532 (10079) 9/76

Table 6.2-8b Pipe Support Design Loads Without A "Y" Snubber At Nodal Point 60

BECHTEL

SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 & 3
PIPE SUPPORT DESCRIPTION LIST
JOB NO. 10079

* 1201-032-1
1201-034-1
1201-035-1

PROBLEM NO. PSG-283
STRESS ISO DWG NO. 1201-032-1 PAGE ___ OF ___
ORIGINATOR [signature] DATE 6-22-82
CHECKER [signature] DATE 6-23-82 REV 4 DATE ___

TITLE PRESSURE RELIEF VALVE LINE

PS NO. / DATA PT NO. / TAG NO.	SUPPORT TYPE / FORM NO. PER STDS	*SUPPORT LOCATION ON PIPE (N-S / ELEV / E-W)	PER P.S.G.	WEIGHT LOADS (X / Y / Z) LBS	HYDRO TEST LOADS	DBE LOADS ⚠4 ⚠2	THERM LOADS	‡S.A.M. LOADS ~~DBE~~ ZPA (DBE)	OTHER LOADS FORCE ⚠2 ⚠3 ⚠4	DBE MOV'T (X / Y / Z) INCH	THERM MOV'T	‡S.A.M. MOV'T DBE	OTHER MOV'T	DESIGN ⚠4 ⚠3 ⚠2 LOADS (LBS)	DESIGN MOV'TS (INCHES)	APPR'L DATE	COMMENTS:
		2011.5								.021	.486				.507 / -.021		MIN SPRING PRELOAD: 910 lbs.
157	Y SPR	59.417		-910	-2313						1.407			⊖ / -2313	1.407 / ⊖		WT. LOAD: 740 **
		376.331									-1.547				⊖ / -1.547		UPWARD FORCE ON PIPE: 910 - 740 = 170 lbs
		2011.5				3248			1839 / -4898		.465			3248 / -4898	.465 / ⊖		
160	X SNB	59.417									1.256				1.256 / ⊖		
		379.831									-1.384				⊖ / -1.384		
		2011.5									.465				.465 / ⊖		
160	Y SNB	59.417				478			85 / -565		1.256			478 / -565	1.256 / ⊖		
		379.831									-1.384				⊖ / -1.384		
		2011.5								.013	.466				.419 / -.013		
165	Z SNB	59.417								.002	.926				.928 / -.002		
		387.331				1580			5 / -17593		-1.036			1580 / -17593	⊖ / -1.036		
		2011.5				2238			3613 / -689		.340			3613 / -2238	.340 / ⊖		
170	X SNB	59.417									.578				.578 / ⊖		
		394.831									-.687				⊖ / -.687		
		2011.5									.340				.340 / ⊖		
170	Y SNB	59.417				168			237 / -60		.578			237 / -168	.578 / ⊖		
		394.831									-.687				⊖ / -.687		
		2011.5								.002	.316				.318 / -.002		
173	Y SPR	59.417		-807	-2136					.001	.554			⊖ / -2136	.555 / -.001		
		397.831									-.548				⊖ / -.548		

*SUPPORT LOCATIONS ARE GIVEN IN THE OVERALL PLANT COORDINATE SYSTEM
'ON PIPE' SUPPLIED BY STRESS INCLUDES A ± 12" TOLERANCE OR AS NOTED.
'PSG' IS LOCATION SHOWN ON PIPE SUPPORT DETAIL SHEET.
‡ S.A.M. = SEISMIC ANCHOR MOVEMENT ANALYSIS

** SEE SNUB NB 247
⚠2 REVISED SEISMIC AND FORCING FUNCTION LOADS
⚠3 REVISED HYDRO-THERMAL LOADS CASE 3
⚠4 DELETED "Y" SNUBBER @ DATA POINT 60

	STRESS CALC. NO.	SNUMB NO.	DATE
THERM			
WEIGHT			
SEIS. INT.			
S.A.M.			
SUMMARY			

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Table 6-2-8C Pipe Support Design Loads Without A "Y" Snubber At Nodal Point 60

SAN ONOFRE NUCLEAR GENERATING STATION U[illegible] & 3

PIPE SUPPORT DESCRIPTION LIST

JOB NO. 10079

*1201-032-1
1201-034-1
1201-035-1

PROBLEM NO. PSG - 283

STRESS ISO DWG NO. *1201-032-1 PAGE ____ OF ____

ORIGINATOR J. Liao DATE 6-22-82

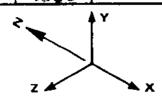
CHECKER [illegible] DATE 6-23-82 REV 4 DATE ____

TITLE PRESSURE RELIEF VALVE LINE

PS NO. / DATA PT NO. / TAG NO.	SUPPORT TYPE / FORM NO. PER STDS	*SUPPORT LOCATION ON PIPE (N-S / ELEV / E-W)	*SUPPORT LOCATION PER P.S.G.	WEIGHT LOADS (X / Y / Z) LBS	HYDRO TEST LOADS	DBE LOADS ④ ②	THERM LOADS	‡S.A.M. LOADS DBE ZPA (DBA)	OTHER LOADS FORCING FUNCTION ⑤ ②	DBE MOV'T (X / Y / Z) INCH	THERM MOV'T	‡S.A.M. MOV'T DBE	OTHER MOV'T	DESIGN ④ LOADS ② (LBS)	DESIGN MOV'TS (INCHES)	APPR'L DATE	COMMENTS:
		2007.67							④		.120				.120 ⊖		
180	Y SNB	59.417				464			530 / -105		.529			530 / -464	.529 ⊖		
		406.078									-.120				⊖ -.120		
		2007.67				838		1044	2962 / -1993		.120			2962 / -1993	.120 ⊖		
180 (181)	PARALLEL SNB	59.417									.529				.529 ⊖		
		406.078				838		1044	1993 / -2962		-.120			1993 / -2962	⊖ -.120		
		2007.67		-55	19	120	1174		1448 / -83		.120			1448 / -1140	.120 ⊖		
180 (182)	⊥ RAD	59.417									.529				.529 ⊖		
		406.078		-55	19	120	1174		1448 / -83		-.120			1448 / -1140	⊖ -.120		
		2008.333				4698			2185 / -7230		.146			4698 / -7230	.146 ⊖		
225	X SNB	78.667									1.906				1.906 ⊖		
		372.331								.081	.123				.204 -.081		
		2008.333									.146				.146 ⊖		
225	Y SNB	78.667				3560		609	7706 / -1757		1.906			7706 / -3612	1.906 ⊖		
		372.331								.081	.123				.204 -.081		
		2008.333									.146				.146 ⊖		MIN. SPRING PRELOAD = 10% HC
225	Y SPR	78.667		-708	-1057						1.906			⊖ / -1057	1.906 ⊖		WT. LOAD = 357** UPWARD FORCE ON PIPE =
		372.331								.081	.123				.204 -.081		708 - 357 = 351 lbs
		2008.333									.194				.197 -.003		
227	Z SNB	73.323									1.663				1.663 ⊖		
		372.331				2246			179 / -356		-.365			2246 / -2246	⊖ -.365		

