John D. O'Toole
Vice President

Consolidated Edison Company of New York, Inc.
4 Irving Place, New York, NY 10003
Telephone (212) 460-2533

July 1, 1982

Re: Indian Point Unit No. 2
Docket No. 50-247

Director of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

ATTN: Mr. Steven A. Varga, Chief
Operating Reactors Branch No. 1
Division of Licensing

Dear Mr. Varga:

This letter and enclosures represent part of our response to meet the July 1, 1982 submittal requirements of NUREG-0737 Item II.D.1. As indicated in our April 1, 1982 submittal, Consolidated Edison is a participant in the Generic PWR Safety and Relief Valve Test Program implemented by the Electric Power Research Institute (EPRI). The tests have been completed and the EPRI reports describing the results of these tests have been transmitted to you. (These generic reports were cited in our April 1, 1982 submittal).

Following the completion of the EPRI tests, Consolidated Edison initiated plant specific evaluations for the Indian Point Unit No. 2. The scope of the evaluations included pressurizer safety and relief valves, their associated piping and support, and block valves. This effort is still on-going, and the current status of each task is as follows:

1. Plant Specific Evaluation of Safety and Relief Valves:

   This task is completed and the report of the evaluation is provided in Enclosure 1.

2. Plant Specific Evaluation of Block Valves:

   This evaluation is still on-going with a final report scheduled for submittal on or before September 15, 1982.

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3. Plant Specific Evaluation of Piping & Supports:

This effort is on-going with additional analysis required to be completed by our consultant. Enclosure 2 provides a brief description of the piping stress analysis, the analytical method, action plan and the status of the evaluation. As indicated in the report, preliminary results show that the original design loads are either conservative or are of the same order of magnitude as the loads being calculated now. In addition the calculated maximum upstream pressure is significantly below the maximum permissible pressure. Upon completion of the thermal hydraulic analysis, detailed comparisons will be made. The final report for this task is also scheduled to be submitted on or before September 15, 1982.

We also wish to inform you of the current compliance status of NUREG-0737 Items II.B.3, "Post Accident Sampling" and II.F.1, Attachment 6, "Containment Hydrogen Monitor". By letter dated April 1, 1982, Con Edison provided estimated dates for completion of these two items of July 15, 1982 and June 30, 1982, respectively. However, due to planned installation of a sump gear pump to facilitate flow of liquid waste from the analysis panels, the addition of a boron analyzer to the Post Accident Sampling System, and the installation of two (2) new recorders for the Containment Hydrogen Concentration Monitor System, the estimated completion dates for these items have been revised. Our best estimate for completion of these Task Items is prior to returning the Unit to service from the upcoming Fall 1982 refueling/maintenance outage.

Should your or your staff have any questions, please contact us.

Very truly yours,

John D. O'Toole
Vice President

ENCLOSURE 1

PWR SAFETY AND RELIEF VALVE
ADEQUACY REPORT
FOR
CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.
INDIAN POINT UNIT 2

July 1, 1982

1.0 INTRODUCTION

In accordance with the initial recommendation of NUREG 0578, Section 2.1.2 as later clarified by NUREG 0737, item II.D.1 and revised September 29, 1981, each Pressurized Water Reactor (PWR) Utility was to submit information relative to the pressurizer safety and relief valves in use at their plant on or before July 1, 1982. Specifically, this submittal should include an evaluation supported by test results which demonstrate the capability of the relief and safety valves to operate under expected operating and accident conditions.

The primary objective of the Electric Power Research Institute (EPRI) test program was to provide full scale test data confirming the functionability of the primary system power operated relief valves and safety valves for expected operating and accident conditions. The second objective of the program was to obtain sufficient piping thermal hydraulic load data to permit confirmation of models which may be utilized for plant specific analysis of safety and relief valve discharge piping systems. Relief valve tests were completed in August 1981 and safety valve tests were completed in January 1982. Reports have been prepared by EPRI which document the results of the test program. Additional reports were written to provide necessary justification for test valve selection and valve inlet fluid test conditions. These reports were transmitted to the USNRC by David Hoffman of the Consumers Power Company on behalf of the participating PWR Utilities and are referenced herein.

This report provides the final evaluation of these and other submittals and reports prepared during the review of the test data as they apply to the valves used at Indian Point Unit 2.

2.0 VALVE AND PIPING PARAMETERS

Table 2-1 provides a list of pertinent valve and piping parameters for the Indian Point Unit 2 Safety and Power-Operated Relief Valves. The PORV and safety valves installed at Indian Point Unit 2 were not specifically tested by EPRI; however, valves of a similar design and operation were tested in a configuration similar to that of the actual system configuration at the plant. Justification that the valves tested envelope those valves at Indian Point is provided in the Valve Justification report.(1) The justification was developed based on evaluation performed by the valve manufacturers and considered effects of differences in operating characteristics, materials, orifice sizes and manufacturing processes on valve operability.

Typical inlet piping configurations for Indian Point Unit 2 are provided in Figures 2.1-2.2.

Tables 2-2 and 2-3 compare the Indian Point Unit 2 inlet piping configuration with that of the EPRI test piping arrangement for the Crosby Safety Valves and compares the actual plant-specific pressure drop with the test pressure drop for the test valve arrangements.

As can be seen by these comparisons, the EPRI test piping arrangement envelopes the actual piping arrangement for the Indian Point Unit 2.

TABLE 2-1

VALVE AND PIPING INFORMATION

1. SAFETY VALVE INFORMATION

Number of valves	3
Manufacturer	Crosby
Type	Self-actuated
Size	4M6
Steam Flow Capacity, lbs/hr	408,000
Design Pressure, psig	2485
Design Temperature, ^{O}F	650
Set Pressure, psig	2485
Accumulation	3 percent of set pressure
Blowdown	5 percent of set pressure
Original Valve Procurement Spec.	E-676279

2. RELIEF VALVE INFORMATION

Number of Valves	2
Manufacturer	Copes-Vulcan
Type	Power Relief
Size	3 inch
Steamflow Capacity, lbs/hr	210,000
Design Pressure, psig	2485
Design Temperature, ^{O}F	650
Opening Pressure, psig	2335
Closing Pressure, psig	2315

3. SAFETY AND RELIEF VALVE INLET PIPING INFORMATION

Design Pressure, psig	2485
Design Temperature, °F	650
Configuration of Piping	A200644 and A200645
Pressurizer Nozzle Configuration	A200644 and A200645
Steady State Flow	
Pressure Drop	See Appendix 1
Acoustic Wave Pressure	
Drop	See Appendix 1

4. SAFETY AND RELIEF VALVE DISCHARGE PIPING INFORMATION

Design Pressure, psig	600
Design Temperature, °F	450
Configuration	A200644 and A200645
Pressurizer Relief Tank	
Design Pressure, psig	100
Backpressure, Normal, psig	3
Backpressure, Developed, psig	350