*SUPPORT LOCATIONS ARE GIVEN IN THE OVERALL PLANT COORDINATE SYSTEM
'ON PIPE' SUPPLIED BY STRESS INCLUDES A ± 12" TOLERANCE OR AS NOTED.
'PSG' IS LOCATION SHOWN ON PIPE SUPPORT DETAIL SHEET.
‡ S.A.M. = SEISMIC ANCHOR MOVEMENT ANALYSIS

** SEE SHOE [illegible]
② REVISED SEISMIC AND FORCING FUNCTION LOADS
③ REVISED HYDRO, THERMAL LOADS CASE 3
④ DELETED "Y" SNUBBER @ DATA POINT 60



	STRESS CALC. NO.	SNUMB NO.	DATE
THERM			
WEIGHT			
SEIS. INT.			
S.A.M.			
SUMMARY			

PF-1532 (10079) 9/76

Table 6.2-8d Pipe Support Design Loads Without A "Y" Snubber At Nodal Point 60

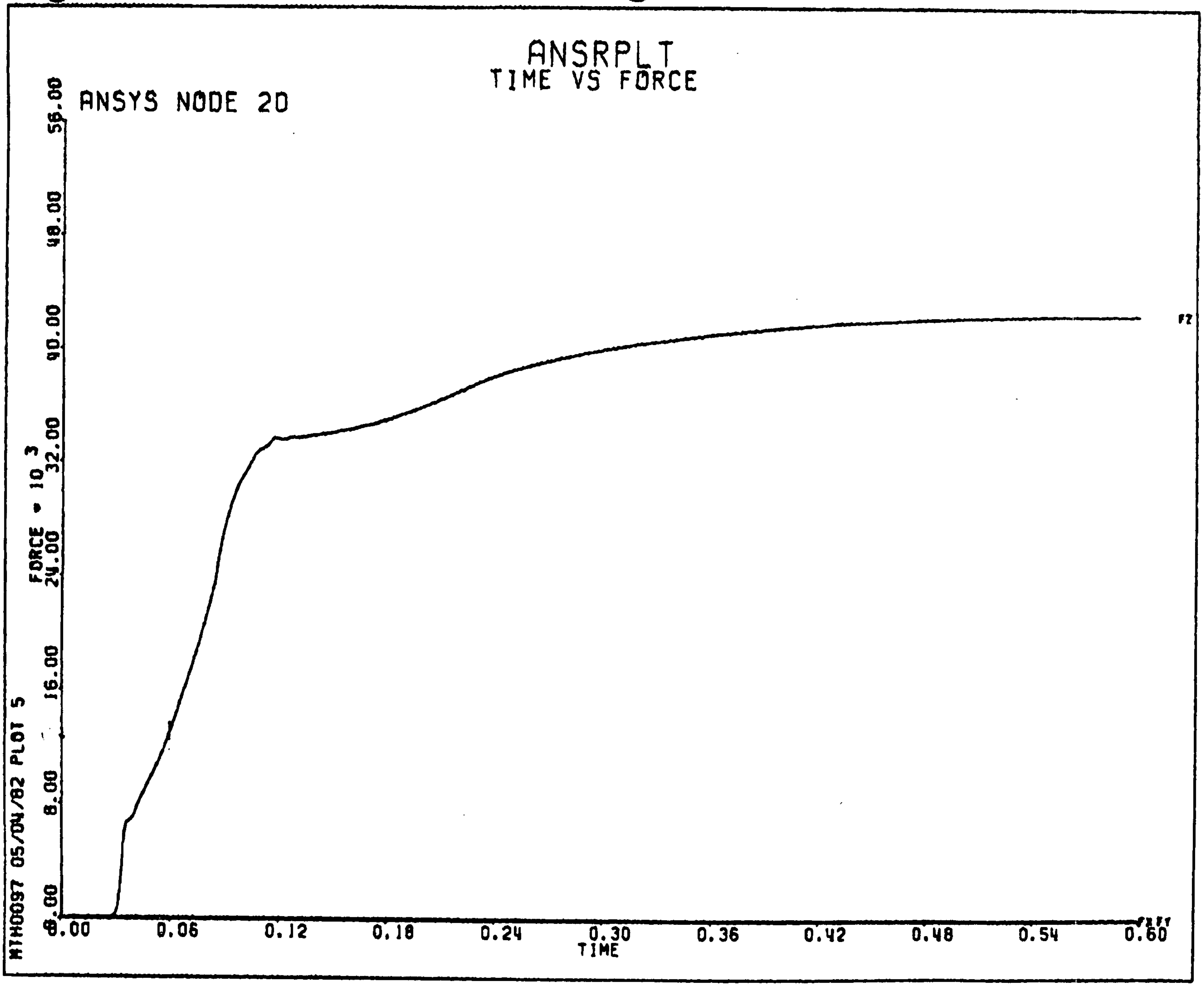


Figure 6.1-1 FORCE-TIME HISTORY PLOT (CASE 1)

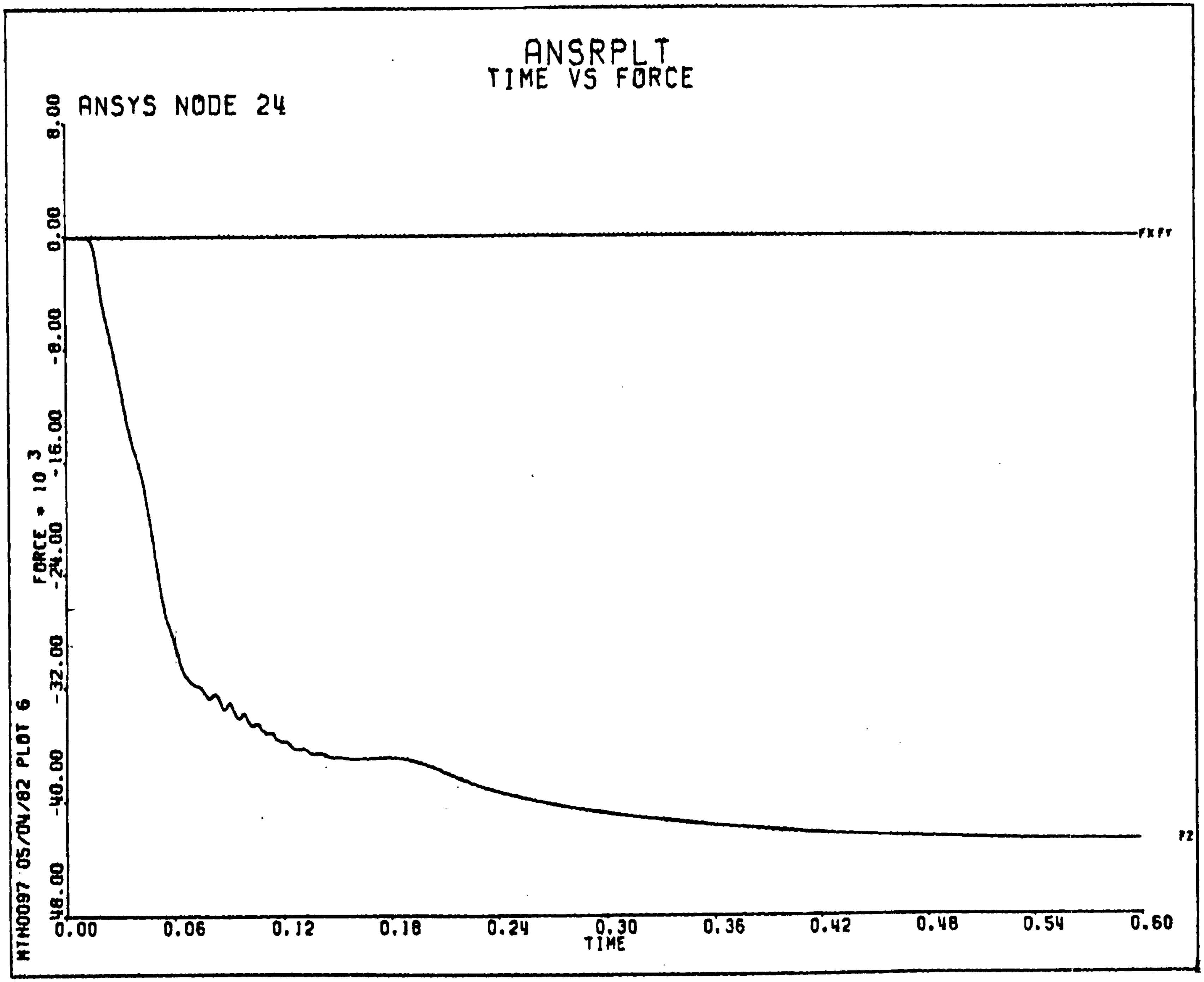


Figure 6.1-2 FORCE-TIME HISTORY PLOT (CASE 1)