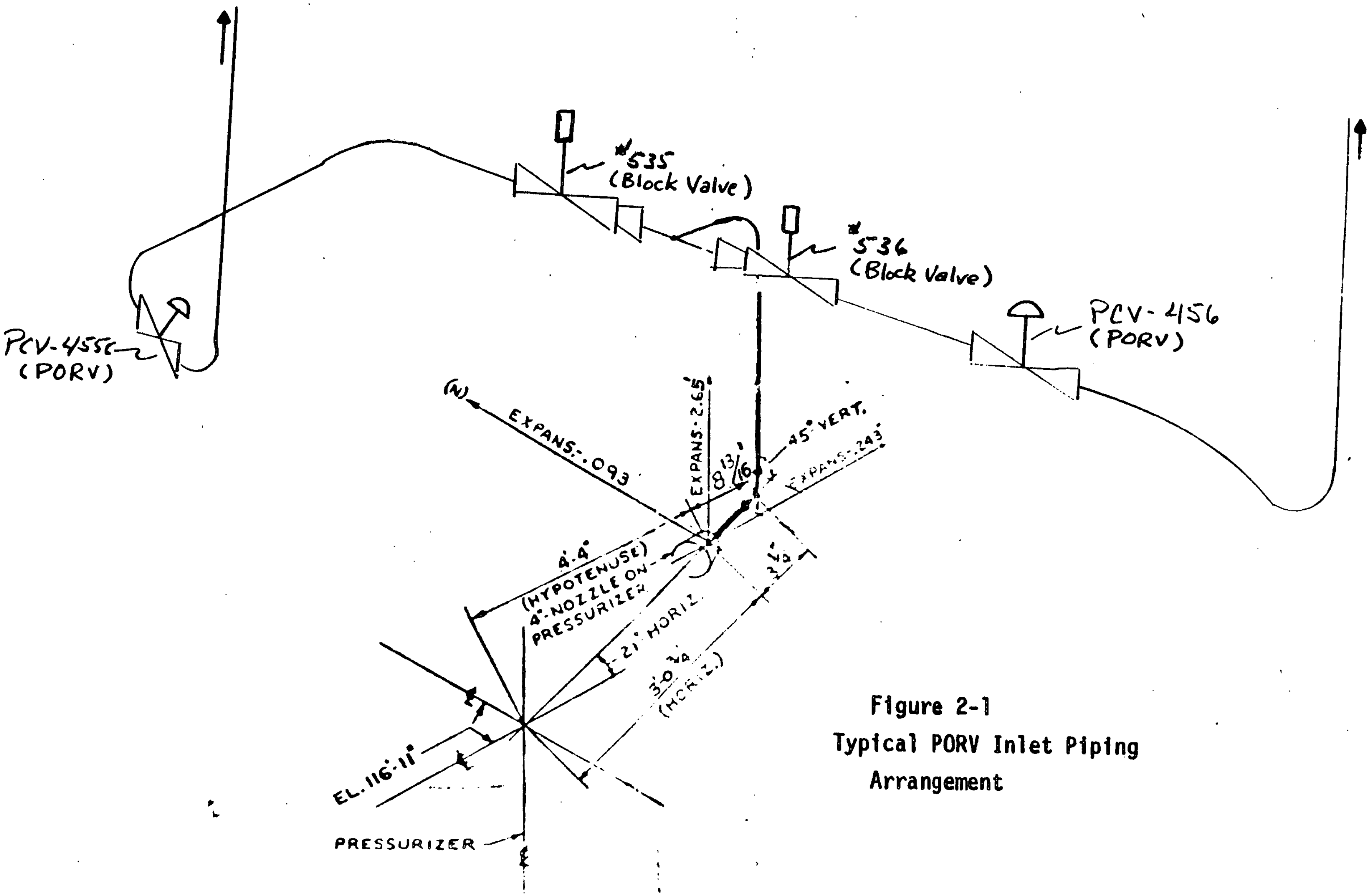

Figure 2-1
Typical PORV Inlet Piping Arrangement

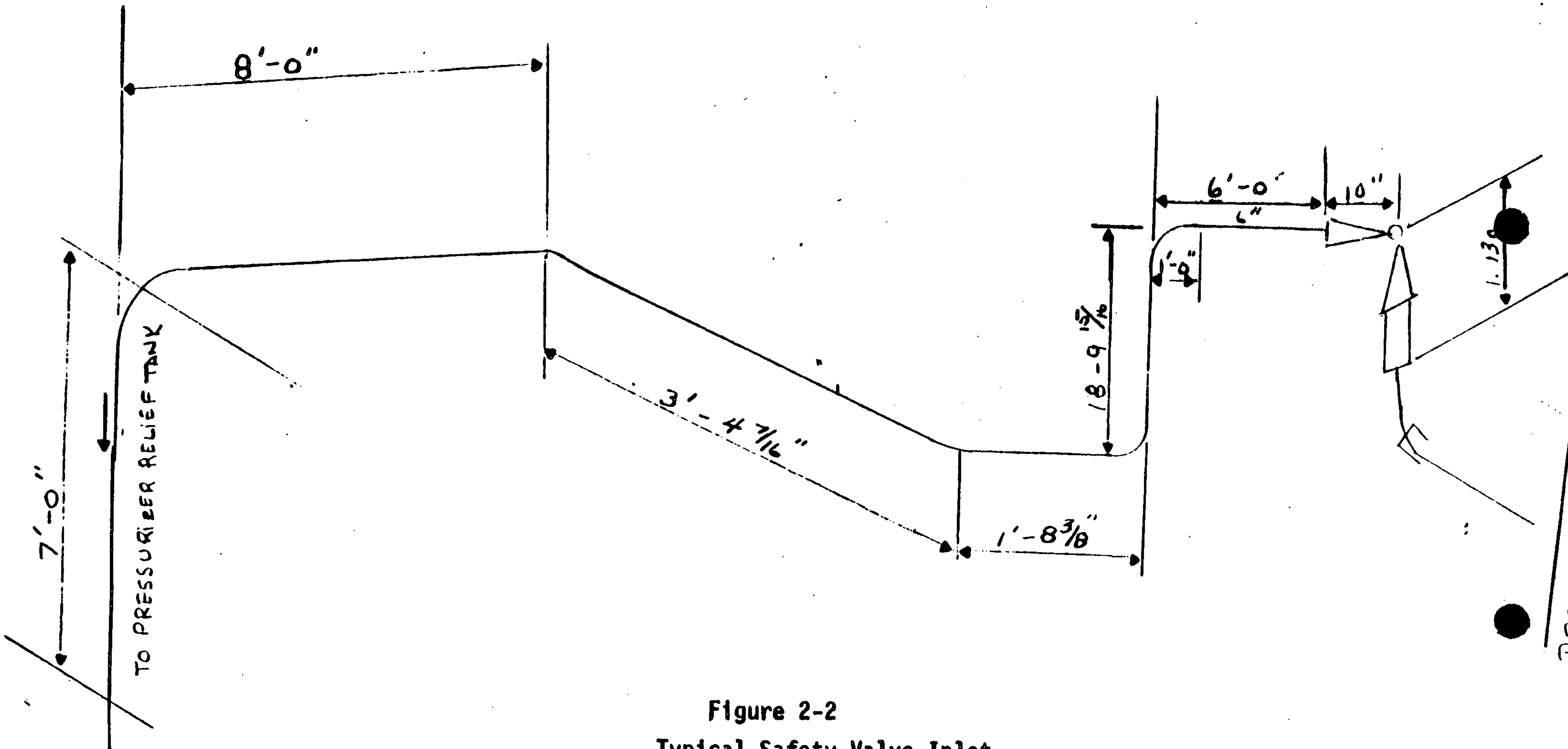

Figure 2-2
Typical Safety Valve Inlet
Piping Arrangement

TABLE 2-2

SAFETY VALVE INLET PIPING COMPARISON

	Typical Indian Point Inlet Piping	Crosby 3K6 Inlet Piping*	Crosby 6N8 Inlet Piping*
Length of straight pipe, in.	13	10	85
Number of 90° elbows	-	-	-
Number of 45° bends	1	-	-
Nozzles, Venturi, Reducer & Flange		Yes	Yes (withoutVenturi)

* Source: Reference (7.)

TALBE 2-3

COMPARISON OF TEST PRESSURE DROP WITH PLANT SPECIFIC PRESSURE DROP

Plant Specific* Pressure Drop	Crosby 3K6 Test Pressure Drop, psi	Crosby 6N8 Test Pressure Drop, psi
Indian Point 2		
164.50	56	270

* Appendix I
** Source: Reference (8)

3.0 VALVE INLET FLUID CONDITIONS

Justification for inlet fluid conditions used in the EPRI Safety and Relief Valve tests are summarized in References 2 and 3. These conditions were determined based on consideration of FSAR, extended High Pressure Injection, and Cold Overpressurization events, where applicable.

For plants of which Westinghouse is the NSSS supplier, a methodology was used such that a reference plant was selected for each grouping of plants considered.(3) Valve fluid conditions resulting from limiting FSAR events, which result in steam discharge and an Extended High Pressure Injection event which may result in liquid discharge, are presented for each reference plant. Use of reference plants results in fluid conditions enveloping those expected for Indian Point Unit 2.

Table 3-1 presents the results of loss of load and locked rotor analyses for four loop plants in which Indian Point Unit 2 was included. The inlet fluid conditions expected at the safety valve and PORV inlets are identified. The limiting Extended High Pressure Injection event was the spurious activation of the high-high head safety injection system at power. However, Indian Point Unit 2 does not have the high-high head safety injection system system and thus is not subject to this event. In general, safety valves open on steam and no liquid discharge is observed. Consequently, the design specification for safety valves in the Indian Point Unit 2 is for steam service only. Fluid inlet conditions for cold overpressure protection are provided in Table 3-2. Cold overpressure is not a design basis for the safety valves but is for the PROVs.