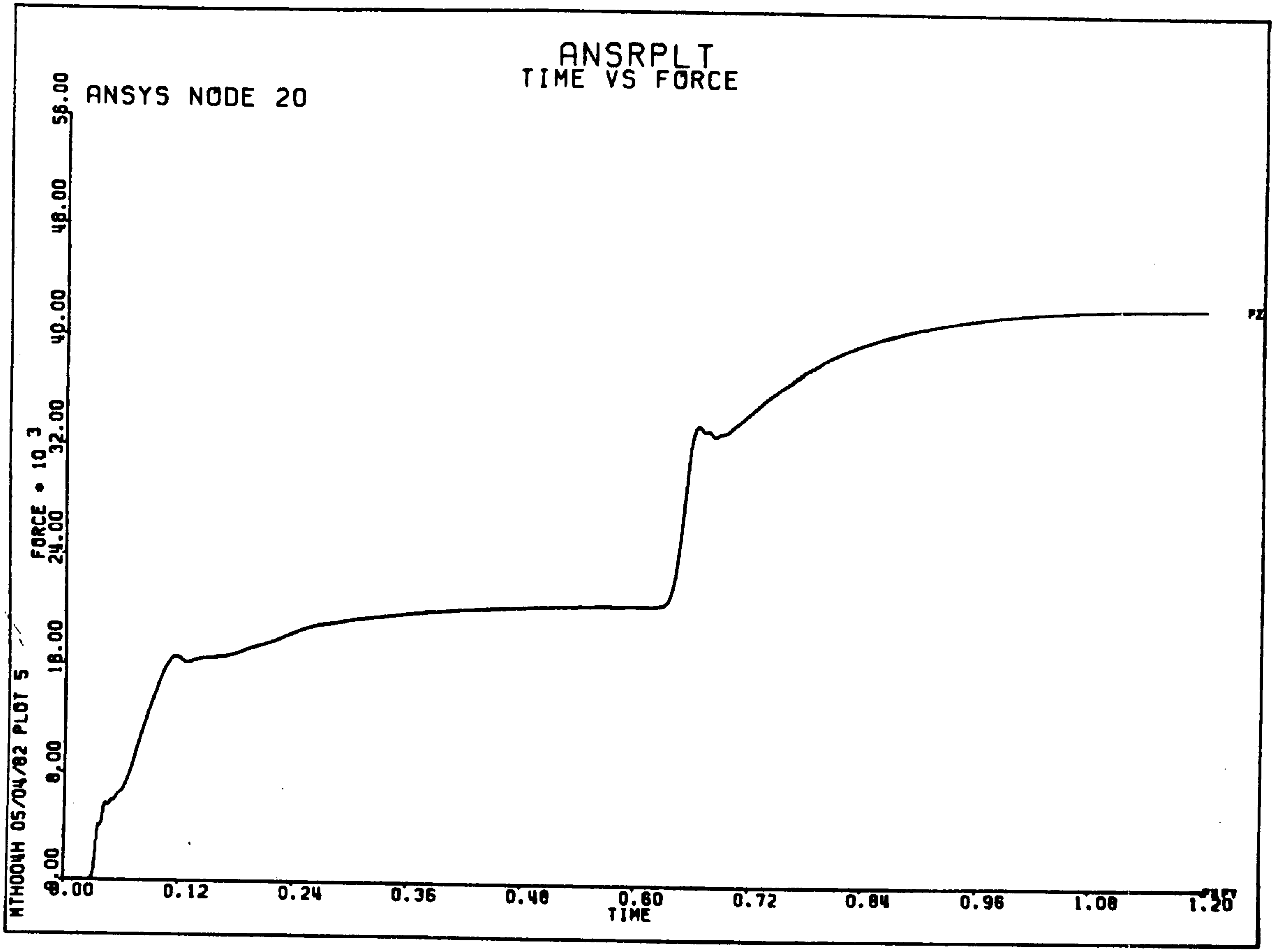


Figure 6.1-3 FORCE-TIME HISTORY PLOT (CASE 2)

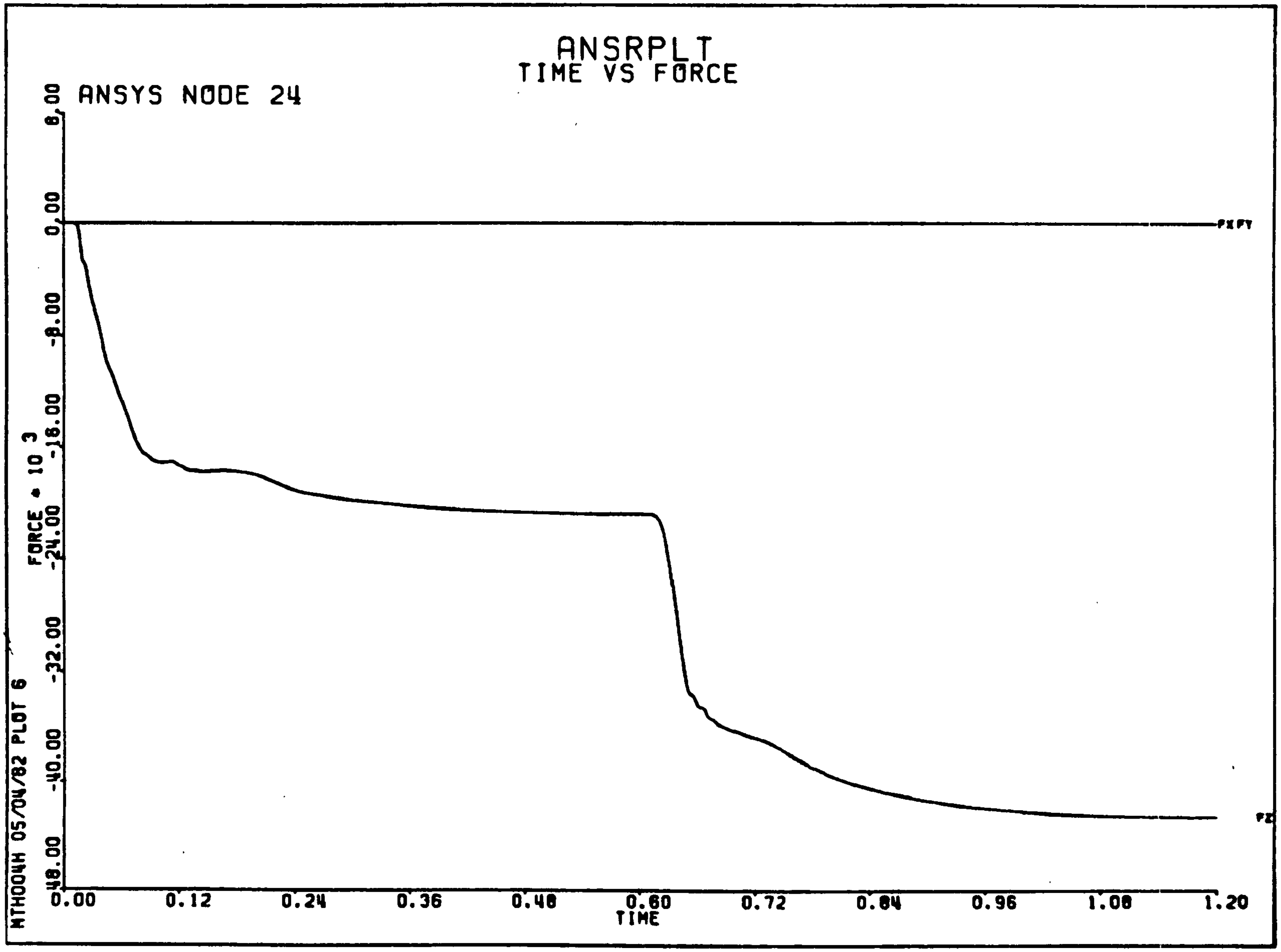


Figure 6.1-4 FORCE-TIME HISTORY PLOT (CASE 2)