TALBE 3-1

VALVE INLET CONDITIONS FOR FSAR EVENTS RESULTING IN STEAM DISCHARGE

Reference Plant	Valve Opening Pressure (psia)	Maximum Pressurizer Pressure(psia)/ Limiting Event	Maximum Pressure Rate (psia/sec)/ Limiting Event
Safety Valves Only			
4-Loop	2500	2555/Loss of Load	144/Locked Rotor
Safety and Relief Valves			
4-Loop	2350	2532/Loss of Load	130/Locked Rotor

Source: Reference (2)

TABLE 3-2

PORV INLET CONDITIONS FOR COLD
OVERPRESSURE PROTECTION RESULTING IN WATER DISCHARGE

	Reactor Coolant Pressure (psig)	Temperature Range, °F
Unit 2	1500	about 290 max.

4.0 COMPARISON OF EPRI TEST DATA WITH PLANT-SPECIFIC REQUIREMENTS

The Electric Power and Research Institute (EPRI) conducted full scale flow tests on pressurizer safety and relief valves.[4] Tests were conducted at three sites over a period of 1-1/2 years. PORVs were tested at Marshall Steam Station[5] and Wyle Laboratories,[6,7] while safety valves were tested at the Combustion Engineering Test Site in Connecticut.[7]

4.1 Relief Valve Testing

Test results applicable to the PORVs installed in Indian Point Unit 2 are contained in Section 4.6 of Reference 7, Copes-Vulcan Relief Valve (316/Stellite Plug and 17-4PH Cage).Table 2-4 of Reference 7 identifies the test results of this test valve that are applicable to the Copes-Vulcan (316 stellite plug and Haynes No. 25 cage installed at Indian Point Unit 2.

This valve fully opened and closed on demand for each of the eleven evaluation tests at the Marshall Test Facility. Nine additional tests were conducted at the Wyle Test Facilitiy; during all of these tests the valve fully opened and closed on demand. Subsequent disassembly and inspection revealed no damage that would affect future valve performance.

A comparison of the "As-Tested" inlet fluid conditions for the Marshall and Wyle tests is provided in Table 4-1. This table indicates the Indian Point Unit 2 fluid conditions summarized in Section 3.0 of this report were tested. The results of this testing indicates the valves functioned satisfactorily, opening and closing on demand and discharging the required flow rate.

4.2 Safety Valve Testing

Test results applicable to the safety valves installed at Indian Point Unit 2 are contained in Section 3.3 and 3.6 of Reference 7. Although the Crosby 4M6 safety valve used in Indian Point Unit 2 was not specifically tested by EPRI, justification for extension of the EPRI test results to this valve was provided by the valve vendor.[1] As the Crosby 4M6 Safety valves at

Indian Point Unit 2 are installed on a short inlet pipe (without loop seals) the Crosby 3K6 and 6N8 Safety Valves tested by EPRI with steam internals will be used for comparison. This is consistent with EPRI remarks in paragraph 2.3.1 of Reference 7.

4.2.1 Crosby 3K6 Safety Valve (Steam Internals)

Fourteen tests were conducted on the Crosby 3K6 Safety Valve (Steam Internals) mounted on a short inlet pipe configuration.

Tests 406-411 were run at high and low ramp rates and high backpressure with the valve vendor's recommended ring settings. In these tests the valve had stable behavior and met the EPRI Screening criteria and closed with 10-11 percent blowdown. Subsequently, ring adjustments were made to lower the blowdown. These tests, 415-425, decrease the blowdown to 8 percent with the valve performance remaining stable. These final ring settings were maintained for the non-steam tests.

During the high back pressure, steam-to-water transition test, the valve was stable and closed with 8 percent blowdown.

Three high back pressure water tests were performed at 650 and 550°F. For the 650°F water test the valve opened, had stable performance and closed with 13 percent blowdown.

The valve then reopened at 2280 psia and had stable behavior. Closing data is not available.

Two 550°F water tests were conducted. For the first test the valve opened to a partial lift position and the pressure increased to 2750 when the test was terminated. In the second test the valve opened and chattered after which the test was terminated. No further attempts were made at any other ring positions.

4.2.2 Crosby 6N8 Safety Valve (Steam Internals)

Eight tests were conducted on the Crosby 6N8 Safety Valve mounted on a long straight inlet pipe configuration. Flow measurements were not taken during these tests as the flow venturi was not in place.

Five steam tests were conducted at ramp rates from 2-325 psi/sec. using three different ring settings. For all tests the valve opened and had stable performance achieving a lift position 96-97 percent of rated lift. For the "as-installed" ring settings blowdown ranged from 15 to 16.5 percent. Both tests at the as-installed ring positions were high back pressure tests.

The ring settings were modified twice to reduce blowdown. The last setting resulted in 9.6-9.8 percent blowdown. No further attempts were made to reduce blowdown any further. Using these "final" ring settings the transition and water tests were conducted.

One low ramp rate, high back pressure transition test was conducted. Four total actuations occurred and the valve showed stable behavior for each. The first actuation resulted in 8.5 percent blowdown. The other actuations resulted in opening pressures ranging from 2420-2480 psia and closing pressures ranging from 2120-2305 psia.

Two high backpressure water tests were run at 650 and 550°F.

The 650°F test had stable behavior and 20.8 percent blowdown. The 550°F test opened at 2526 psia and chattered. No further tests were tried at any other ring settings.