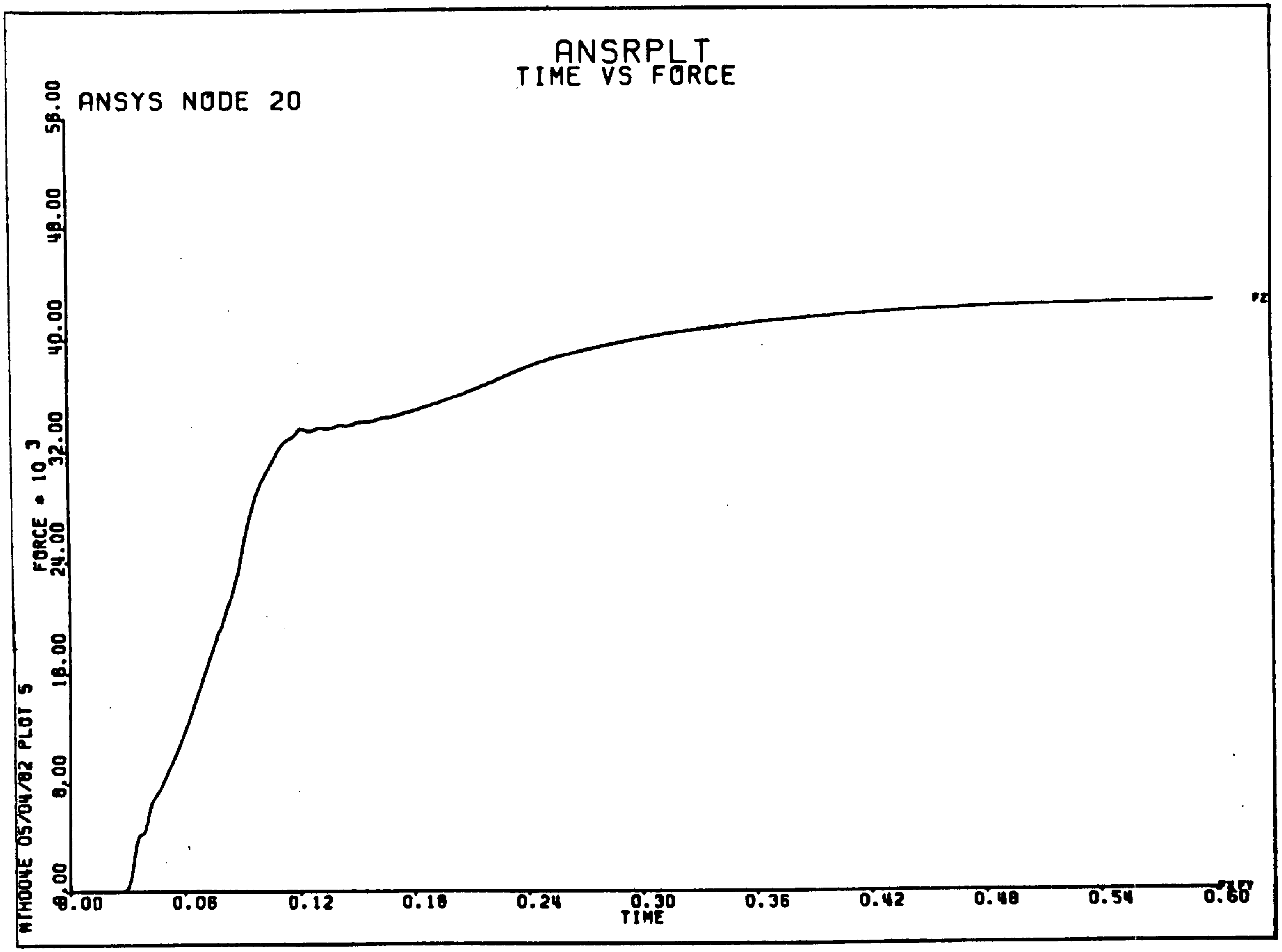


Figure 6.1-5 FORCE-TIME HISTORY PLOT (CASE 3)