4.2.3 Discussion of Observed Safety Valve Performance

In addressing observed valve performance, one must differentiate between the valves and fluid conditions tested and the actual valves and actual fluid conditions for the specific plant. The EPRI inlet piping arrangement, flow and acoustic pressure drops, and inlet fluid conditions bound the same plant-specific parameters for the Indian Point units. Valve performance observed during the EPRI tests, therefore, reflects worst case performance as compared to results that would be observed had the testing been conducted using actual plant-specific piping arrangements and fluid conditions.

A review of Table 4-3 shows the Crosby tested valves exhibited stable operation on a straight piping configuration at pressurization rates of 2.0-335 psi/sec with initial opening and pop pressures of (2417-2545) psi.

The EPRI data also indicates that steam flow rates in excess of rated flows are attainable.

Safety valve performance observed in the EPRI tests is addressed in Reference 9 for Westinghouse Plants and the results and conclusions of this report can be extended to Indian Point Unit 2. In general, the valves tested showed acceptable results, opening and closing on demand and passing rated flow.

Since the EPRI testing was conducted at enveloping fluid and piping conditions, adjustments were made to the safety valve ring positions in order to obtain stable valve performance on steam discharge for the test arrangement. These adjustments resulted in varying blowdowns for the test valves. The ring positions determined during the test represent the adjustment required for a particular valve when exposed to the particular test piping arrangement, fluid conditions, backpressure and pressurization rate. For Indian Point Unit 2, the adjustment of ring setting is being reviewed with the valve manufacturer (Crosby) and Westinghouse to assure adequate valve performance.

An investigation was conducted to determine those parameters which are critical to the onset of valve chatter under steam discharge conditions. The results of this study are detailed in Reference 9.

Finally, acceptable steam/water transition and 650°F solid water performance was obtained for the test valves, even though no attempt was made to optimize ring settings.

TABLE 4-1

COMPARISON OF PORV INLET FLUID CONDITIONS
WITH "AS-TESTED" CONDITIONS

Steam Conditions

	PORV Inlet Fluid Conditions	Wyle Test 71-CV-316-1S	Marshall Test (No. 1-No. 11)
Set Point Pressure (psig)	2335	2700	(2420-2460)
Temperature (°F)	650	682	(sat.)
Fluid Type	steam	steam	steam
Flow Rate (lbs/hr)	210,000	255,600	(232,000-236,000)

Water Conditions

	PORV Inlet Fluid Conditions		Wyle Tests 77-CV-316-7S/W	79-CV-316-9N/W
Set Point Pressure (psia)	2350	1500	2532	1533
Temperature (°F)	565-569	~290 max	670	299 (in accumulator) 262 (at valve inlet)
Fluid Type	Steam/water	GN_2/Water	Steam/Water	GN_2/Water
Flow Rate (lbs/hr)	113-1104(gpm)	-	540,000	864,000

TABLE 4-2

TABULATION OF OPENING/CLOSING TIMES FOR PORV

Test	Opening Time (Sec.)	Closing Time (Sec.)
Marshall		
1	1.70	1.60
2	1.70	1.50
3	1.75	1.50
4	1.65	1.55
5	1.85	1.60
6	1.80	1.50
7	1.40	1.60
8	1.40	1.55
9	1.40	1.60
10	1.70	1.65
11	1.45	1.50
Wyle		
71-CV-316-1S	0.60	1.43
72-CV-316-3W	0.65	1.31
73-CV-316-4W	1.01	0.60
74-CV-316-5W	0.98	0.66
75-CV-316-6W	0.64	1.44
76-CV-316-2W	0.72	1.38
77-CV-316-7S/W	0.70	1.37
78-CV-316-8W/W	0.61	1.44
79-CV-316-9N/W	0.78	0.88

Note: Required Opening Time - 2.0 Sec.
Required Closing Time - 2.0 Sec.

Source: Reference (7)

TABLE 4-3

COMPARISON OF SAFETY VALVE INLET FLUID CONDITIONS WITH "AS-TESTED" CONDITIONS

	Safety Valve Inlet Fluid Conditions	3K6 Tests 406-425	6N8 Tests 1202-1208
Set Point Pressure (psia)	2500	2500	2500
Temperature (°F)	650	650	650
Fluid Type	Steam	steam	steam
Flow Rate pct of Rated at 3 pct. accumulation	408,000 lb/hr	117-123%	*
Pressurization Rate (psi/sec)	130-144	1.6-335	2.0-325
Stability		Stable**	Stable**
Initial opening Pressure (psia)		2417-2545	2445-2487
Pop Pressure, (psia)		2417-2547	2447-2487

* Flow rate not reported, flow venturi removed.

** As reported by EPRI in Performance data tables of Reference (7).

NOTE: Chatter reported on Test 415. This was a high backpressure, high ramp rate test not representative of Indian Point Unit 2.

5.0 CONCLUSIONS

The preceeding sections of this report and the reports referenced herein indicate the valves, piping arrangements, and fluid inlet conditions for Indian Point Unit 2 are indeed bounded by those valves and test parameters of the EPRI Safety and Relief Valve Test Program. The EPRI tests confirm the ability of the Safety and Relief Valves to open and close under the expected operating fluid conditions.

APPENDIX

INLET PIPING PRESSURE EFFECTS(8)

1. Inlet Piping Flow Pressure Drop (ΔP_F)

The flow pressure drop is given by,

$$\Delta P_F = \frac{(k+1 + \frac{fL}{D})\, M^2}{2 g_c \rho A^2}$$

where,

- k = expansion or contraction loss coefficient (dimensionless)
- f = friction factor (dimensionless)
- $\frac{L}{D}$ = piping equivalent length/diameter considering effects of fittings and friction (dimensionless)
- M = maximum valve flowrate for steam (as established by the safety valve manufacturer) (lb/sec)
- g_c = gravitational constant (32.2 lb-ft/lb-sec^2)
- ρ = steam density at nominal valve set pressure (lb/ft^3)
- A = inlet piping flow area (ft^2)

2. Acoustic Wave Amplitude (ΔP_{AW})

The acoustic wave amplitude is calculated as follows. (8) There are two situations to consider:

- If $T_{op} \leq 2\, L/a$,

$$\Delta P_{AW} = \frac{aM}{g_c A}$$

- If $T_{op} > 2L/a$,

$$\Delta P_{AW} = \frac{2LM}{g_c A T_{op}}$$

where,

a = steam sonic velocity at nominal valve set pressure (ft/sec)

L = inlet piping length (ft)

T_{op} = valve opening time for steam inlet conditions as established from the EPRI testing effort is 10msec for the Crosby safety valves and 15msec for the Dresser safety valves. These valves are typical of the fastest opening times measured during the tests.

The other variables are the same as defined in the previous section.

3. Plant-Specific Pressure Drop

The plant-specific pressure drop associated with valve opening is equal to the sum of the friction pressure drop (ΔP_F) and the acoustic wave amplitude (ΔP_{AW}) as determined above.

4. Calculation of Inlet Piping Flow Pressure Drop for Indian Point Unit 2

$$\Delta P_F = \frac{(K + 1 + f \frac{L}{D}) M^2}{2 g_c \rho A^2}$$

where,

$k = 0.5$ (sudden contraction at Pressurizer Nozzle)

$f = .017$ (Reference 10)

$\frac{L}{D} = \frac{1.1}{.287} + 1 \times 16 = 19.8$ (Reference 10)

$\rho = 7.65\ lb/ft^3$ (saturated steam at 2500 psia)

$A = 0.064\ ft^2$

$M = \frac{408{,}000\ lb/hr}{3600\ sec/hr} = 113\ lb/sec$

The Flow Pressure Drop for Indian Point 2 is,

$$\Delta P_f = \frac{(0.5 + 1 + .017 \times 19.8) \times (113)^2}{64.4 \times 7.65 \times .064^2 \times 144} = 80.7\ psi$$

TABLE A-1

Indian Point Unit 2 Inlet Piping Configuration

- Total Pipe Length	= 1.1 ft
- Pipe Diameter	= 4" sch 160
- Fittings	= 1 - 45° elbows

- Crosby 4M6 Safety Valve
  408,000 lb/hr rated capacity
  .010 sec opening time

5.0 Acoustic Wave Amplitude

Indian Point Unit 2

For the configuration described in Table A-1, the Parameters are,

T_{op} = .010 sec.

$$\frac{2L}{a} = \frac{2 \times 1.1}{1300 \text{ ft/sec}} = .002 \text{ sec}$$

Since $T_{op} > \frac{2L}{a}$,

$$\Delta P_{AW} = \frac{2LM}{g_c A T_{op}}$$

$$\Delta P_{AW} = \frac{2(1.1) \times 113}{(32.2)(.064)(144)(.010)}$$

$$\Delta P_{AW} = 83.8 \text{ psi}$$

6.0 PLANT-SPECIFIC PRESSURE DROP

$$\Delta P = \Delta P_F + \Delta P_{AW}$$

INDIAN POINT 2

$$\Delta P = 80.7 + 83.8$$

$$\Delta P = 164.50 \text{psi}$$

REFERENCES

1. "EPRI PWR Safety and Relief Test Program, Valve Selection/Justification Report", Interim Report, March 1982.

2. Westinghouse Electric Corporation Report, "Valve Inlet Fluid Conditions for Pressurizer Safety and Relief Valves in Westinghouse - Design Plants (Phase C)", Interim Report, December 1981.

3. EPRI PWR Safety and Relief Valve Test Program, "Test Condition Justification Report", Interim Report, April 1982.

4. "EPRI PWR Safety and Relief Valve Test Program, Description and Status", April 1982.

5. "EPRI - Marshall Power-Operated Relief Valve Interim Test Data Report: EPRI NO-1244-2D, Interim Report, February 1982.

6. "EPRI/Wyle Power-Operated Relief Valve Test Report, Phase I and II", EPRI NP-2147, LD, Interim Report, December 1981.

7. "EPRI PWR Safety and Relief Valve Test Program, Safety and Relief Valve Test Report", Interim Report, April 1982.

8. "EPRI PWR Safety and Relief Valve Test Program Guide for Application of Valve Test Program Results to Plant-Specific Evaluations", Interim Report, March 1982.

9. "Review of Pressurizer Safety Valve Performance as Observed in the EPRI Safety and Relief Valve Test Program", June 1982.

10. Crane Technical Paper No. 410, "Flow of Fluids Through Valves, Fittings, and Pipe", 1976.

ENCLOSURE 2

PRESSURIZER SAFETY AND RELIEF LINE PIPING AND SUPPORT EVALUATION

INTERIM REPORT

CONSOLIDATED EDISON COMPANY OF NEW YORK

INDIAN POINT UNIT 2

JULY 1, 1982

TABLE OF CONTENTS

1.0 INTRODUCTION

The pressurizer safety and relief valve (PSARV) discharge piping system for pressurized water reactors, located on the top of the pressurizer, provides over-pressure protection for the reactor coolant system. A water seal is often maintained upstream of each pressurizer safety and relief valve. However, for the Indian Point Unit #2 plant,a water seal does not exist. The piping between the pressurizer nozzle and the valve inlets are steam-filled. Upon actuation of the valves, the steam driven by high system pressure generates hydraulic shock loads on the piping and supports.