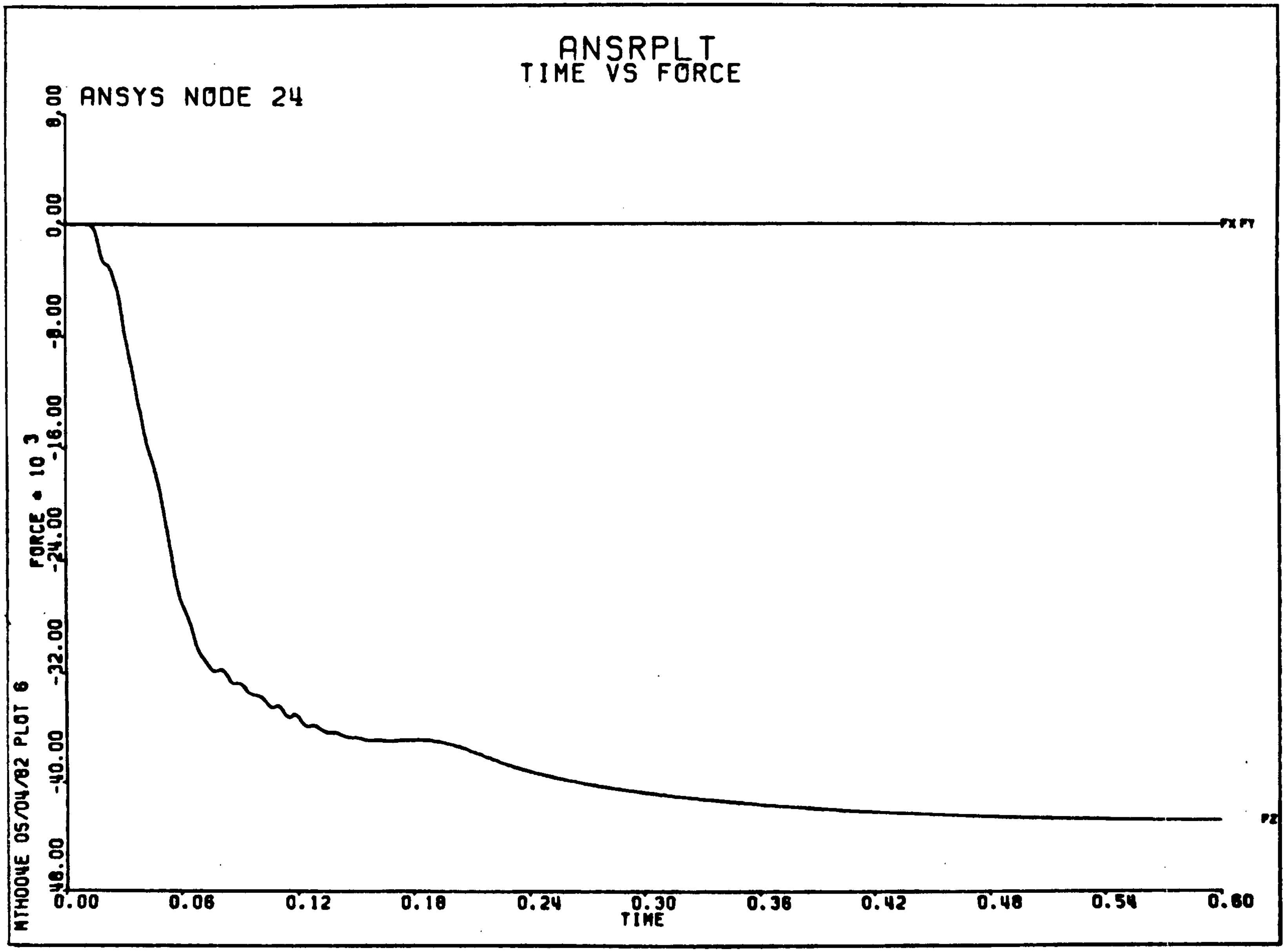
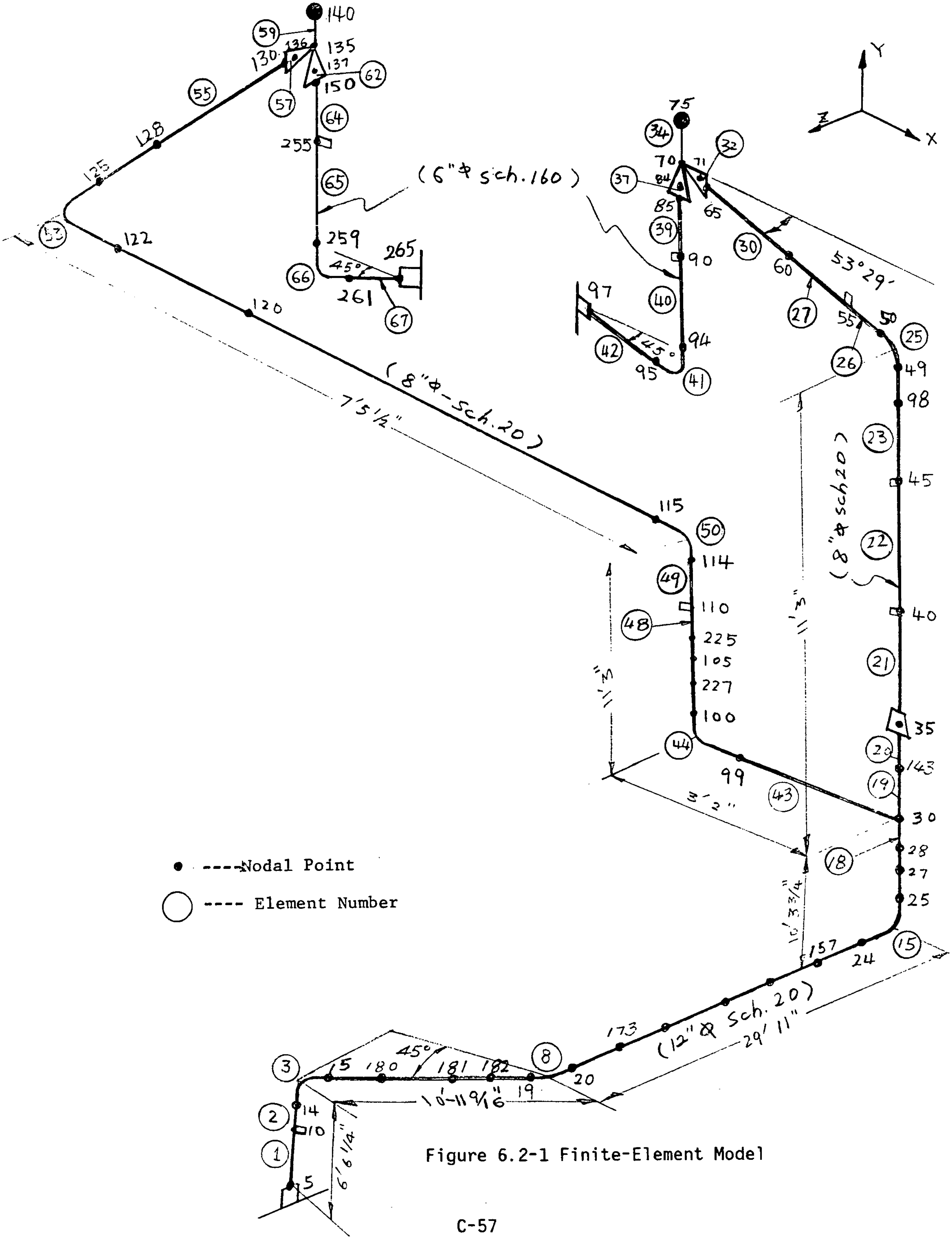


Figure 6.1-6 FORCE-TIME HISTORY PLOT (CASE 3)



● ----Nodal Point

◯ ---- Element Number

Figure 6.2-1 Finite-Element Model

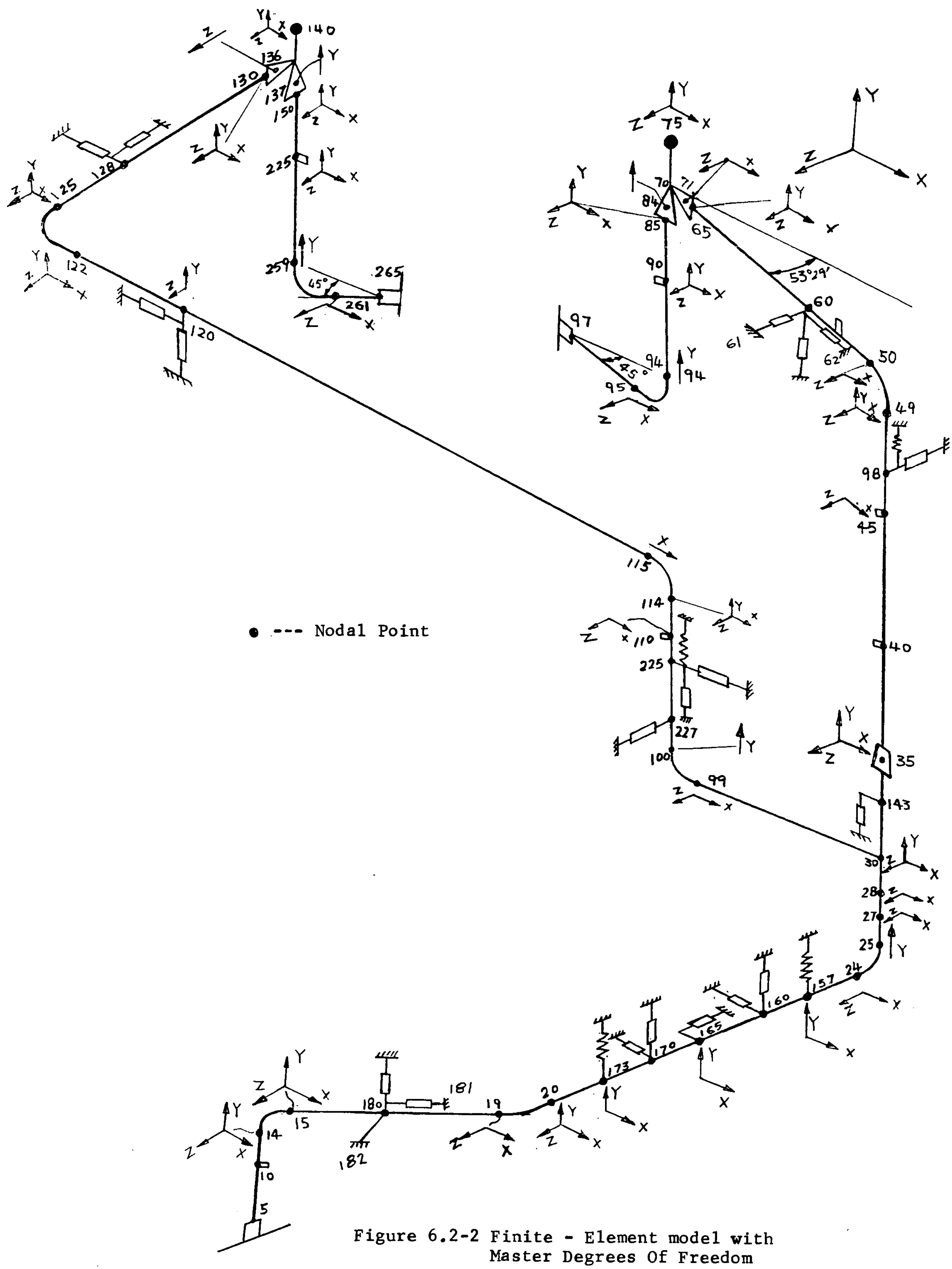


Figure 6.2-2 Finite - Element model with
Master Degrees Of Freedom

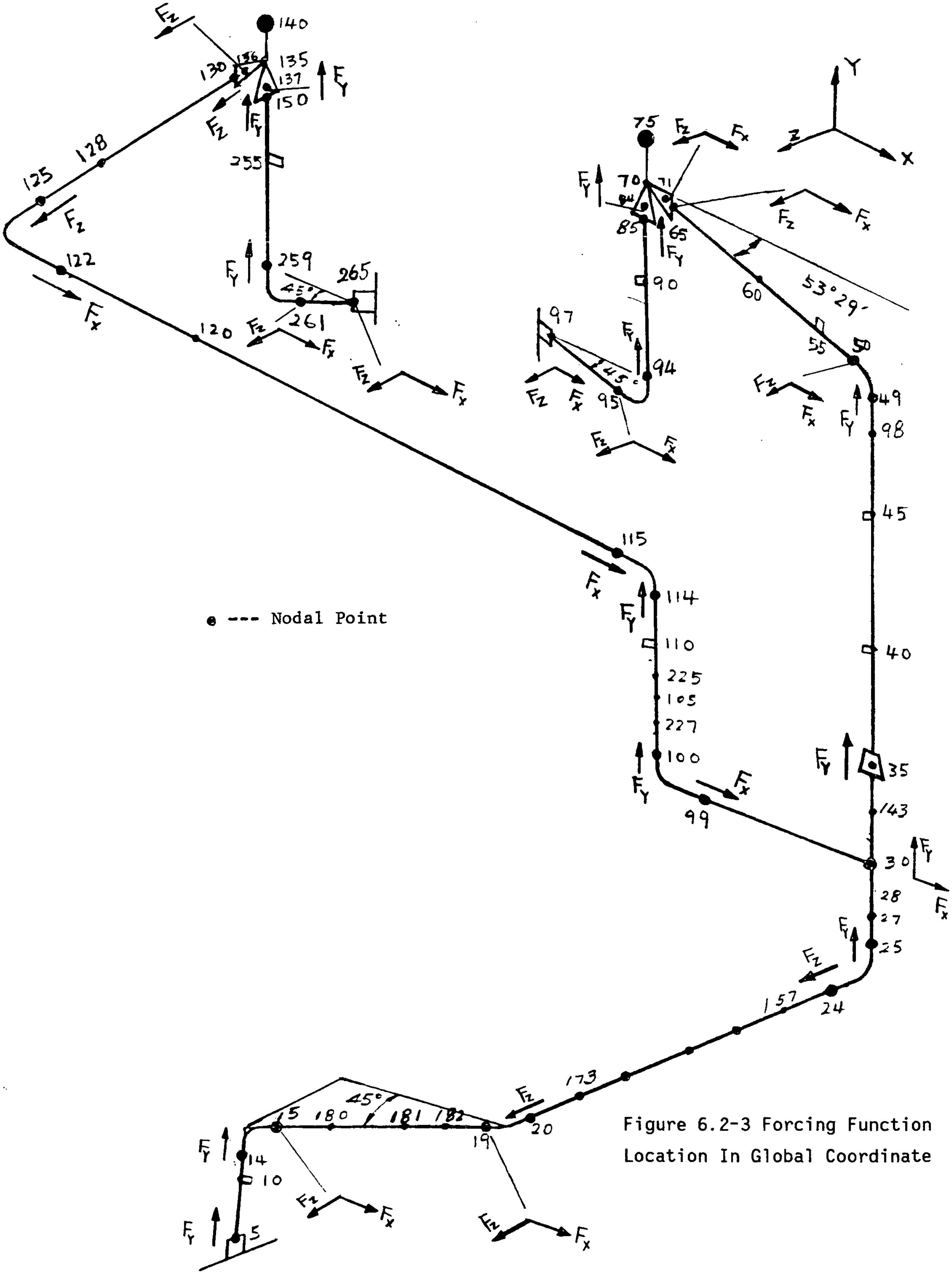


Figure 6.2-3 Forcing Function Location In Global Coordinate

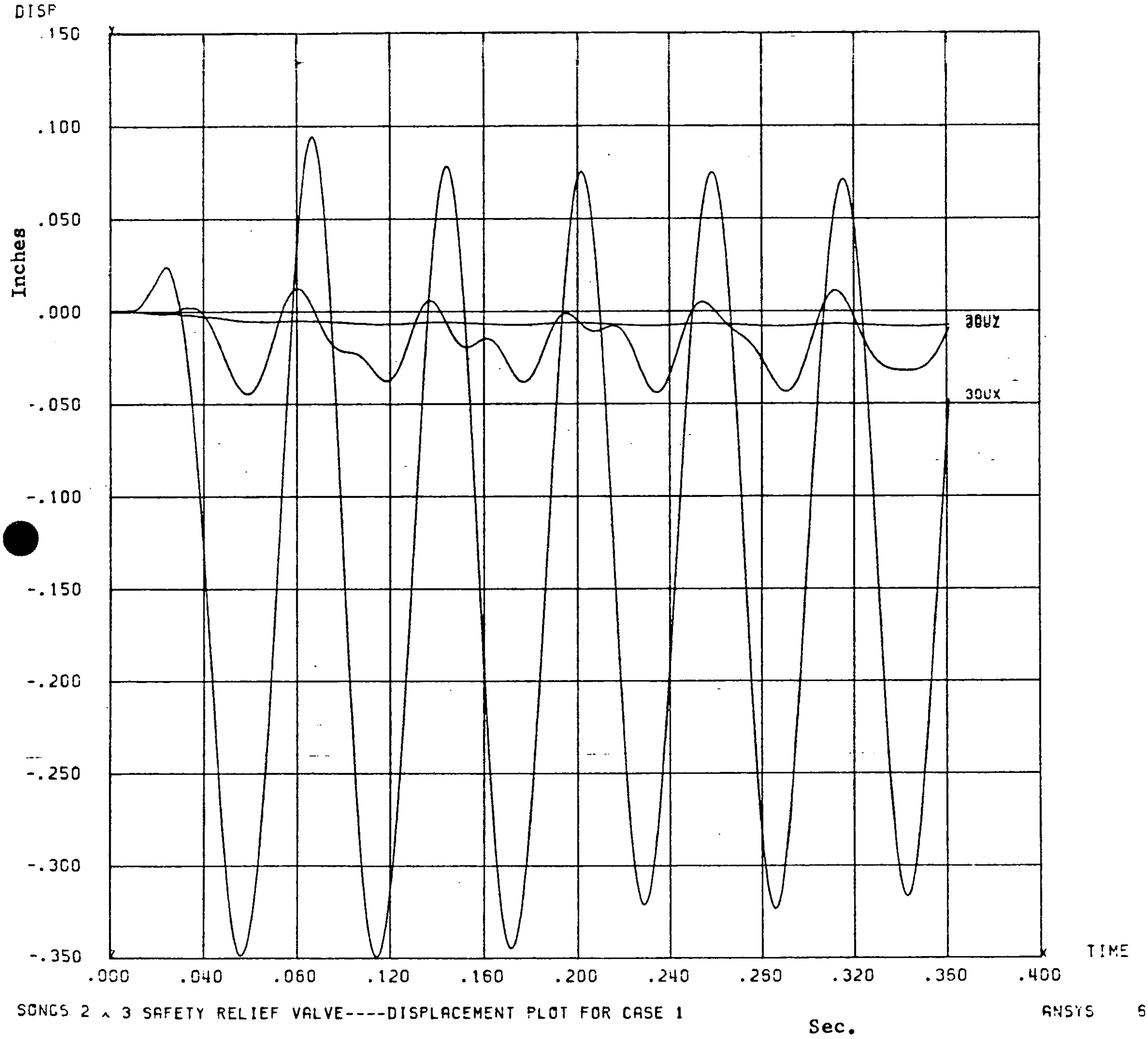


Figure 6.2-4 Displacement vs. Time Plot At Modal Point 30 For Case 1

7.0 SUMMARY

The dynamic forcing functions on the San Onofre Units 2&3 discharge piping system during the safety valve discharge event were generated by RELAP4/ANSYR under a saturated steam condition. These dynamic forcing functions were used as input loads for the dynamic structural analysis using the ANSYS code. Three (3) cases (see section 6.1) with different valve operating sequences were analyzed. Case 3 and Case 1 represent the critical cases. Although the results due to Case 3 were used as the design base in this report, it is noted that: i) Case 3 is only marginally more conservative than Case 1, ii) Case 3 is not probable due to short time frame for occurrence (i.e., 16 msec safety valve opening time). The results of the evaluation are summarized as follows:

a. The RELAP4/ANSYR Code was used to model the EPRI sample case, test number 1411. The comparison of results between RELAP4/ANSYR and RELAP5/MOD1 show that the safety valve discharge dynamic loads obtained from the RELAP4/ANSYR run are conservative based upon a saturated steam condition.

b. The analysis showed that the highest displacement and maximum stress occurred at nodal point 30. The highest support reaction loads occurred at nodal points 60 and 143. However, the analysis also showed that loads experienced by a vertical snubber at nodal point 60 exceeded the manufacturer's recommended load rating.