Under NUREG-0737, Section II.D.1, "Performance Testing of BWR and PWR Relief and Safety Valves", all operating plant licensees and applicants are required to conduct testing to qualify the reactor coolant system relief and safety valves under expected operating conditions for design-basis transients and accidents. In addition to the qualification of valves, the functionability and structural integrity of the as-built discharge piping and supports must also be demonstrated on a plant specific basis.

In response to these requirements, a program for the performance testing of PWR safety and relief valves was formulated by EPRI. The primary objective of the Test Program was to provide full scale test data confirming the functionability of the reactor coolant system power operated relief valves and safety valves for expected operating and accident conditions. The second objective of the program was to obtain sufficient piping thermal hydraulic load data to permit confirmation of models which may be utilized for plant unique analysis of safety and relief discharge piping systems. Based on the results of the aforementioned EPRI Safety and Relief Valve Test Program, additional thermal hydraulic analyses are required to adequately define the loads on the piping system due to valve actuation.

This report is the response of the Consolidated Edison Company of New York to the July 1, 1982 U. S. NRC plant specific request for piping and support evaluation and is applicable to Indian Point Unit #2.

2.0 PIPE STRESS CRITERIA

2.1 Pipe Stress Calculation

The piping between the valves and the pressurizer relief tank was initially analyzed, prior to the EPRI Test Program, in accordance with the requirements of USAS B31.1.0-1967 Code and the Indian Point Unit #2 Design Criteria. These requirements establish limits for stresses from sustained loads and occasional loads (including earthquake), thermal expansion loads, and sustained plus thermal expansion loads, respectively. The appropriate allowable stresses for use were determined in accordance with the requirements of the Code.

2.2 Load Combinations

In order to evaluate the pressurizer safety and relief valve piping, appropriate load combinations were developed. The load combinations and the associated allowable stress limits used for the piping and piping components in the initial analysis were:

$$P + D \leq S_h$$

$$P + D + OBE + TR \leq 1.2\ S_h$$

$$T \leq S_A = f(1.25\ S_c + .25\ S_h)$$

Where:

P - Stress due to internal design pressure

D - Stress due to deadweight

OBE - Stress due to operational basis earthquake

T - Stress due to thermal expansion & anchor movement

TR - Stress due to transient valve operation

S_h - Allowable stress at hot temperature, as defined in the Code

S_c - Allowable stress at ambient temperature, as defined in the Code
S_A - Allowable stress range, as defined in the Code
f - Stress range reduction factor, as defined in the Code

These load combinations are more restrictive than the criteria recommended by the piping subcommittee of the PWR Test Program.

To account for fatigue effects of the transient loads, it was assumed that the transient produce secondary stresses. The number of equivalent full temperature cycles used to determine 'f' was calculated as follows for selected points of higher thermal stress:

$$N = N_T + T_1^5 N_{TR}$$

$$T_1 = \frac{TR}{T}$$

Where:

N = Equivalent full temperature cycles
N_T = Number of full temperature cycles
N_{TR} = Number of transient cycles
T_1 = Ratio of transient stress to expansion stress

Total pressurizer nozzle loads were calculated using the following load combinations:

$$\overline{D} + \overline{T} + \overline{OBE} + \overline{TR}$$

Where:

$\overline{D}$ = Nozzle load (forces & moments) due to deadweight
$\overline{T}$ = Nozzle load (forces & moments) due to thermal expansion anchor movement and associated operating temperatures
$\overline{OBE}$ = Nozzle load (forces & moments) due to operational basis earthquake
$\overline{TR}$ = Nozzle load (forces & moments) due to transient

Total valve nozzle loads were calculated using the following load combinations:

$$P + \overline{D} + \overline{T} + \overline{OBE} \text{ and } P_o + \overline{D} + \overline{T_o} + \overline{TR}$$

Where: (P, $\overline{D}$, T, $\overline{OBE}$ and $\overline{TR}$ as previously defined)

P_o = Stress due to internal pressure during plant heat-up mode of operation

$\overline{T_o}$ = Nozzle load (forces & moments) due to thermal expansion and anchor movement during plant heat-up mode of operation

The pipe internal pressure and temperature considered in the above P_o and $\overline{T_o}$ load cases were respectively 400 PSIA and 445°F

3.0 LOADING

The following loading conditions were considered in the initial piping stress analyses:

A. Internal pressure
B. Deadweight
C. Normal operating thermal moment loadings
D. Additional thermal moment loadings due to the different possible combinations of safety or relief valve operations
E. Loadings due to postulated seismic events
F. Thrust loadings due to steam and/or water discharge during safety or relief valve operations

4.0 ANALYTICAL METHODS

The three-dimensional piping system model which includes the effect of supports, valves and equipment was represented by an ordered set of data which numerically describes the physical system. All piping and piping components are assumed to behave in a linear elastic manner.

The thrust evaluation conducted prior to the EPRI Test Program was performed in two distinct steps:

A. Generation of thermal hydraulic time-history loads upon actuation of the safety and relief valves, utilizing the W proprietary computer program, FLASH-IV.

B. Application of the forces generated from (A) with appropriate dynamic load factors to the static structural model to determine component stresses and loads.

The static model from the deadweight and thermal analysis was utilized for the thrust analysis. The overall approach employed to evaluate the effects,due to the discharge of either safety or relief valves,was:

- A general approach to determine the forcing functions acting on the piping system which are induced by transients of the type investigated, was developed.

- An investigation was conducted to determine which valve and which cycling operating mode would result in significant effects on the piping system.

- For these selected transients, a detailed analysis was performed to determine time-histories of the forces acting on the piping system.

- These force time-histories were evaluated to identify the times and the associated forces which induced significant effects on the piping system.

- Finally after determining the Dynamic Load Factor (DLF) to be applied to these selected force sets, a static pipe stress analysis was performed.

The seismic analysis was performed using the response spectral method with a lumped multi-mass piping model. The stiffness representation of the system in the mathematical model included piping, pressurizer, supports, and restraints. The results generated from the seismic analysis were combined in accordance with Section 2.2.

5.0 THERMAL HYDRAULIC MODELING - EPRI TEST RESULTS

Piping load data has been generated from the tests conducted by EPRI at the Combustion Engineering Test Facility. Pertinent tests simulating dynamic opening of the safety valves for representative upstream environments were carried out. The resulting downstream piping loadings and responses were measured. Upstream environments for particular valve opening cases of importance, which envelope the commercial scenarios, are:

A. Steam discharge - steam between the pressure source and the valve.

B. Cold water discharge followed by steam - steam between the pressure source and the loop seal - cold loop seal between the steam and the valve,

C. Hot water discharge followed by steam - steam between the pressure source and the loop seal - hot loop seal between the steam and the valve.

Case B and Case C are not applicable to the Indian Point Unit #2 plant as the layout does not include a loop seal immediately upstream of the safety valves.

Specific thermal hydraulic analyses utilizing the Westinghouse Proprietary Program ITCHVALVE have been completed and structural modeling is in progress for the Combustion Engineering Test Configuration. The capacity of the computer program for calculating the fluid-induced loads on the piping downstream of the safety and relief valves has been demonstrated by comparing the analytical results with the test data.

Additionally, the capability has been verified by direct comparison to solution of classical problems.

The thermal hydraulic analysis is performed in order to obtain transient hydraulic parameters, such as pressure, mass flow rate, fluid density, etc., subsequent to initiation of valve opening. The analytical model consists of a series of single pipes joined together at one or more places by two or three way junctions. Each of the single pipes has associated with it flow area, length, elevation angles, friction factor, initial pressure and initial fluid enthalpy. The thermal hydraulic computer program solves the conservative equations using the method of characteristics, after which a post-processing program computes the unbalanced transient hydraulic forces along each straight run of pipe upstream, and downstream of the valve.

6.0 ACTION PLAN

Because there is no loop seal and the length of inlet piping is short, the Indian Point Unit 2 pressurizer safety and relief line piping has a favorable configuration. Also, a detailed analysis and Code evaluation was performed for the pressurizer safety and relief system prior to the EPRI tests. All pertinent prior results will be used in the reevaluation of the piping and support system.

A. Thermal hydraulic analyses will be performed consistent with Section 5.0. All pertinent valve discharge cases will be included.

B. The resulting loads and forces from this thermal hydraulic analysis (A) will be compared to the hydraulic forces and structural responses derived from the pre-EPRI Test Program effort, as described in Sections 2.0, 3.0 and 4.0. The results of the deadweight and seismic analysis previously performed will be combined, as defined in Section 2.0, with the thermal hydraulic results developed in (A) to obtain pipe comparative stresses throughout the piping system. In addition to the pipe stress evaluation, valve nozzle loads will be evaluated.

C. If the evaluation in (B) indicates all pertinent stresses are within the allowable limits, the final report summarizing the results will be prepared.

D. In the unlikely event of system overstresses resulting from (B), either a more detailed structural evaluation will be performed or system modifications based on analytical results and engineering judgment, which potentially would resolve all overstress or overload problems, will be proposed.

E. If the refined analysis and/or design modifications indicate system overstresses or overloads, action (D) will be repeated until all overstresses/overloads have been resolved. The final report summarizing the results will be prepared.

3.0 EVALUATION STATUS

The original design basis analysis for the safety and relief valve discharge piping system was reviewed. The hydraulic analysis was performed using appropriate analysis methods. The hydraulic loads derived were amplified by a dynamic load factor of 2.0 and a quasi static structural analysis was performed on that conservative basis. Subsequently, a static analysis was performed for water solid discharge to protect against overpressurization. Again, conservative factors were applied to the loads.

Reanalysis of the system for the applicable operating conditions was initiated subsequent to the availability of EPRI test data generated at the Combustion Engineering Test Facility. Preliminary results indicate that the original design loads are either conservative or are of the same order of magnitude. Judging from the data for safety valve discharge with no loop seal, the original design basis loads are in good agreement with those observed from the full scale EPRI test data. Upon completion of the thermal hydraulic analysis, comparison will be made either with the original design data or against piping and support load capabilities. If necessary, structural analysis will be performed again.

Based on analytical work and tests to date, all acoustic pressures in the upstream piping calculated or observed prior to and during safety valve loop seal discharge are below the maximum permissible pressure. An evaluation of this inlet piping phenomenum was conducted and the results are documented in a report entitled "Review of Pressurizer Safety Valve Performance As Observed In the EPRI Safety and Relief Valve Test Program", WCAP-10105, dated June,1982. There is approximately one foot of 4-inch schedule 160 piping between the Indian Point Unit 2 pressurizer nozzle and the inlet of the safety valves. There is no loop seal. No significant pressure perturbations were observbd in tests or analytically calculated for configurations without loop seals. The calculated maximum upstream pressure is, therefore, significantly below the maximum permissible pressure.