c. A reanalysis showed that removal of the "Y" snubber at nodal point 60 did not jeopardize the capability of the safety valve discharge piping to withstand the safety valve operation. Accordingly, this snubber has been deleted from the San Onofre Units 2 and 3 Safety Valve discharge piping configuration.

8.0 CONCLUSION

All components of the pressurizer safety valve discharge piping, when subjected to dynamic loads due to safety valve discharge, satisfy the requirements of Power Piping Code ANSI B31.1. The safety valve discharge piping system including pipe supports, snubbers, and their structures can safely withstand safety valve operation.

REFERENCES

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3. "Assessment of Analysis Methods for PWR Safety/Relief Valve Discharge Piping", EPRI Report, NP-80-9-LD, Dec., 1980.

4. "ANSYS Engineering Analysis System", Rev. 3, Swanson Analysis Systems, Inc. Houston, Pa. July 1979.

5. RELAP5/MOD1 Codes Manual" EG&G, Idaho, November, 1980.

6. "Application of RELAP5/MOD1 for Calculation of Safety and Relief Valve Discharge Piping Hydrodynamic Loads", Intermountain Technologies, Inc. March, 1982.

7. EPRI letter to Utility Technical and Licensing Contracts, PWR NSSS primary contracts and Dresser Industries, dated Feb. 18, 1982, attachments 1 and 2.

8. EPRI letter to Utility Technical Contacts Piping subcommittee members dated Nov. 5, 1981, attached Note 2.

9. ME101, "Linear Elastic Analysis of Piping Systems" Ver. H3, Bechtel Power Corporation, Jan., 1981.